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Subnational Population Imbalances and Male Childlessness in Finland

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Subnational Population Imbalances and Male Childlessness in Finland

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Abstract

Male childlessness is increasing in many high-income countries. In Finland in 2022, the share of all men who were childless at age 45 had reached 29%. What is causing these high levels of childlessness is unclear. In this paper, we use rich Finnish population register data to examine whether gender imbalances in regional partner markets are a potential driver of male childlessness. Partner markets are unbalanced in a given region if there is a surplus of men relative to women, or vice versa. The data generally shows increasingly imbalanced partner market situation for men over time, but with considerable regional heterogeneity. Regression results indicate an increased probability of childlessness at age 45 after extended exposure to unbalanced partner markets over the life course. This association is particularly strong for low-income men. These findings are robust across indicators and specifications. Overall, the regional context seems to play a crucial role in the risk of childlessness.

1 Introduction

Levels of childlessness have been rising steeply in the Nordic countries (Jalovaara et al., 2019; Zeman et al., 2018), particularly among men. For instance, in Finland, childlessness among men aged 40 to 44 has increased continuously from 19% in 1990 to 29% in 2022, and it exceeds the corresponding levels for women by about 10 percentage points. The increase in childlessness has been a key driver of declines in Nordic fertility since 2008 (Hellstrand et al., 2020, 2021; Jalovaara et al., 2019). High fertility rates in the Nordic region before 2008 have been attributed to these countries' generous welfare states in general and family policies in particular as well as to their progress in terms of gender equality (Duvander et al., 2010). This leaves the development after 2008 largely unexplained, including trends and levels in childlessness.

Most research on childlessness focuses on women, even though the levels for men exceed the levels for women (Tanturri et al., 2015). Among the strongest predictors for childlessness among men are the absence of a romantic relationship and relationship instability (Andersson, 2023; Jalovaara and Fasang, 2017; Rahnu and Jalovaara, 2023; Saarela and Skirbekk, 2020). The importance of partnerships is also reflected in the individual perceptions of childless male Finns, as the majority of them giving not having found a suitable partner as the primary reason for being childlessness (Miettinen, 2010). The role of relationship histories for childlessness raises questions about the structural determinants of partner availability (Miettinen, 2010). Regional partner markets are crucial determinants of the likelihood of having a partner (Eckhard and Stauder, 2019; Häring et al., 2014; Ní Bhrolcháin and Sigle-Rushton, 2005; Stauder, 2011; Stauder and Eckhard, 2016; Stauder and Röhlke, 2022; Uggla and Mace, 2017). Thus, imbalanced partner markets - that is, partner markets in which it might be difficult for men to find a partner due to structural constraints - could be an important driver of childlessness. Such structural constraints might also influence the socioeconomic gradient in childlessness, as childlessness is disproportionately concentrated among males of low socioeconomic status and the link between socioeconomic status and childlessness has grown stronger over time (Bratsberg et al., 2021; Jalovaara et al., 2019).

This paper examines whether regional partner markets are associated with male childlessness at the individual level in Finland. These regional partner markets are structurally determined by the regional population structure. In particular, we investigate whether regional imbalances in the age-sex-education structure drive Finland's male childlessness levels using Finnish population register data for the years 1987 to 2020. We estimate several partner market measures at the subnational level to assess the partner market opportunities over time and across regions. These metrics encompass factors such as the demographic distribution of the opposite sex, the level of competition for potential partners, and individual preferences, including age preferences and educational homogamy. In a second step, we use these measures to model the relationship between the partner market situation throughout the life course and being childless at the end of the reproductive period. The main specification regresses being childless at age 45 on the average lifetime partner market measure. Moreover, we estimate several additional models, including sibling fixed effects models, to account for potential issues such as unobserved heterogeneity and model misspecification, as well as discrete time survival models.

In line with recent findings from Gulczynski (2023) and Menashe-Oren and Sánchez-Páez (2023), we hypothesize that regional partner markets may have become unfavorable for Finnish men as a result of several interrelated processes. We therefore argue that the regional context is a crucial factor in the debate on contemporary fertility and childlessness. Changes in the economy and society may contribute to sex-selective migration, given that jobs and educational institutions are not evenly geographically distributed. Together with increasing educational attainment and employment levels among women, these developments can cause migration pattern of men and women to diverge. Urban areas are becoming the main destinations for women, because they are more likely to be enrolled in tertiary education or to be working in service sector jobs, which are usually concentrated in cities. By contrast, men are more likely to be employed in the agriculture and manufacturing industries, which are more often located in rural areas. Thus, the geographic dispersion of jobs and educational institutions might be the underlying driver of sex differences in mobility, which may, in turn, increase the subnational heterogeneity of partner availability. Moreover, improved education and public health campaigns have reduced the mortality hump among males, which has narrowed the sex gap in mortality. Thus, the male surplus resulting from from the skewed sex ratio at birth (SRB) is now sustained throughout the life course.

There are multiple potential mechanisms connecting partner markets to childlessness. Research has shown that partner markets with sex imbalances reduce mating chances (Eckhard and Stauder, 2019; Häring et al., 2014; Ní Bhrolcháin and Sigle-Rushton, 2005; Stauder, 2011; Stauder and Eckhard, 2016; Stauder and Röhlke, 2022; Uggla and Mace, 2017) as well as the quality of the matches between partners (Lyngstad, 2011). Partner markets also affect relationship quality (Stauder and Röhlke, 2022), have implications for the division of roles within partnerships (Stauder and Röhlke, 2022), and increase the risk of separation (Becker, 1977). Lower union formation rates and lower union quality may lead to higher childlessness in the population (Rijken and Liefbroer, 2009). Moreover, we hypothesize that a lack of partners could increase childlessness among men with low socioeconomic status in particular, as they have less resources to cope with the heightened competition on the partner market (Stauder and Kossow, 2021).

This paper adds to the existing literature on partner markets and childlessness by providing the first micro-level analysis of regional partner markets and male childlessness. Previous work in this area has often focused on the macro level and on women. As results based on macro-level data might be driven by compositional change, they may not translate directly to the individual level, and might not be able to capture the effects of partner markets that unfold over the life course. Moreover, results for women do not represent the experiences of men, as male and female fertility have long been known to differ, in some cases quite substantially (e.g., Dudel et al., 2021; Schoumaker, 2019). Moreover, we address two methodological issues. First, we use several indicators to quantify the partner market situation in a specific region at a specific time. Filser and Preetz (2021) and Eckhard and Stauder (2019) demonstrated that the measurement of partner markets has implications for results on partnership formation and individual perception of partner markets. Hence, using a variety of indicators allows us to asses the stability of the results. Second, we address the modifiable areal unit problem (Openshaw, 1983). Administrative boundaries rely on arbitrarily drawn spatial units, which produce measurement error and might affect the results. Aggregating fine-scaled data at the municipality level based on spatial proximity allows us to reduce this arbitrariness, and to improve the ability of the measure to capture the spatial proximity of partner markets.

2 Background

2.1 Partner search and markets

Oppenheimer (2000; 1988; 2003; 1997) conceptualized the complexities of the partner search by drawing inspiration from job search theory. Individuals, guided by rational decision-making to maximize utility from potential partners, navigate uncertainties using a reservation value as a heuristic. This value sets a minimum standard for accepting a match, guiding the search until a qualified match is found.

The individual partner searches are embedded in wider partner markets. The partner market serves as a sociological concept that helps to explain the dynamics of partnership formation (Haandrikman, 2019; Haandrikman et al., 2008; Uggla and Andersson, 2018). At its core is a twosided search process, in which both parties must mutually agree to form a partnership (Van Bavel, 2021, p. 220). This market perspective connects individual-level partner search behaviors with larger demographic trends. Imbalances in partner markets, influenced by boundedness, preferences, availability, and competition, significantly shape and constrain individual partnering decisions.

Mate selection unfolds within a spatially bounded area (Haandrikman, 2019; Haandrikman et al., 2008); though online dating has the capacity to modify these spatial constraints. Preferences, especially in terms of age (Kolk, 2015; Skopek et al., 2009), income (Chudnovskaya and Kashyap, 2020), and education (Mare, 1991; Skopek et al., 2011), exert a profound influence on individual partner searches. Assortative mating, reflecting age and education cues, results in non-random partnering patterns across time and countries (Ausubel et al., 2022; Schwartz, 2013). Partner markets due to factors such as sex ratios at birth, cohort sizes, and mortality differences (Eckhard and Stauder, 2019) have socioeconomic implications for individual mating decisions and union formation.

2.2 Effects of unbalanced partner markets on fertility

The influence of partner markets on fertility operates through various channels, including partner availability and other mechanisms. Initially, partner markets contribute to the rates of union formation. In regions where one gender is more prevalent, heightened competition and a limited pool of available options can impede mating opportunities. As a result, less favorable partner market conditions may reduce individuals' chances of attracting and forming relationships. Previous research has consistently shown that a scarcity of available partners impedes partnership formation. Research conducted in the United States has highlighted how imbalances in partner markets affect marriage rates (Akers, 1967; Albrecht, 2001; Albrecht et al., 1997; Lichter et al., 1991, 1995, 2020; Pollet and Nettle, 2008). Similar trends have been observed in Mexico (Parrado and Zenteno, 2002) and Europe (Inoue et al., 2013; Klein and Stauder, 2015; Stauder, 2008, 2011; Stauder and Eckhard, 2016), where imbalanced partner markets contribute to reduced union formation rates.

Second, it has been suggested that a scarcity of available partners in the market could impact matching quality. Increased competition and limited options may lead individuals to select a partner quickly, without fully knowing the person's characteristics (Oppenheimer, 1988). Research exploring the impact of partner availability on matching quality has indicated that educational mating is influenced by the opportunity structure within the partner market (Grow and Van Bavel, 2015; Stauder and Kossow, 2021; Van Bavel and Nitsche, 2013; Van Bavel et al., 2018). As well as increasing the risk of relationship dissolution, lower matching quality may reduce the likelihood of transitioning to parenthood (Rijken and Liefbroer, 2009).

However, partner markets can have also the opposite effect, as an excess of available partner can disrupt existing partnerships through several mechanisms. As Becker (1973) has argued, an abundance of potential partners in a region can destabilize partnerships, as having alternative mating options has been identified as a primary reason for union dissolution. Several studies, such as Rapp et al. (2015), have found that increased partner availability and interactions with the opposite sex elevate the risk of separation. Additionally, according to exchange theory, the partner of the scarcer gender may possess heightened bargaining power within the union, and could leverage this advantage (Guttentag and Secord, 1982; Stauder and Röhlke, 2022). This power dynamic increases the risk of union dissolution (Lyngstad, 2011; South and Lloyd, 1995), and may decrease the likelihood of having children (Fostik et al., 2023), thus representing a mechanism in the opposite direction.

Finally, unbalanced partner markets may alter the socioeconomic gradient of childlessness rendering groups with fewer resources childless. By benefiting from their increased market value, members of the scarcer sex can seek higher-value partners (Becker, 1981), while members of the abundant sex have to contend with intensified competition. Unbalanced partner markets tilt the scale in favor of individuals with greater resources and higher market value, thus contributing to an elevated prevalence of childlessness, especially among men with lower educational and income levels. Empirical studies have consistently shown supported the notion of amplified selection for members of the abundant sex (Pedersen, 1991; Schacht and Kramer, 2016). For example, Van Bavel and Nitsche (2013) and Grow and Van Bavel (2015) discovered that the reversal of the educational inequality gap reduced partnering opportunities for low educated men. Consequently, we hypothesize a deepening of the socio-economic gradient in male childlessness in areas with a surplus of men.

2.3 Previous research

As early as the 1970s, demographers were discussing disparities in the sizes of male and female populations, which coincided with the divergence of fertility rates between the genders at the national level. These discrepancies resulted from imbalances in sex ratios, which were influenced by events such as World Wars I and II, as well as abrupt shifts in cohort sizes during the transition from the baby boom to the baby bust era (Akers, 1967; Brouard, 1977; Muhsam, 1974; Schoen, 1983, 1985). While these observations prompted speculations that variations in age-sex structures would inevitably lead to sex-specific differences in reproduction, scholars primarily focused on fertility rates, rather than specifically exploring childlessness.

The few existing studies on childlessness support the assumption that the further the sex distribution is from equilibrium, the higher the levels of childlessness in the larger gender group will be. Across most countries, men remain more likely than women to childless. and Chudnovskaya and Ueda (2021) have estimated that 10-20% of the sex-difference in childlessness in Sweden is due to population imbalances. Similarly, it has been shown that the higher levels of male childlessness in Norway can be largely attributed to population imbalances (Kravdal, 2021). However, these results are based on national-level data, which may overlook substantial subnational heterogeneity in partner availability. Existing studies on Finland have shown that male childlessness is higher in regions, where men outnumber women (Lainiala and Miettinen, 2013), and, conversely, that there is a positive association between female childbearing and a surplus of men (Pettay et al., 2021).

3 Trends in Finland

3.1 Partner markets in Finland

We argue that the impact of population imbalances on partner markets is likely to be specifically large in Finland due to its population sparseness. Low population densities may reinforce the effect of unbalanced partner markets because the impact of sex-selective migration is amplified when the overall numbers of inhabitants are low. When one person moves out, the impact on the population structure is larger in areas with sparse population. This claim is further supported by previous research indicating that a low population density strengthens the link between imbalanced partner markets and union formation, possibly due to the reduced visibility of potential partners (Stauder and Röhlke, 2022). Finland's 5.5 million inhabitants are spread over an area of 338.445 km^2, which translates into a population density of around 16 inhabitants per km^2. This makes Finland the third least populated country in Europe.

Beyond its geographic setup, recent macro-sociological trends may affected partner markets in Finland- and, by extension, the childbearing opportunities of Finnish men. First, the number of women has exceed the number of men in the highest educational category since the cohort born 1955-1955. Moreover, this gender gap in education has been widening, as shown in Figure B.7 in the Appendix. The reversal of the gender gap in education may have had two implications for the partner search of men. First, as universities are located in urban areas, the reversal of the gender gap might have resulted in sex-selective migration, assuming that students move to the areas where the educational institutions are placed. Gulczynski (2023) found that the higher the population density is in Finland, the less male skewed the population is. Second, as education hypergamy and homogamy (the woman has the same or lower level of education than the partner) have long been prevailing pattern, the reversal of educational inequality could produce a mismatch in the population, which might further squeezes the partner market.

Second, the economic structure may affect regional partner markets in Finland given the uneven sex distribution across occupations. Women tend to concentrate in the service sectors, while men are more heavily represented in industrial sectors, as depicted in Figure B.5 in the Appendix. For instance,large shares of women are working in human health and social work activities (15%), trade (5%) and education (5%), while substantial shares of men are employed in manufacturing (9%) and construction (6%). These sex differences in the occupational distribution may also have an imprint on the geographic distribution of the two sexes, as female-dominated branches are mainly located in urban areas, producing sex-selective migration.

3.2 Childlessness in Finland

Childlessness in Finland is higher than that in other countries, and it has been increasing over recent decades, particularly among men (Jalovaara and Fasang, 2017; Jalovaara et al., 2022; Rotkirch and Miettinen, 2017). Childlessness among women at age 45 increased from 13% in 1990 to 19% in 2022. The levels for men at the same age surpass those for women by 10 percentage points, with childlessness among men increasing from 19% to 29% in the same period. At least for men, increasing fertility postponement may inflate these findings, given that male childlessness levels might be lower at older levels. Nonetheless, the numbers show a clear trend. Studies that have investigated this phenomenon have found that among the strongest predictors of childlessness are the late entry into a union and unstable unions (Jalovaara and Fasang, 2017; Saarela and Skirbekk, 2020).

A recent study by Jalovaara et al. (2022) found two types of polarisation in childbearing behaviour in Finland. First, there is a polarisation in childlessness between individuals with low and high education, with childlessness being less common among highly educated men and women (Jalovaara et al., 2019, 2022; Nisén et al., 2014). The second polarisation occurs within the low educated stratum, in which both childless people and people with many children are becoming more numerous. This form of polarisation may point to a strong selection into union and mating for men with low SES. Among low-educated women and men with many children, multi-partner fertility is a frequent phenomenon (Jalovaara et al., 2022).

3.3 Research aims

The study mainly aims to examine *the relationship between lifetime partner market exposure and childlessness among men*. To do so, we assess the development of partner markets in Finland between 1990 and 2018. The male share in the population may be increasing, because both more men than women are born on average and overall sex differences in mortality at young ages have vanished. This trend might be heterogenous across regions because of sex-selective migration. Hence, we look at *the trend in the ratio of men to women, examining whether this trend is accentuated particularly in rural areas that continue to have a male-dominated demographic composition.* Partner markets affect the probability of union formation, the quality of matches and relationship stability. Therefore, we investigate whether *the probability of men remaining childless increases in areas with excess men.* Furthermore, partner market imbalances increase the competition for partners. Therefore, we expect to find that *in areas where men outnumber women, men's transition into fatherhood is more selective depending on their socio-economic characteristics.*

4 Data & Methods

4.1 Administrative registers

Throughout the analysis, we use Finnish register data provided by Statistics Finland covering the period between 1986 and 2020. The data contains all individuals who are registered in Finland on the last day of each year. We restrict our sample to Finnish cohorts born in the years 1968-1975 because we can observe their full reproductive and residential histories from age 18 to age 45. The final data form a pooled cross-section of these cohorts, which consists of Finnish-born men aged 45. The cumulative sample contains 276,000 men.

We restrict our analysis to Finnish-born men for three major reasons. First, childbirth outside of Finland is not captured in the data; thus, for men who enter Finland after the beginning of the reproductive phase, it is not clear whether they are childless, even if they have no birth in Finland. This issue also applies to Finnish-born men if they leave the country and return at a later time, but it is much less likely to be relevant for them. Second, homogamous partner preferences with respect to country of birth or nationality might be perceived as particularly important by migrants, which implies that regional partner markets could work differently for migrants than for natives (Elwert, 2020). Finally, it may be assumed that some migrants maintain relationships to their country of origin, which makes partner markets outside of Finland more relevant for them.

4.2 Measuring regional partner markets

In looking at how regional partner markets relate to childlessness, we need to assess a person's exposure to partner opportunities over the life course. This involves making some important decisions. First, we have to select an indicator for partner availability and decide what it considers (e.g., education). Second, we have to decide what ”regional” means by setting clear boundaries when creating the indicator. Lastly, we have to find a way of aggregating the indicator over the entire life course. The following sections explain these steps in more detail.

Our focus in this study is on the relationship between lifetime partner market exposure and childlessness. The lifetime exposure is captured by aggregating the age-specific partner market indicator over the life course. This approach is less volatile than including age-specific partner market measures. In addition, it more closely reflects the theoretical argument that the partner search unfolds over the life course. Nonetheless, a potential disadvantage of this approach is that the partner market condition during periods when an individual is in a relationship affect the outcome. Moreover, it is a crude measure of the partner market. We estimate the average value of the partner market indicator for the ages between 18 and the age at first conception (the year before first childbirth), or between ages 18 and 45.

When measuring partner market indicators, we need to define the spatial boundaries of the area we are measuring, and who is counted within these boundaries. Previous research on regional partner markets relied on administrative boundaries to define the borders for partner markets. However, this approach, which is illustrated by the green dashed line in Figure 1, can lead to measurement error when a individuals reside close to the border of the administrative unit, because neighbouring regions may serve as partner markets for them. Thus, partner markets based on large administrative units do not reflect the spatial proximity. This is a case of the modifiable areal unit problem (MAUP), which states that while spatial units are modifiable and subject to whoever did the aggregating, they can have a strong impact on results (Openshaw, 1983).

To overcome this limitation, we move the analysis to the lowest spatial granularity in the data, which is the level of municipalities (fin. *Kunta*, n = 309). We aggregate the population data for the specific municipality and all others with a border within a certain distance to the municipality of interest. This yields a spatial pattern, as visualized by the solid yellow line in Figure 1. We selected a distance of 9.2 kilometers for the aggregation based on the study by Haandrikman (2019), which reflects the average distance of partner choice in a study on Sweden. Although we are examining Finland, not Sweden, the cultural and geographic similarities between the two countries lead us to use believe that the value may serve as a reasonable approximation of the geographic distance for partner selection. To account for the uncertainty embedded in this decision, we have re-estimated the models using 0 kilometer (which encompasses all neighbouring municipalities) and 20 kilometers as alternative distances, which yielded similar results (see also Appendix A.2).

The main partner market indicator in our analysis is based on the availability ratio of Goldman et al. (1984), see also Stauder (2008) and Eckhard and Stauder (2019). It is defined as follows:

$$\mathrm{AR}(x,e) = \frac{\sum_y \sum_b w_{x,e}(y,b) F(y,b)}{\sum_y \sum_b w_{x,e}(y,b) \cdot \sum_x \sum_e w_{y,b}(x,e) M(x,e)}. \tag{1}$$

$w_{x,e}(y,b)$ is the partner preference of men in age x with education level e for women with education b in age y. These are standardized weights conditional on the male characteristics such that $\sum_y \sum_b w_{x,e}(y,b) = 1$. The calculation of these preference weights is discussed below. $w_{y,b}(x,e)$ is the partner preference of women in age y with educational level b for men in age x and with educational attainment e. $F(y,b)$ is the number of women at age y with education b in the partner market and $M(x,e)$ is the corresponding number of men with at age y with education e, which have been drawn from the population registers. These components reflect

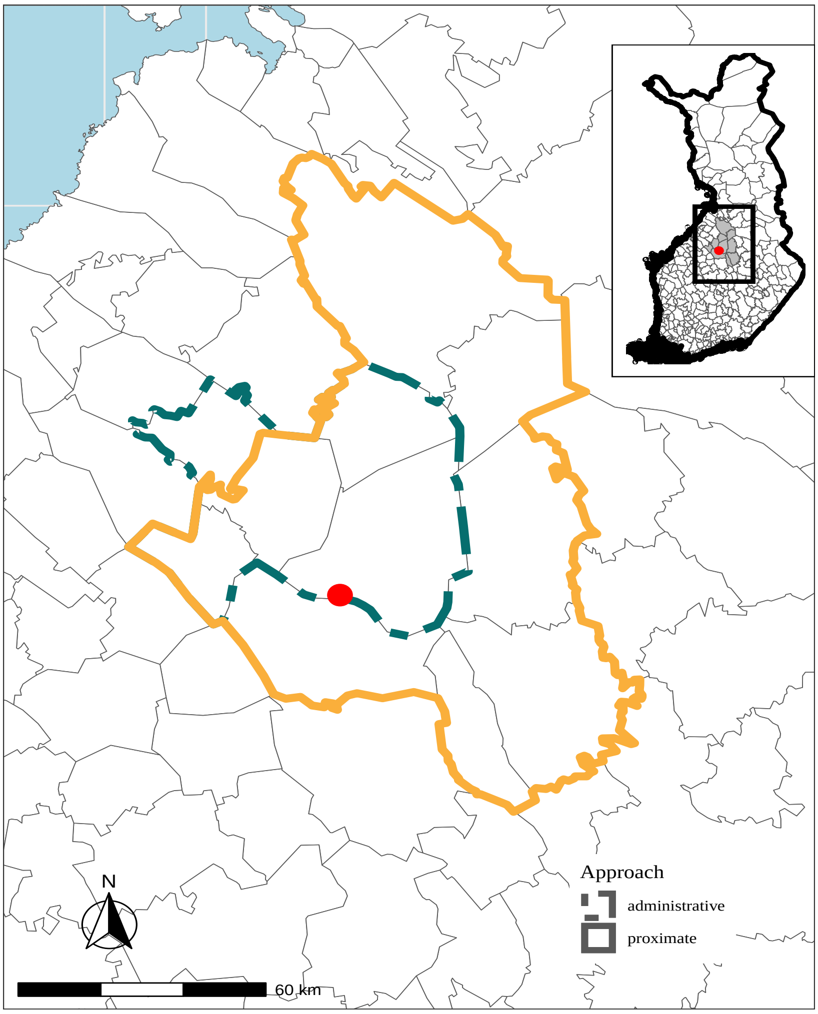

Figure 1: This graph illustrates through an example the difference between the administrative boundary approach and the spatial proximity approach used in the analysis. The red point in the graph illustrates the exact residence of a person, which is not given in the data. The area marked with the green dashed line corresponds to the partner market based on the administrative boundaries; in this case, the subnational economic unit (Seutukunta) the person lives in. The area surrounded by the solid yellow line illustrates the spatial partner based on the spatial proximity approach. **Interpretation:** when a person lives near the border of a subnational economic unit, the partner market involves a large measurement error, which is reduced in the spatial proximity approach.

the availability of potential partners (the number of women) and the number of competitors (the number of men). If the indicator takes values higher than one, the partner market exhibits a surplus of women relative to men in age x and with educational attainment e, while values below one indicate a lack of potential partners and increased competition.

The estimation of the availability ratio relies on weights that account for partner preferences, $w_{x,e}(y,b)$. We estimate these weights as the conditional distribution of characteristics of the mother dependent on the characteristics of the father from the national birth statistics for the period between 1994 and 2020; i.e., only among childbearing couples. This procedure has some benefits and potential drawbacks compared with other approaches used in the literature, which often rely on surveys and stated preferences. Such stated preferences might deviate from actual behavior. Moreover, survey questions often ask respondents about their partner preferences, and not about the partners with whom they would consider having children (e.g., Stone et al. (2007)). In contrast, our approach is based on revealed and realized preferences, and thus avoids these issues. It might, however, be affected by circularity (De Hauw et al., 2017), as realized preferences depend on the partner market situation, and may not fully reflect the true underlying preferences. This might be less relevant for the national-level data we use, which averages over regional partner markets with imbalances in both directions. Moreover, our approach assumes that childless people have, on average, the same preferences as individuals with children.

In our robustness checks we use two alternative partner market measures, which indicate to what extent the results might depend on the measurement of the partner market (for an overview, see Table C.5 in Appendix C). Previous research found evidence that the choice of indicator might be relevant for the results and their interpretation (Eckhard and Stauder, 2019; Filser and Preetz, 2021). The first alternative is an age-specific sex ratio that relates the number of women at a particular age, $F(y)$, to the number of men at the same age, $M(x)$. While this measure is simple and does not rely on assumptions regarding preferences, it ignores the existence of age and educational preferences (Buss and Schmitt, 2018; Skopek et al., 2011). Moreover, it excludes the impact of varying cohort sizes on partnering behavior, because the potential partners are from the same cohort. As a second alternative, we have estimated a preference ratio that weights the availability by preferences as shown in equation 2. In the denominator is the sum of the weighted number of women across ages in the specific region, while in the numerator is the number of men at age x. The measure is more stable than the availability ratio, because it reflects only age preferences, which are found to be relatively robust over time and across countries (Ausubel et al., 2022; Dudel and Klüsener, 2021; Skopek et al., 2009), and because it reflects mating behaviour more realistically than the sex-ratio which ignores preferences completely (Filser and Preetz, 2021). The availability index is estimated in the following way:

$$\text{Preference ratio}(x) = \frac{\sum_{y=18}^{55} w_x(y) \cdot F_i(y)}{M(x)}. \tag{2}$$

4.3 Outcome: Childlessness

The outcome of interest is being childless at age 45 ($childless = 1$, $father = 0$). Childlessness is derived from not being listed as a parent in the birth registers, while fatherhood is inferred from being listed as a parent in the birth registers. Age 45 represents almost the end of the reproductive period, as our date on previous cohorts indicate that less than 5% of all births are to men older than 45. Thus, childlessness at age 45 provides a good approximation of ultimate childlessness. Furthermore, the number of first births after age 45 is even smaller. We experimented with different age cut-off points and the results remained largely stable. If a person becomes a father before age 45, the year of conception is used as the last observation, which is the year of birth minus one. Moreover, we account for evidence indicating that migration and fertility are interrelated processes (Kulu and Steele, 2013). Studies have shown that the probability of movement is particularly high between conception and childbirth, and thus that the birth might not occur in the region where the parents originally met, which introduces reversed causality. The rich micro-level data we use allow us to tackle this issue by dating the timing of the birth a year back to provide an estimate of the time of conception.

4.4 Control variables

Several control variables accounting for individual characteristics and contextual factors are included in the regression models, which are described in the next section. The variables are summarized in Table 1.

Household economic theory and research on fertility consistently point to the relevance of socio-economic characteristics (Becker, 1981; Kreyenfeld and Konietzka, 2017). Hence, we include disposable income in the last spell grouped into quantiles, which accounts for inflation. This variable is only available from 1995-2020. Moreover, we account for education by including the highest educational attainment. We group the education variable in the following way: basic (ISCED 2011: 0-2), medium (ISCED 2011: 3-4), and high education (ISCED 2011: 5-8). Moreover, men's employment is crucial for the partner market (Bolano and Vignoli, 2021; Bukodi, 2012), and unemployment creates uncertainty affecting fertility (Miettinen and Jalovaara, 2020). For that reason, we add the duration of unemployment as a control variable. This measure also functions as an approximation of the level of labour market attachment (Oppenheimer et al., 1997).

A set of controls on the regional context is added to the models as well, since contextual factors might confound the relationship, because structural possibilities and economic uncertainty might be correlated with partner markets and fertility (Campisi et al., 2022). Therefore, the general unemployment rate, the average income, the share of tertiary educated, and the share of poor individuals, which together approximates the income inequality in the region, are calculated for all regions and years, and are linked to the individual data via the residence biography. Subsequently, the contextual information throughout the life course are aggregated in a manner similar to the procedure for the availability indices.

Table 1: Summary statistics of indicators in the cumulative data.

Statistic	N	Mean	St. Dev.	Min	Max
Outcome:					
Childlessness	188,407	0.3167	0.465	0	1
Demographic:					
Max age	188,407	34,08	7.923	18	45
Cohort	188,407	1972.16	2.017	1969	1,975
Availability indicators:					
Availability Ratio (near)	188,407	0.09	0.21	−1.019	0.638
Preference Ratio (near)	188,407	0.006	0.069	−0.718	0.253
Sex Ratio (near)	188,407	−0.03	0.071	−0.942	0.449
Individual characteristics:					
Log Income	188,407	9.616	8.923	0	11.565
Education	188,407	2.192	0.884	1	3
Duration unemployment	188,407	1.528	3.038	0	25
Regional context:					
% Unemployed	188,407	10.941	2.533	0.834	23.017
% Tertiary: high	188,407	54.04	0.498	0	1
Inequality: high	188,407	50.00	0.500	0	1
Urban:	188407	0.647	0.415	0	1

4.5 Methods: Main analysis

As our main model, we use logistic regression with childlessness as the outcome and the average of the logged partner market measure over the life course as our main predictor. We use the log of the partner market measure, because it is a ratio, which is not symmetric around one. This becomes evident when looking at the range. Because of the lack of females, the numerator is higher than the denominator, can range from one to infinity, while the surplus of females can range from zero to 1. Taking the log of the measure yields a symmetric and linear relationship centered around zero.

To enhance interpretation and ensure the comparability of effect sizes across models, we generate counterfactual predictions based on the model coefficients. For instance, Karlson et al. (2012) demonstrated that coefficients in logit models can change not only due to confounding but also as a result of rescaling. Hence, we utilized logistic regression for calculating counterfactual scenarios. This approach allows us to assess the population-level impact of unbalanced partner markets by envisioning a scenario in which they do not exist. In a two-step process, we transform unbalanced markets into balanced ones by setting negative log availability values to zero. Subsequently, using model estimates, we predict the probability of being childless for all individuals in the sample and aggregate the share of childlessness in this counterfactual population. The disparity between model predictions for observed and counterfactual data highlights the population-level influence of partner market imbalances on male childlessness. Nevertheless, we acknowledge and address other model limitations through robustness checks.

4.6 Methods: Robustness checks

In our robustness checks, we use alternative regression approaches that account for model limitations. First, we estimate a sibling fixed effects model (sibling FE) to account for unobserved, time-constant confounders that are shared among siblings, such as upbringing and genetic factors (Barclay and Kolk, 2020). We use a linear probability FE model for the estimation(Allison, 2009b; Wooldridge, 2002). While this approach comes with more assumptions than an FE logistic regression, it allows us to calculate the marginal effect of the availability ratio, which is not possible with a FE logistic regression. A caveat of the sibling FE approach is the limited generalisability, as it restricts the sample to men who have at least one male sibling born between 1968 and 1975. The sibling data used for the sibling fixed effects models are composed of 65,000 men, who belong to 32,000 sibling groups. Second, we estimate a discrete time event-history model (Allison, 2009a), which builds on the temporal structure of the events to estimate a causal effect. The model assesses how the partner market affects the transition to first childbirth, instead of the association between lifetime partner markets and childlessness at the end of the reproductive period. Third, we follow the matching procedure suggested by Ho et al. (2007) to reduce the sensitivity of results with respect to assumptions regarding the functional form. First, we create a dichotomous treatment variable by transforming the availability index into two categories: 1. lack of potential partners; and 2. excess potential partners. We then perform *exact matching* based on siblings, which reduces model dependency and reduces bias from selection into treatment. This pre-processing ensures that the treatment and control groups are similar, which reduces the relevance of the parametric specification for the results (Ho et al., 2007). A logistic regression model is then run using the new treatment variable along with the control variables.

5 Results

5.1 Descriptive results

Figure 2 shows the regional levels of childlessness in Finland for the male cohorts born between 1968 and 1975 across subnational economic units (*fin.* Seutukunta). The bluer the colours, the higher the level of childlessness among men. Childlessness varies considerably by region, ranging from 24% to 41%. Moreover, there is a geographic pattern, with childlessness levels being low in the west and particularly high in the north, but also in the east. In the capital region of Helsinki, 29.6% of men are childless, placing it in the middle of the ranges.

The spatial pattern of the availability ratio for 30-year old men is displayed for three years (cross-sectional data) and educational levels in Figure 3, which confirms hypothesis 1 that the availability of potential partners has declined over time. The emerging unfavorable position for men on local mating markets is indicated by a growing number of grey and red regions, which correspond to balanced or unfavorable local partner markets. In 1987, all municipalities exhibit an excess in availability in the partner markets. However, just 18 years later, the map changes, showing more regions with a lack of available partners. This trend is particularly strong for lower educated men. In 2019, the spatial distribution of partner availability changes partially, as some regions in the south and in the middle of Finland also have favorable partner markets for men, while the east of Finland remains unbalanced to the disadvantage of men, which confirms hypothesis 2. Values of the availability ratio range from 0.27 to 2.00. The lowest value indicates that four men are competing for one women in the preferred range, while the highest value indicates that there are on average two women per man. Intriguingly, a comparing of Figure 2 and Figure 3 reveals some overlap of the regions exhibiting high levels of childlessness and

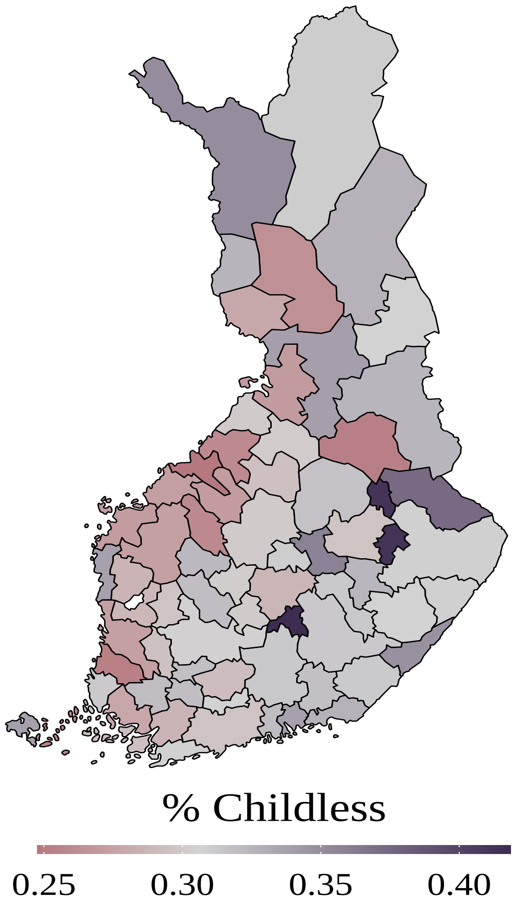

Figure 2: This graph illustrates the percentage of childless men at age 45 across subnational economic units (*fin.* Seutukunta) for the cohorts born in 1968-1975. **Note:** Men who enter fatherhood before age 45 are counted in the region where they where residing one year before the birth in order to avoid reversed causality resulting from moves related to family formation.

unfavorable partner markets, which provides some initial support for the hypothesis that partner markets affect childlessness.

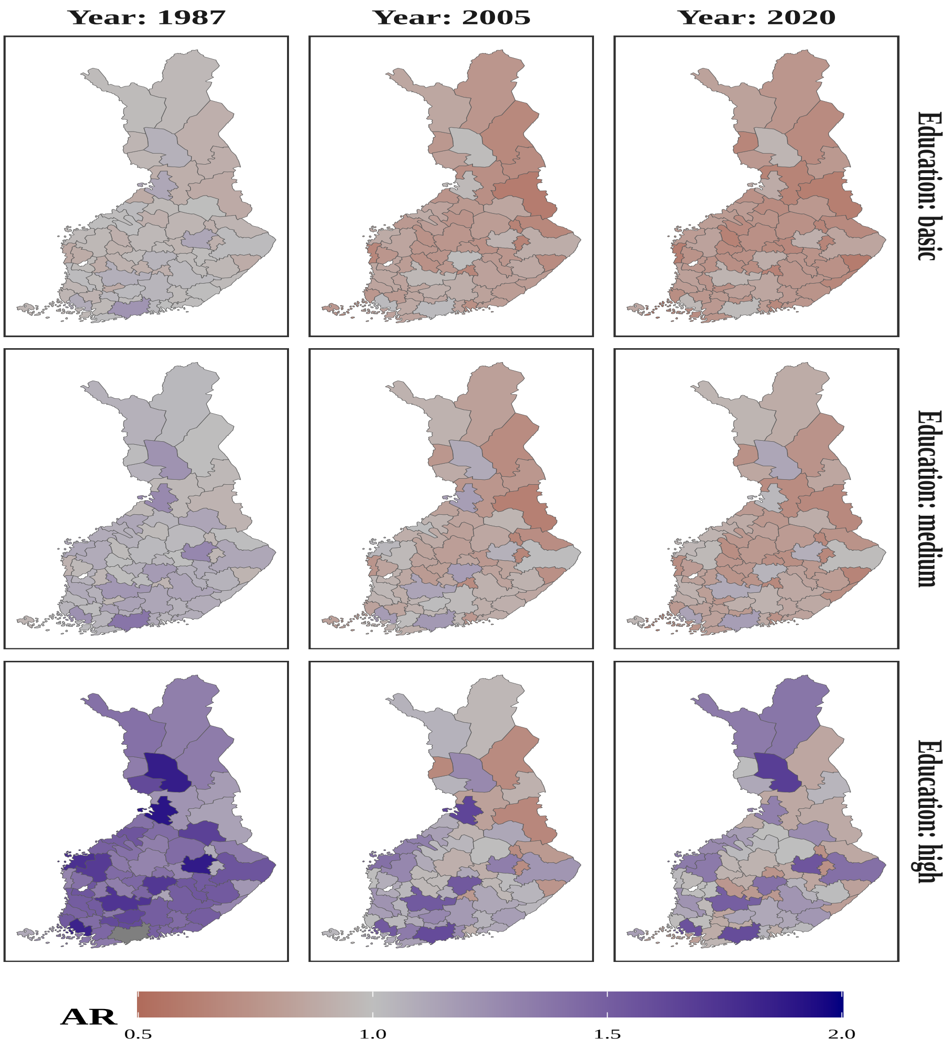

Figure 3: Cross-sectional data on partner availability for men at age 30. **Interpretation:** Red colours indicate a weak partner market situation at age 30, while greyish entities have balanced partner markets, and blue regions have an excess of potential partners.

Figure 4 shows the bi-variate association between life-time partner availability and childlessness in our sample. It indicates the proportion of childless people for the categorised cumulative exposure to the partner market measured using the availability ratio. The cumulative exposure is the mean partner market across the life course until the year before childbirth (conception), or until age 45, if the men remain childless. Figure 4 indicates that the better the partner market

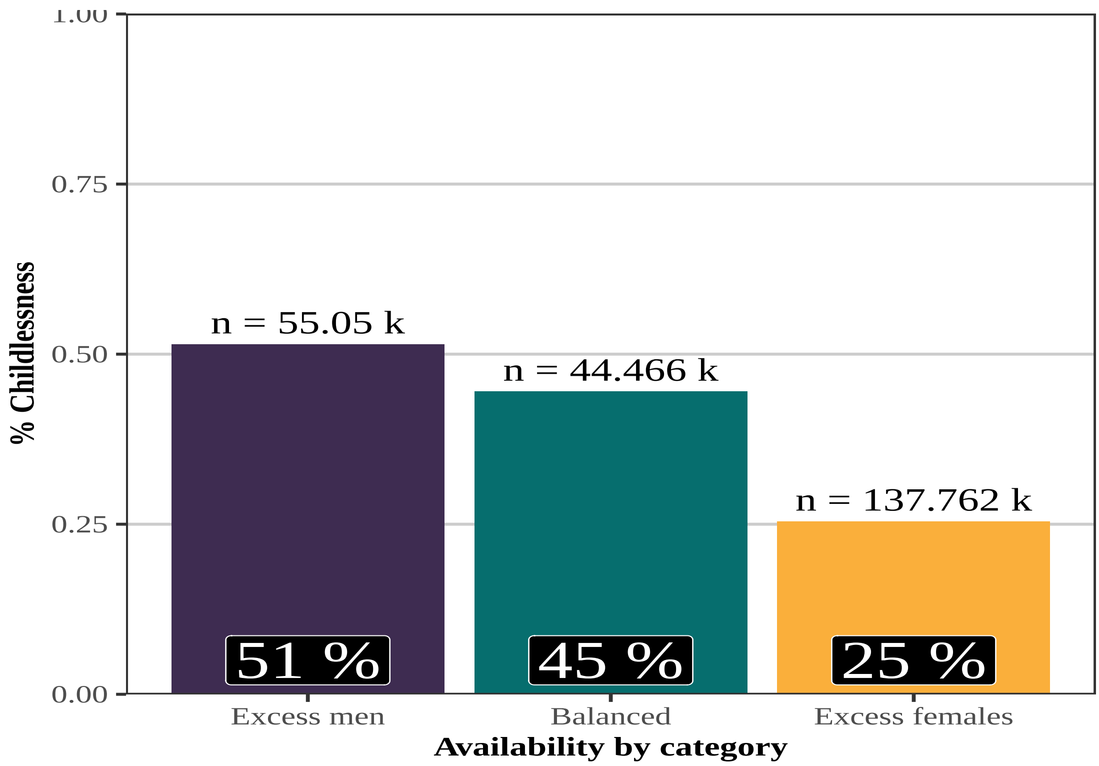

Figure 4: Percent childless across groups with different lifetime partner market situations. The groups are based on the mean availability ratio between age 18 and the age at conception of childbirth or age 45. The sample contains Finnish men born between 1968 and 1975.

situation is over the life course, the lower the share of childless men is, supporting hypothesis 3. Of the group of men with excess partner availability over their lifetime, the share who are of 25%childless men, which is 20 percentage points than that of men,experiencing balanced partner markets (45% childless), and 26 percentage points lower than that of men residing in region where men outnumber women (51% childless).

5.2 The association between regional partner markets and male childlessness

We present the results from the logistic regression models of being childless at age 45 on the cumulative availability ratio in Table 2. Each column shows the logit-coefficients for a different set of model specifications. The bottom part of the table shows the difference in childlessness levels between the model prediction and the counterfactual scenario (*population-level effect*), which indicates the level of male childlessness if there was no lack of availability. In the simple logistic regression without any control variables (Model 1), a one point increase in the life-time availability of females is associated with a decline in the probability of remaining childless as a male, as indicated by the negative sign for the coefficient, -2.413 (CI: -2.474 and -2.353). This suggests that an increase in the availability of women with preferred characteristics is inversely associated with childlessness.

Model 2 in Table 2 adds individual control variables and Model 3 adds contextual control variables. After adding to the model individual control variables for cohort, income quantile and duration of unemployment, the results remain stable and in accordance with hypothesis 3. In Model 2, the coefficient for the logged-availability ratio is -2.191 (CI: -2.259 and -2.124), indicating a reduction in the probability of being childless when partner availability increases. Therefore, the effect remains constant after controlling for socio-economic and demographic characteristics.

Moreover, when adding contextual control variables for the share of tertiary educated persons in the population, the regional unemployment rate and income inequality measured as the standard deviation of the average monthly income the effect remains significant and in the expected direction. Thus, when we take self-selection into regions with specific economic and educational characteristics into account, the results remain stable. After controlling for these contextual variables, the relationship remains significant and does not show a change in direction, indicating that an increase in partner availability decrease the probability of being childless. The coefficient of the log availability ratio is -5.058% (CI: -5.162% and -4.955%).

Table 2: Cumulative logistic regression on childlessness at age 45 using the availability ratio (near) as the predictor variable.

	Dependent variable:			
	Childless at age 45			
	(1)	(2)	(3)	(4)
log ar (near)	-2.413^{***}	-2.191^{***}	-5.058^{***}	-5.716^{***}
	(-2.474,-2.353)	(-2.259,-2.124)	(-5.162,-4.955)	(-5.908,-5.524)
Cohort: 1972-1976		-0.295^{***}	-0.164^{***}	-0.163^{***}
		(-0.316,-0.273)	(-0.189,-0.138)	(-0.188,-0.137)
Income Q2		-0.466^{***}	-0.618^{***}	-0.654^{***}
		(-0.498,-0.433)	(-0.656,-0.580)	(-0.711,-0.596)
Income Q3		-0.695^{***}	-0.783^{***}	-0.892^{***}
		(-0.727,-0.663)	(-0.820,-0.745)	(-0.949,-0.836)
Income Q4		-0.624^{***}	-0.870^{***}	-1.172^{***}
		(-0.657,-0.590)	(-0.909,-0.832)	(-1.231,-1.113)
Duration unemployed		0.194^{***}	0.175^{***}	0.174^{***}
		(0.191,0.198)	(0.171,0.179)	(0.169,0.178)
Education: high		-0.089^{***}	-0.667^{***}	-0.674^{***}
		(-0.124,-0.054)	(-0.709,-0.625)	(-0.716,-0.632)
Education: medium		-0.044^{***}	-0.193^{***}	-0.205^{***}
		(-0.076,-0.013)	(-0.230,-0.156)	(-0.242,-0.167)
% tertiary: high			1.242^{***}	1.253^{***}
			(1.210,1.275)	(1.220,1.286)
% unemployment			-0.531^{***}	-0.532^{***}
			(-0.539,-0.523)	(-0.540,-0.524)
Urban settlement			0.106^{***}	0.109^{***}
			(0.072,0.141)	(0.074,0.144)
Poverty: high			1.542^{***}	1.550^{***}
			(1.508,1.576)	(1.516,1.584)
log ar(near):Income Q2				0.111
				(-0.125,0.348)
log ar(near):Income Q3				0.547^{***}
				(0.325,0.769)
log ar(near):Income Q4				1.509^{***}
				(1.288,1.731)
Constant	-0.260^{***}	-0.113^{***}	4.845^{***}	4.986^{***}
	(-0.275,-0.245)	(-0.156,-0.070)	(4.747,4.943)	(4.882,5.089)
Observed (% childless)	32.6	32.6	32.6	32.6
Counterfactual (% childless)	32.1	32.2	32.0	32.0
Population level effect	−0.467	−0.441	−0.587	−0.585
Observations	194,080	194,080	194,080	194,080
Log Likelihood	-119,316.500	-106,999.400	-85,200.000	-85,072.720
Akaike Inf. Crit.	238,637.100	214,016.700	170,426.000	170,177.400
Note:				*p<0.1; **p<0.05; ***p<0.01

The lower section of Table 2 presents the anticipated childlessness rates derived from both observed and counterfactual data, along with the resulting difference representing the population-level effect. The findings highlight a significant influence of partner markets, with the counterfactual scenario showing a noteworthy decrease of four to six percentage points in childlessness compared to the model using observed data. This figure can be interpreted as the population-wide reduction in childlessness if no men were exposed to unbalanced partner markets, assuming the model's accuracy.

5.3 The steepening of the socio-economic gradient in childlessness

Model 4 demonstrates a pronounced amplification of the socio-economic gradient in male childlessness within unfavorable partner market conditions. This confirms that partner markets have a substantial impact on low-income groups, positioning them unfavorably in unbalanced partner markets. The model incorporates the independent effects of partner availability and its interaction with income quantiles, presenting compelling evidence for an intensified income gradient in imbalanced partner markets. The statistical significance of the interaction between income and partner availability is underscored, leading to an enhanced model fit, as evidenced by a reduction in AIC. Noteworthy is the designation of the lowest income quantile as the reference value, with subsequent quantiles revealing progressively escalating positive coefficients. This suggests that the link between partner market conditions and childlessness weakens in higher income groups. Employing estimates from Model 4, we predict the probability of childlessness (refer to Figure 5) across various partner market indicator values within distinct income groups. At lower levels of partner availability, childlessness diverges significantly across income groups, gradually contracting as partner availability improves. Conversely, in favorable partner markets, the economic gradient in childlessness diminishes and ultimately disappears. For example, the difference in the predicted probability of childlessness between the lowest and the highest income quantiles is 17 percentage points in the 25% quantile of the availability indicator distribution. This difference is reduced to 11 percentage points in a balanced partner market, and narrows even further to six percentage points in the 75%-quantile of the availability indicator.

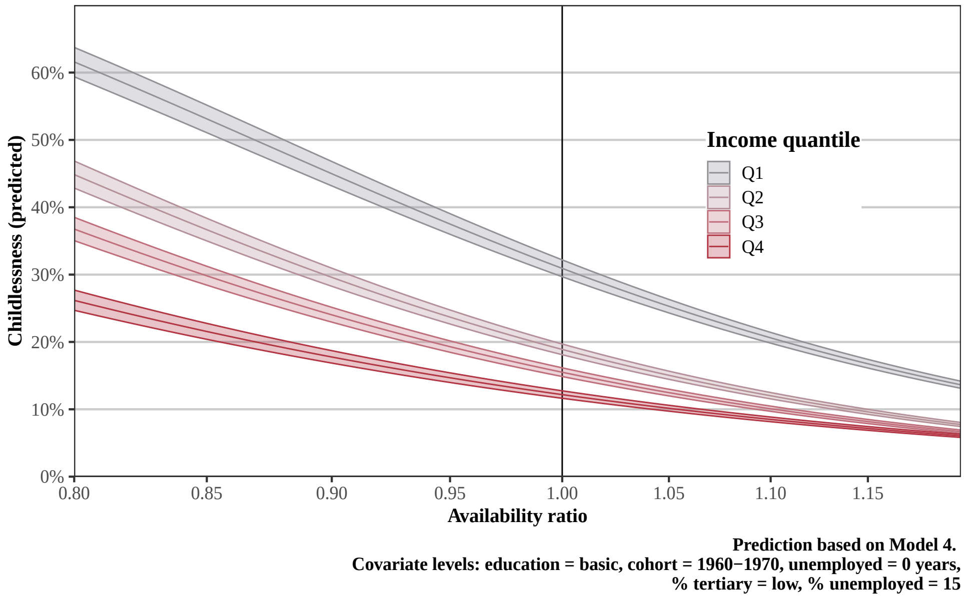

Figure 5: Interaction effect of the availability ratio and income quantile on the probability of being childless at age 45.

5.4 Robustness checks

Several robustness checks are conducted to assess the sensitivity of our main findings. This includes the use of several different modeling approaches, model specifications, and partner market indicators. The population-level effects of all robustness checks are summarised in Figure 6. For each analysis, it shows the difference in aggregate childlessness between average fitted values and the counterfactual analysis with balanced or good partner markets, similar to our main results. A negative value indicates that in the absence of a lack of partners, the population level of childlessness would be lower.

The quantification of partner preferences based on partnership or birth data might be subject to endogeneity because both preferences and population imbalances affect the observed behaviour (De Hauw et al., 2017). In order to quantify the potential impact on our findings, we estimate preferences based on data that are unlikely to be affected by population imbalances. Specifically, we compare the conditional distribution of the age of mothers in the regions 1) with an excess of women and 2) the distribution for all births (for a detailed description of the estimation, see Section A.1). In the former, imbalances should not affect male fertility outcomes, while in the latter regional imbalances might cancel out. Tables A.1 and A.2 in the Appendix present the results from the comparison of the two distributions, which point to a strong overlap. This supports the argument that the estimate of partner preferences is not strongly distorted by partner markets. Moreover, we compare the estimated partner preferences to results from the literature. Studies from dating websites (Skopek et al., 2009) and from surveys (Buss and Schmitt, 2018) yield patterns similar to those found in our data.

In addition, we estimate sibling fixed effects to account for selection based on parental background. The results are in line with the pattern observed for the logistic regression. Table C.12 shows the coefficients for the model, which are similar to those based on the cumulative logistic regression. In Model 3, when we control for individual and contextual variables as well as the parental background by means of sibling fixed effects, we find that a 10% increase in partner availability decreases the probability of being childless by 10.36% (CI: 10.00% and 10.82%).

Furthermore, using discrete time event history models, we estimate the effect of partner availability on the transition to fatherhood (results are displayed in Table C.11). The results are largely robust. The population-level effect in the discrete time event history models is a decline of about 0.198 in childlessness if partner market imbalances did exist. The results remain consistent when using different temporal lags (two and three years), which confirms the lasting impact of partner markets on childbearing (see Figure B.9). The only result that is not in line with our hypothesis comes from the model using the age-specific sex ratios as measure for the partner market. However, as the age-specific sex ratio is the crudest measure, the insignificant result may be due to measurement error.

Moreover, using dichotomatization and matching, we aim to relax the assumption regarding the parametric shape of the effect. The results displayed in Table C.13 are largely consistent with the main results, indicating that the effect is not dependent on the assumption regarding the parametric shape.

Finally, we find preliminary evidence supporting the role of partnership formation as a mechanism that mediates the relationship between partner markets and childlessness. Using the sample from the main analysis, we conducted an analysis using singlehood at age 45 instead of childlessness as the primary outcome, to explore this mechanism further. Remarkably, the results, as detailed in Table C.10, mirror those obtained in our primary analysis.

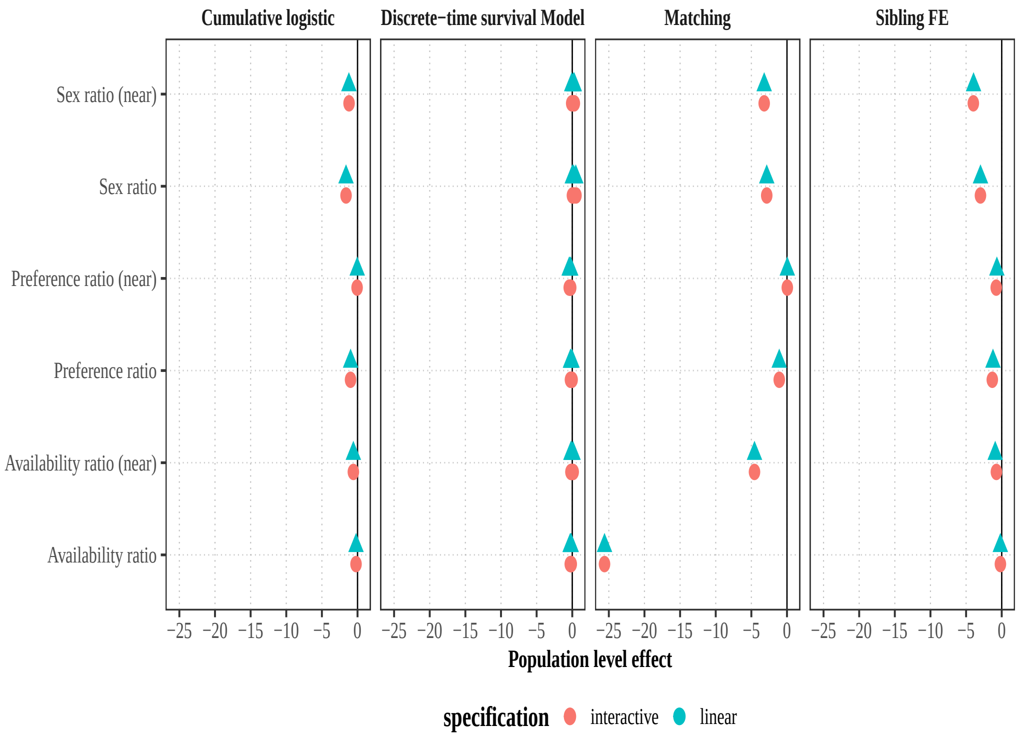

Figure 6: This figure summarises the results across models, control variable selections and availability indicators. The different panels distinguish the model type; the different colours of the points highlight the inclusion of control variables and the different symbols and rows display the results for the different availability indicators.

6 Discussion

6.1 Main findings

In this study, we have investigated the relationship between regional partner markets and childlessness among men in Finland. Descriptive analyses using municipality-level data show that indicators of the number of women relative to the number of men correlate negatively with the level of childlessness; that is, the fewer women there are relative to the number of men, the higher the probability is that men will remain childless. Individual-level regression analysis confirms this finding and indicates that around 0.587 percentage points of male childlessness can be attributed to regional imbalances in partner availability. Our findings are robust to changes in the indicators of the regional availability of partners, to the regression method used for the analysis, and to model specification. Overall, our results indicate that the partner market is likely an important component for explaining the recent fertility declines among men in Finland.

Our descriptive analyses show that the average availability of partners for men across regions has declined over time. This finding is robust across partner market indicators, but is strongest when only looking at age and sex structures. Declining partner availability mirrors changes in the subnational population and education structures, which may be related to cohort sizes, sex ratios at birth, and/or mortality. Moreover, the overall shift has been accompanied by increasing heterogeneity in partner availability across regions, probably driven by internal migration (Gulczynski, 2023). This highlights the importance of regional conditions for men's partnership formation opportunities, which have previously been studied mostly at the national level (Van Bavel and Nitsche, 2013).

We find that the probability of being childless at age 45 is negatively associated with lifetime exposure to adverse partner market conditions. Using a counterfactual prediction, we show that if no men in Finland experienced a lack of partner availability, levels of childlessness would decline by around 0.6 percentage points. This corresponds to findings of previous research. Chudnovskaya and Ueda (2021) found for Sweden that in the absence of population imbalances, the sex-ratio in childlessness would decline by 20 to 25%.

Our findings reveal variations in the impact of partner markets across socio-economic groups. The socio economic gradient in childlessness is most pronounced in unbalanced partner market situations, and diminishes as partner market conditions improve. This has two key implications. First, income operates as an asset in attracting and securing partners, gaining significance in unbalanced partner markets. This insight may help to explain simultaneous trends of deteriorating partner markets and an escalating socio-economic gradient in childlessness (Jalovaara et al., 2019). Second, childlessness tends to concentrate among males with low income in rural areas, leaving this group without sufficient kin relationships, economic resources, and institutional support in old age. This situation may have repercussions for levels of loneliness, care needs, and health in the future. Consequently, we recommend that policymakers plan for this triple disadvantaged group.

Combining regional-level trends in partner market indicators and our individual-level regression analysis, we show that partner markets play a substantial role in the current growth and polarization in male childlessness. Overall, male childlessness at age 45 increased from 18% in 1990 to 30% in 2020. Using a counterfactual approach and assuming that partner market indicators stayed constant at their 1990 values through this period, childlessness in 2020 would be only 22.2%. Thus, changing partner markets may account for as much as 35% of the 12 percentage point increase in male childlessness. Moreover, if partner markets remained unchanged, the educational gradient would be attenuated. The 9.8 percentage-point difference in childlessness between the highly educated (childlessness = 29.9%) and the basic educated (39.6%) would diminish to a difference of 5.5 percentage points (basic education: 25.5%, high education: 20.0%).

Several potential mechanisms that could explain our findings have been proposed in the literature, such as partnership formation and relationship stability (see Section 2.2). We conducted additional analyses reported in the supplementary materials, which indicate that partnership formation is indeed a major link between regional partner markets and childlessness. We find for the same sample of men that not just childlessness, but also the probability of being single (e.g. not married or cohabiting) at age 45 is related to the lifetime exposure to partner markets.

A subject of discussion is the role of online dating in past and future partnership formation and stability, as advances in internet dating may mitigate the impact of regional partner markets over the long-term. Hence, it would be interesting to investigate the role of internet dating in childlessness. Internet dating might change the relationship between partner markets and childlessness by making geographic proximity less important. However, according to existing studies, the residential location remains crucial for the mate selection even in online dating (Rosenfeld and Thomas, 2012).

6.2 Strengths & Limitations

The impact of partner markets on childlessness is robust across partner market measures. Using a simple sex ratio, a preference ratio, and a sophisticated partner availability ratio yields similar results. Moreover, we use a proximate approach to measure partner markets, which reduces potential measurement error that has been an issue in previous research using administrative units. However, using both spatially narrower and wider definitions of partner markets leads to similar results. Overall, these findings provide some evidence that even simple measures can serve as good proxies for local partner markets.

We are aware of three methodological limitations of our study. First, the analysis may suffer from selection bias because decisions to live in regions with high and low partner availability are not random, as both men and women with certain characteristics may actively migrate because of a lack of partners. However, this bias is difficult to address empirically. Second, future research is encouraged to test whether the finding can be generalized to other contexts. Finland is a particular case, as Finnish women have comparatively high employment and tertiary education enrollment rates. In addition, the population density of the country is very low, which prevents us from generalising our findings. Finally, in this article we have only touched upon the different mechanisms. Thus, future research should examine the concrete mechanisms connecting partner markets to childlessness.

Moreover, our study is subject to two conceptual limitations. First, we treat childlessness as a binary category, even though substantial research has highlighted the heterogeneity within the childless population. Childlessness can be categorized as temporary or permanent, as well as involuntary or voluntary. Second, the partner market indicators differentiate individuals solely based on their socio-economic characteristics, while neglecting other factors that are crucial for partnership formation and childlessness. For example, the inclusion of respondents who are homosexual, not seeking a partner, or uninterested in childbearing may obscure the analysis. While constrained by the available data, a more nuanced categorization could enhance the accuracy of our distinctions.

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A Methodological Appendix

A.1 Robustness checks of the preferences

This section describes the robustness checks of the preferences that are estimated based on the conditional distribution of births. Estimating preferences based on behavioural data, in this case for births, are subject to endogeneity, because population imbalances may affect the results. In order to test how robust the estimates are, we estimate the preferences based on all births and on births that occurred in regions with excess women, which neutralizes the impact of partner availability.

In order to quantify the difference between the distributions we estimate the cumulative absolute difference of the two discrete distributions. The estimation is as follows:

$$\Delta(f_1, f_2) = \sum_{x=18}^{55} \frac{|f_1(x) - f_2(x)|}{2} \tag{3}$$

The result can be interpreted as the percentage points that would need to be redistributed in order to obtain identical distributions. Hence, the lower the value is, the more similar the two distributions are.

Age	Difference
20	0.0610
30	0.139
40	0.0327
50	0.132

Table A.1: This table displays the cumulative difference between the overall preference distribution and the estimated preferences based on data for regions in which a sustained excess of females exist. The preferences are based on the conditional age distribution of the mother based on the age of the father. **Interpretation:** Overall, there is a small difference between the two distributions. However, the result for highly educated males at age 20 points to larger differences. These differences may be attributable to the low case numbers of highly educated males in that age, which may lead to large random fluctuations in the conditional distribution of births.

Age	Education	Difference
20	basic	0.0744
20	medium	0.0681
20	high	0.515
30	basic	0.0827
30	medium	0.0751
30	high	0.0580
40	basic	0.0772
40	medium	0.0803
40	high	0.0390

Table A.2: This table displays the cumulative difference between the overall preference distribution and the estimated preferences based on data for regions in which a sustained excess of females exist. The preferences are based on the conditional age-education distribution of the mother based on the age and education of the father. **Interpretation:** Overall, there is a small difference between the two distributions. However, the result for highly educated males at age 20 points to larger differences. These differences may be attributable to the low case numbers of highly educated males in that age, which may lead to large random fluctuations in the conditional distribution of births.

A.2 Partner market distances

We perform the spatial proximity approach using different distances in order to evaluate the impact of spatial boundaries on the results. We selected a distance of zero kilometer, 9.2 kilometers (main model), and 20 kilometers in our estimations. The zero kilometer specification is equal to the neighbouring municipality approach.

Before turning to the robustness of the results, we describe the impact of the different distances on the sizes of the units measured in number of municipalities. Overall, the larger the chosen distance, the larger the partner markets are. The choice of distance has a stronger effect in the south of Finland, where municipalities are smaller and closer, while the spatial distances between municipalities in the north are larger. Given that we include different municipalities based on the chosen distance, we can compare the results based on the number of included municipalities. The mean number of included municipalities is 12.4 in the zero km approach, it increases to 19.9 in the 9.2 kilometers approach (main approach), and it increases further to 29.1 in the 20 kilometers approach.

Distance	mean	min	max
0 km	12.4	1	30
9.2 km	19.9	1	42
20 km	29.1	2	70

Table A.3: Summary of the impact of the chosen distance for the spatial proximity approach on the number of municipalities aggregated to one partner market

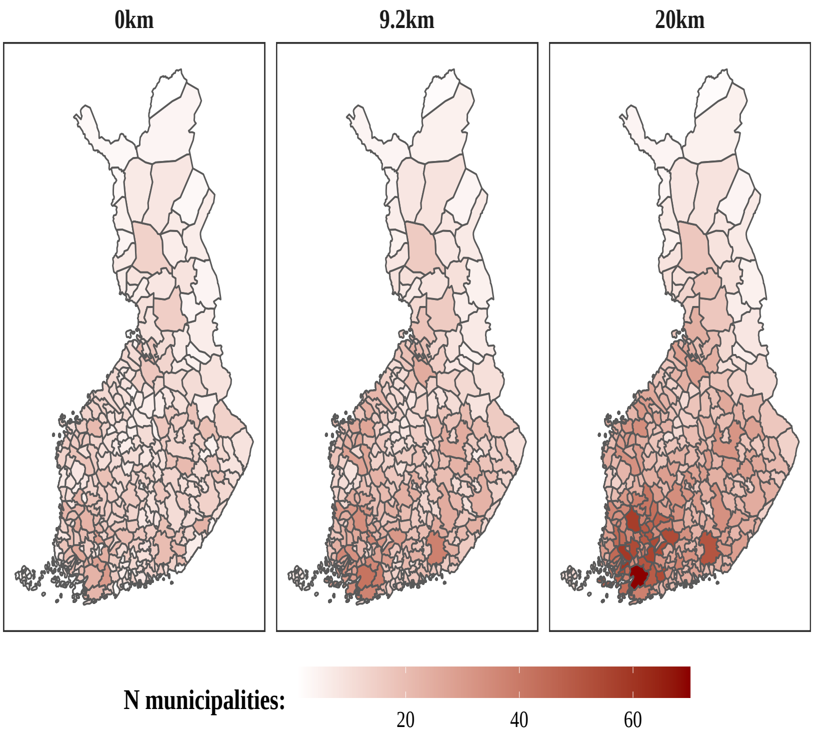


Figure A.1: The number of municipalities included based on the distance measure chosen. The larger the distance measure is, the more neighbouring municipalities are included. The changes mostly affect the smaller units in the South of the country

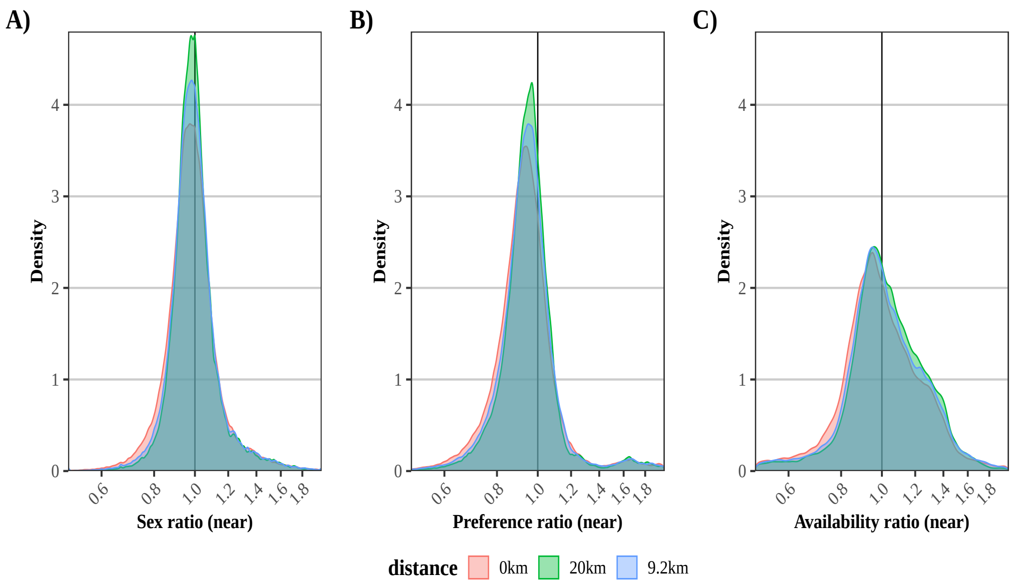


Figure A.2: The impact of the distance measure on the distribution of the availability indicators in the sample. The larger the distance the more the measure concentrates around balance, which may indicate measurement error.

Table A.4: Cumulative logistic regression on childlessness using different spatial distances for the estimation of the partner market indicator variable.

	Dependent variable:		
	Childless at age 45		
	(1)	(2)	(3)
log ar (0km)	-2.354^{***}		
	(-2.439,-2.270)		
log ar (9.2km)		-5.058^{***}	
		(-5.162,-4.955)	
log ar (20km)			-5.835^{***}
			(-5.950,-5.720)
Cohort: 1972-1976	-0.074^{***}	-0.164^{***}	-0.192^{***}
	(-0.099,-0.049)	(-0.189,-0.138)	(-0.217,-0.166)
Income Q2	-0.563^{***}	-0.618^{***}	-0.625^{***}
	(-0.600,-0.526)	(-0.656,-0.580)	(-0.663,-0.587)
Income Q3	-0.745^{***}	-0.783^{***}	-0.776^{***}
	(-0.781,-0.708)	(-0.820,-0.745)	(-0.813,-0.739)
Income Q4	-0.820^{***}	-0.870^{***}	-0.866^{***}
	(-0.858,-0.782)	(-0.909,-0.832)	(-0.905,-0.827)
Duration unemployed	0.189^{***}	0.175^{***}	0.175^{***}
	(0.185,0.193)	(0.171,0.179)	(0.171,0.179)
Education: high	-0.392^{***}	-0.667^{***}	-0.778^{***}
	(-0.432,-0.351)	(-0.709,-0.625)	(-0.821,-0.736)
Eduction: medium	-0.115^{***}	-0.193^{***}	-0.222^{***}
	(-0.151,-0.080)	(-0.230,-0.156)	(-0.260,-0.184)
% tertiary	0.871^{***}	1.242^{***}	1.260^{***}
	(0.841,0.901)	(1.210,1.275)	(1.228,1.293)
Unemployment rate	-0.530^{***}	-0.531^{***}	-0.545^{***}
	(-0.538,-0.522)	(-0.539,-0.523)	(-0.553,-0.536)
Urban	-0.264^{***}	0.106^{***}	-0.017
	(-0.297,-0.230)	(0.072,0.141)	(-0.052,0.017)
Poverty: high	1.710^{***}	1.542^{***}	1.428^{***}
	(1.677,1.744)	(1.508,1.576)	(1.394,1.462)
Constant	4.249^{***}	4.845^{***}	5.290^{***}
	(4.153,4.346)	(4.747,4.943)	(5.188,5.392)
Natural course (% childless)	32.60	32.60	32.60
Counterfactual (% childless)	31.75	32.02	32.01
Population level effect	-0.85	-0.58	-0.59
Observations	194,080	194,080	194,080
Log Likelihood	-88,679.510	-85,200.000	-84,742.480
Akaike Inf. Crit.	177,385.000	170,426.000	169,511.000
Note:			*p<0.1; **p<0.05; ***p<0.01

A.3 Estimating of weights for the availability ratio

The conditional age distribution by age of the father (x):

$$w_x(y) = \frac{B_x(y)}{B_x} \tag{4}$$

For the availability ratio the conditional age distribution of mothers dependent on the age of the father was calculated at the national level $\left(\frac{B(x,y)}{B(x)}\right)$, whereas $B(x,y)$ refers to the number of births of men at age x with women at age y and $B(x)$ denotes to total number of births to men in the same age group.

B Additional Figures

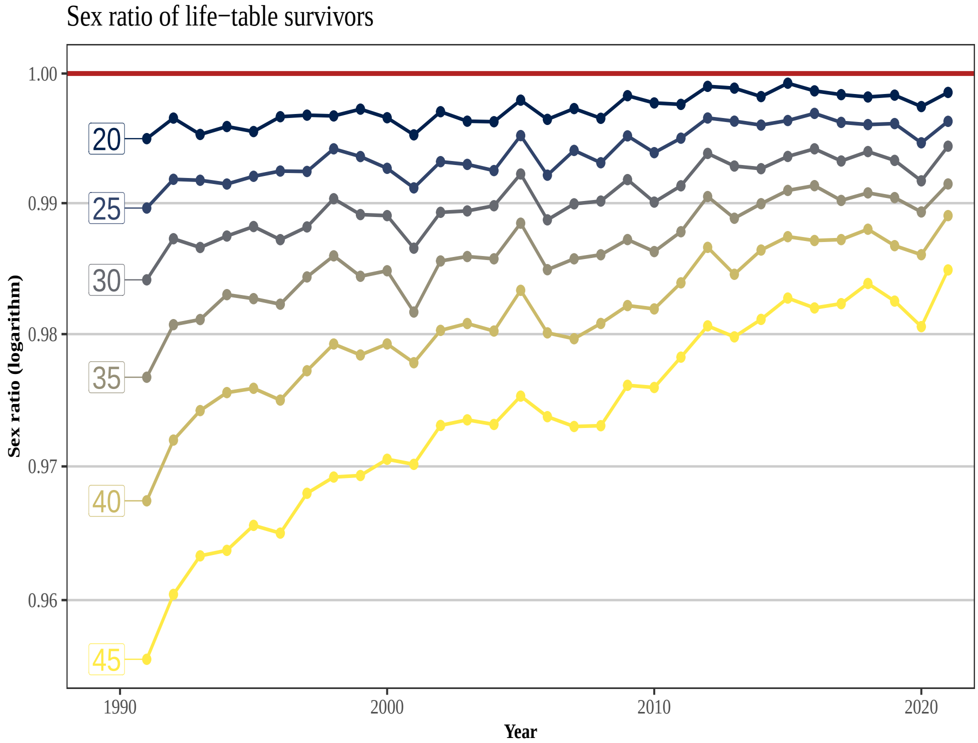


Figure B.3: This figure presents the period life table survivor sex ratio at certain ages over time for Finland. The data was obtained from the Human Mortality Database. The radix for men and women is 100,000.

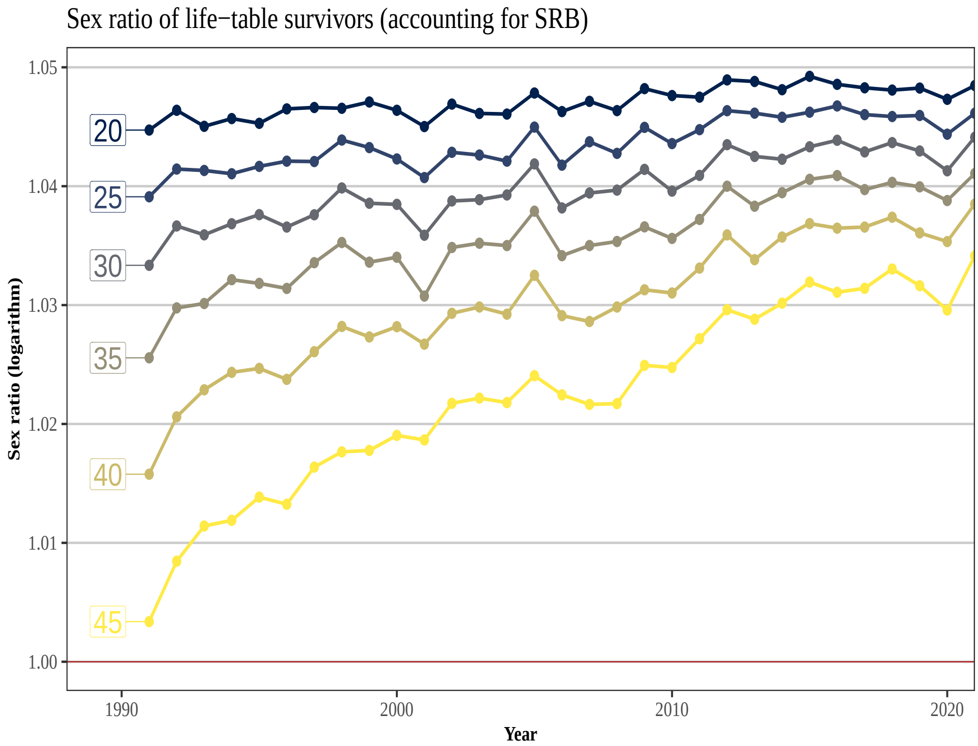


Figure B.4: This figure presents the period life table survivor sex ratio at certain ages over time for Finland, after accounting for the sex ratio at birth of 105. The data was obtained from the Human Mortality Database. The radix for men is 105,000 and for women is 100,000.

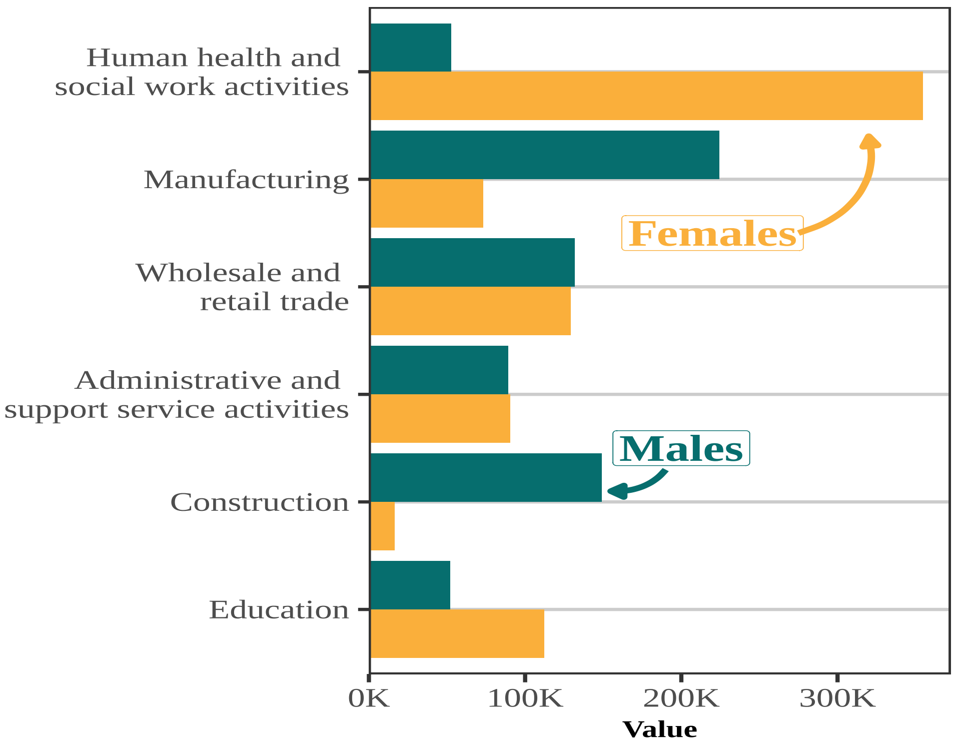
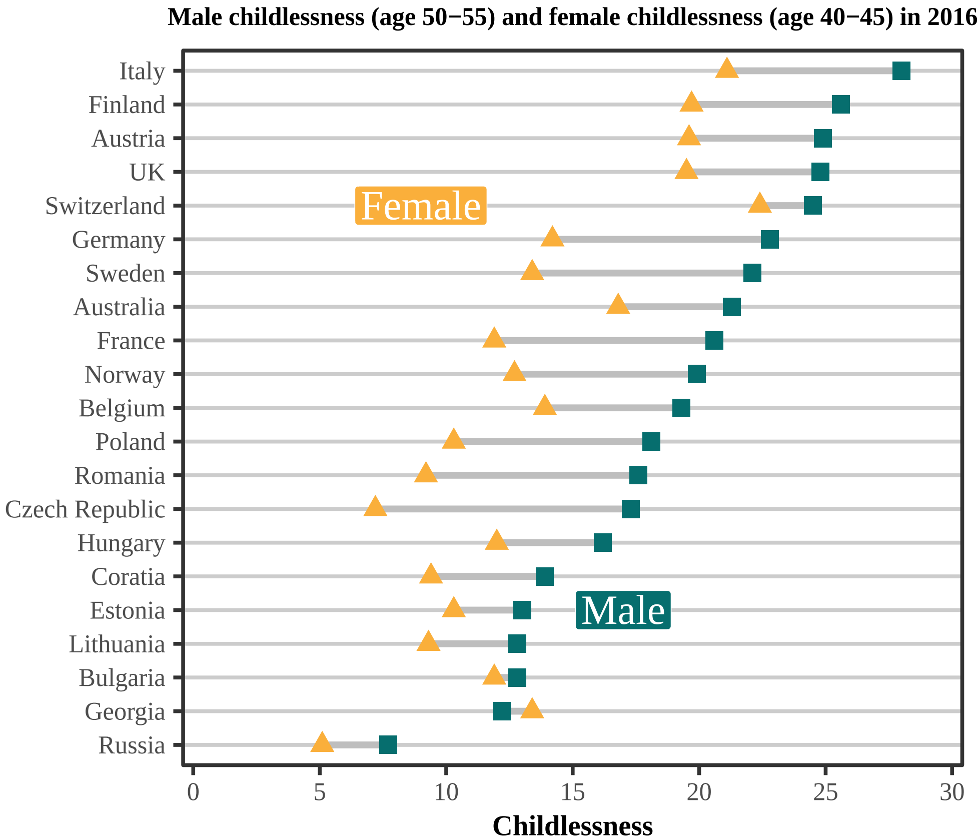


Figure B.5: The distribution of women and men across the 5 largest sectors in Finland 2019. Source: Statistics Finland 2019.



Source: GGS, Register data.

Figure B.6: This picture displays that male childlessness exceeds female childlessness in all countries except for Georgia. Data quality, multi-partner fertility and/or population imbalances are the potential drivers.

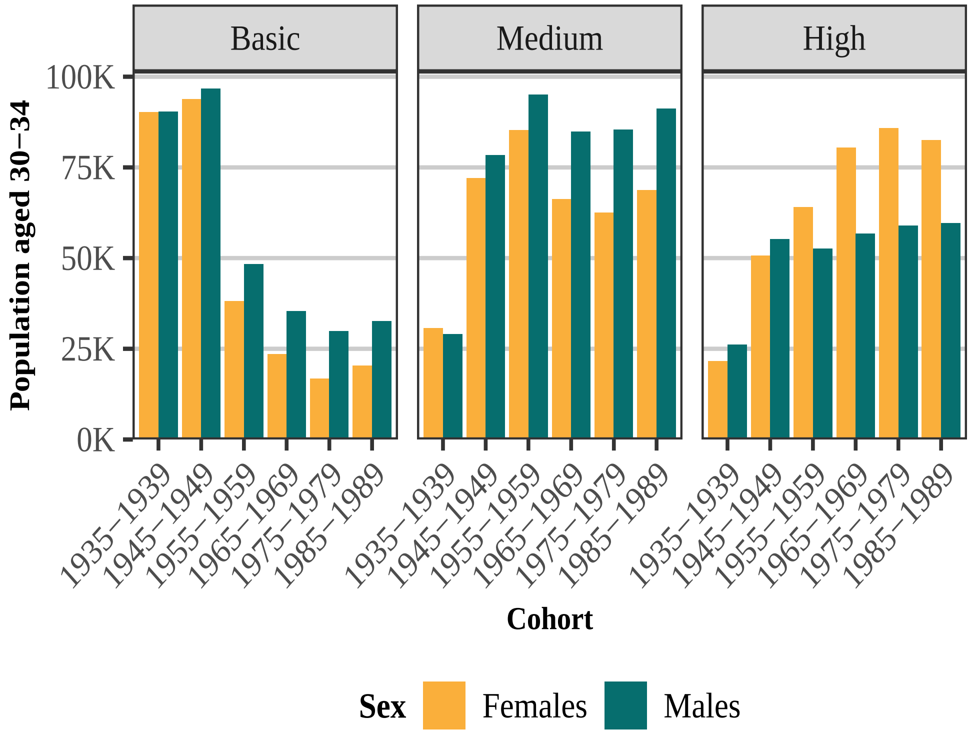


Figure B.7: The distribution of women and men at age 30 to 34 in the cohorts 1935-1989 in Finland.

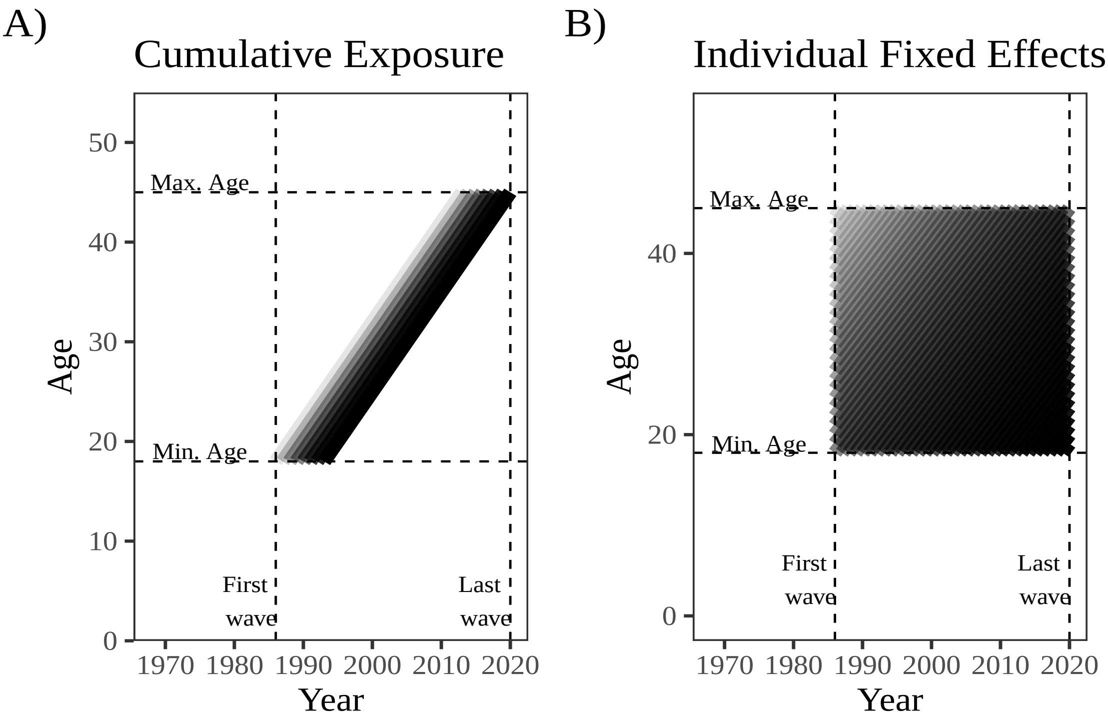


Figure B.8: This graph illustrates the two data structures used in the analysis. The data structure is important as it determines the assumptions and the inclusion of the data. Panel A) shows the cumulative cohort approach, which measures the exposure over the time between age 18 and 45, which restricts the data to cohorts born between 1968 and 1975. Panel B) uses individual fixed-effects, which utilizes the data much more efficiently, however, the exposure to the independent variable may be observed only for a short time.

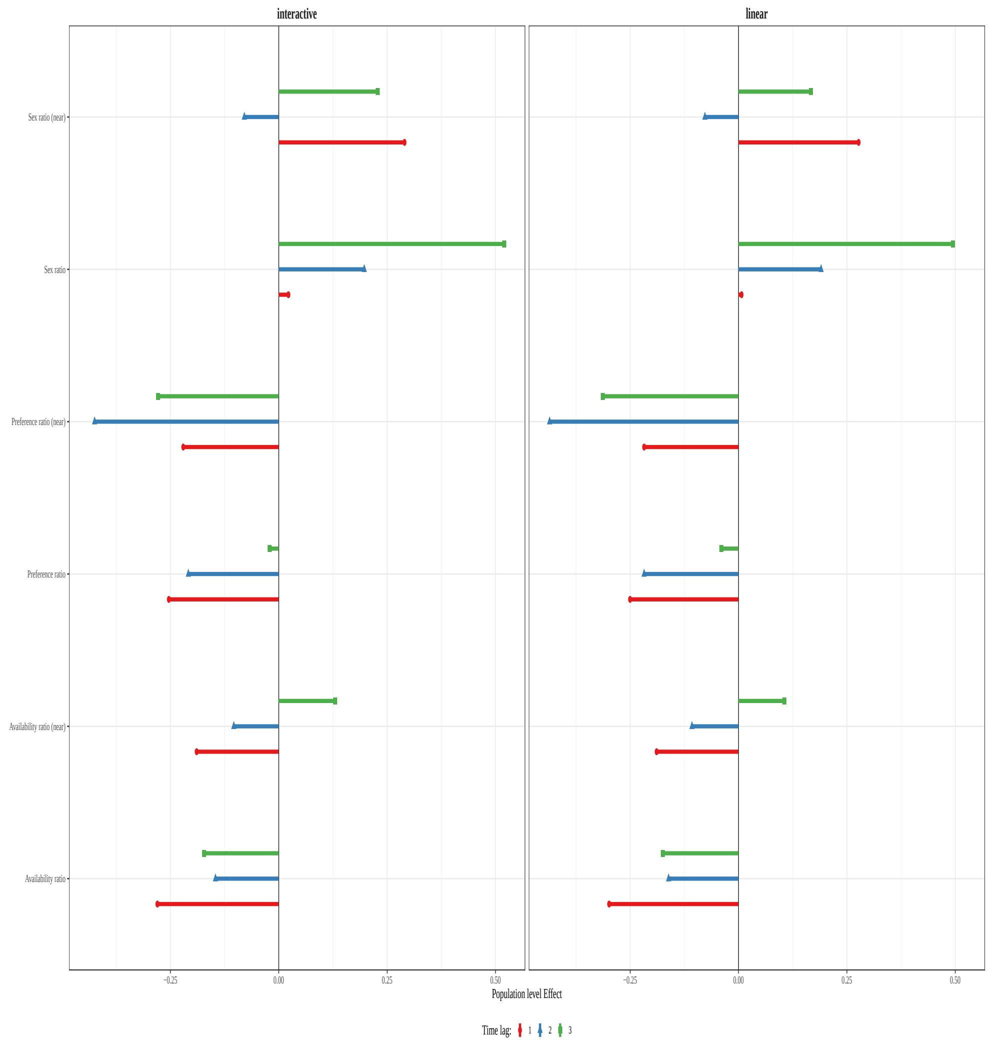
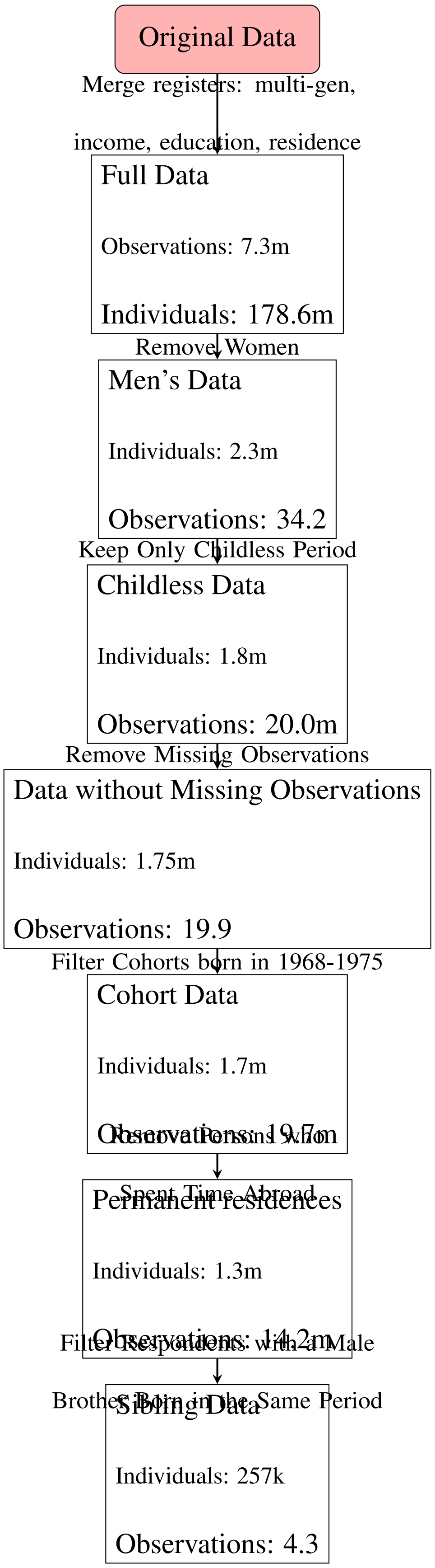


Figure B.9: Population level effects in the discrete-time survival model on the transition to first-birth. A negative value indicates that the absence of partner market imbalances would decrease population level childlessness.


Original Data
Merge registers: multi-gen,
income, education, residence
Full Data
Observations: 7.3m
Individuals: 178.6m
Remove Women
Men's Data
Individuals: 2.3m
Observations: 34.2
Keep Only Childless Period
Childless Data
Individuals: 1.8m
Observations: 20.0m
Remove Missing Observations
Data without Missing Observations
Individuals: 1.75m
Observations: 19.9
Filter Cohorts born in 1968-1975
Cohort Data
Individuals: 1.7m
Observations: 19.7m
Remove Persons who
Spent Time Abroad
Permanent residences
Individuals: 1.3m
Observations: 14.2m
Filter Respondents with a Male
Brother Born in the Same Period
Sibling Data
Individuals: 257k
Observations: 4.3

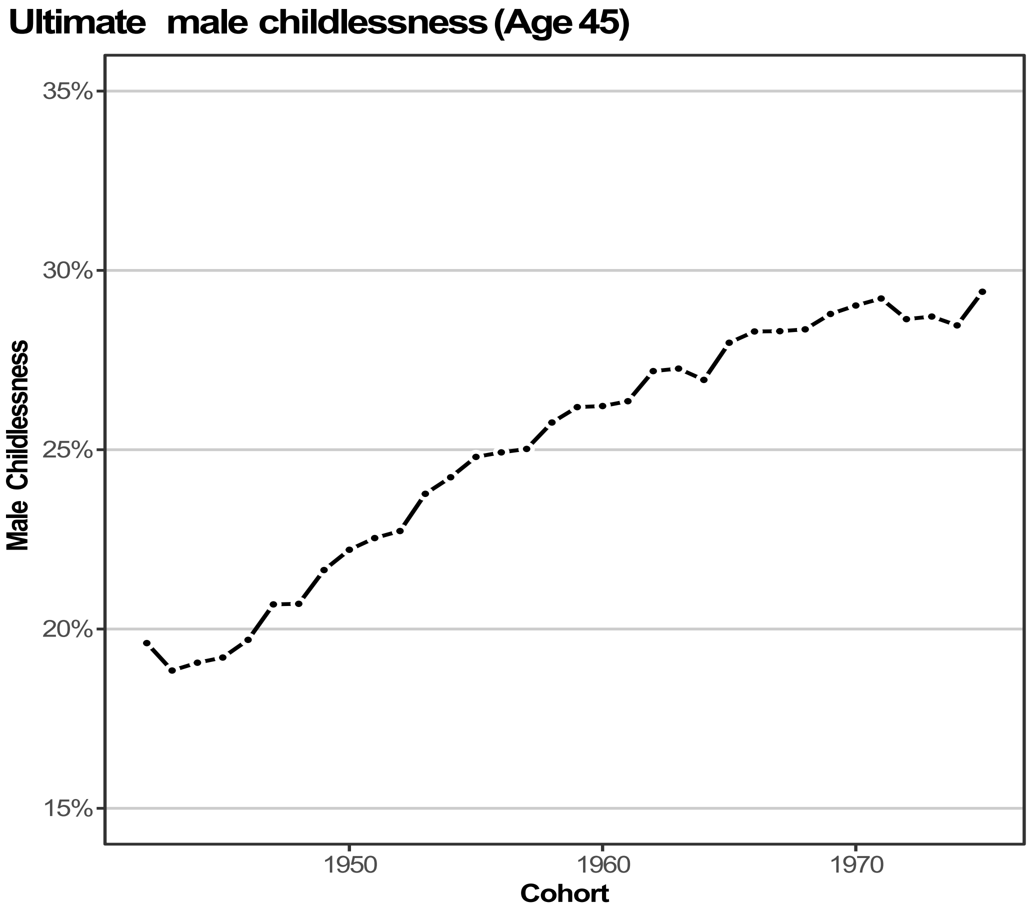


Figure B.10: This figure displays the trend in male childlessness at age 45 over cohorts for the entire Finnish population.

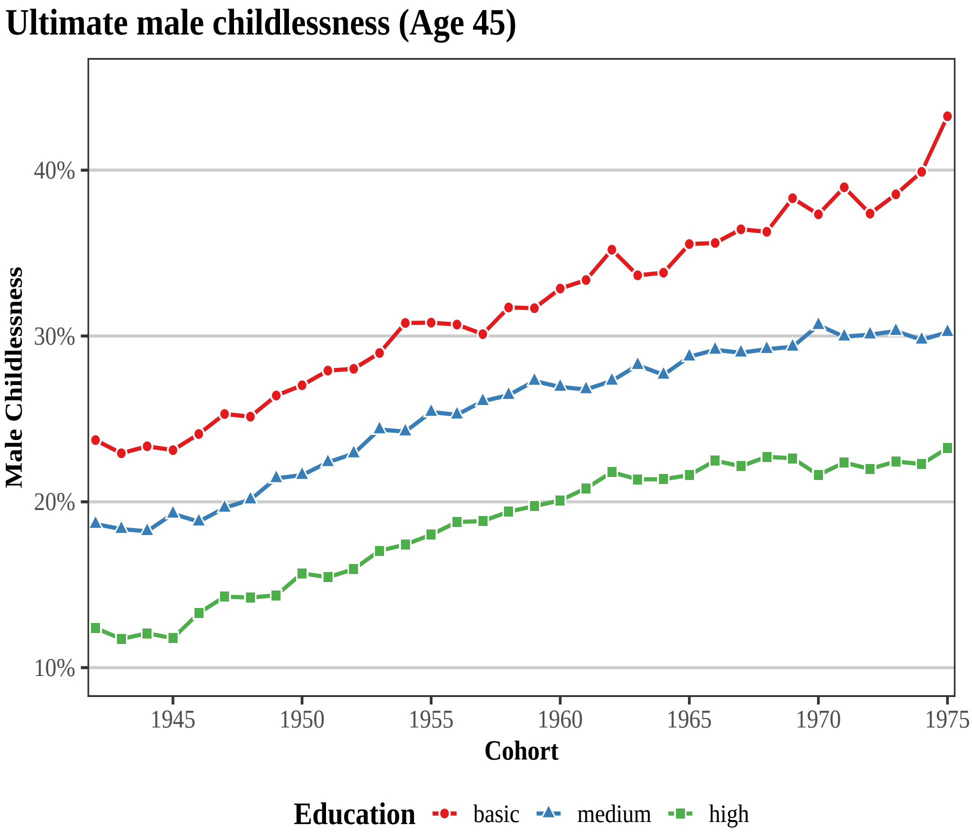


Figure B.11: The trend in male childlessness at age 45 by educational category over cohorts.

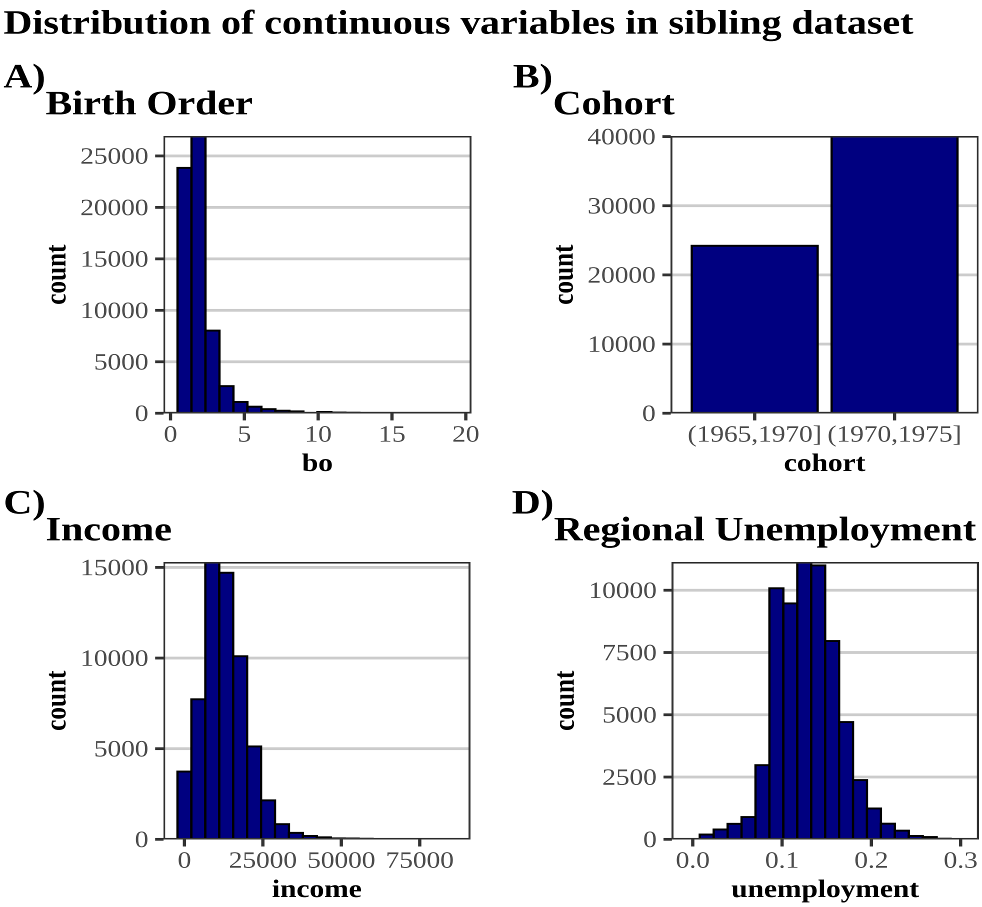


Figure B.12: This figures displays the distribution of some key variables in the sibling data set.

C Additional Tables

Measure	Estimation	Preferences	Availability	Competition
Sex Ratio	$\frac{F(y)}{M(x)}$	Same age	Same age	Same age
Preference Ratio	$\frac{\sum_{y=16}^{55} Prob(y\|x) \cdot F_{we}(y)}{M_{we}(x)}$	All ages	All ages	Same age
Availability Ratio	$\frac{\sum_y \sum_b w_{x,e}(y,b) F(y,b)}{\sum_y \sum_b w_{x,e}(y,b) \cdot \sum_x \sum_e w_{y,b}(x,e) M(x,e)}$	Age×Education	All	All

Table C.5: Comparison of partner market measures. The first column gives the names of the measures ordered by increasing data requirement and complexity. The second column shows the estimation. The third column indicates which preferences are incorporated. The fourth column shows how is competing with the group of interest for the available women. The last column indicates the dimensions that are fully reflected in the measure.

C.1 Summary Tables

Table C.6: Summary statistics of indicators in the individual fixed effects data.

Statistic	N	Mean	St. Dev.	Min	Max
Childbirth	2,372,190	0.054	0.226	0	1
Age of fatherhood	2,372,190	32.103	5.485	19	70
Cohort	2,372,190	1975.769	12.260	1,942	2,002
Availability Ratio (near)	2,372,190	1.128	0.267	0.221	1.931
Preference Ratio (near)	2,372,190 −0.048	0.086	0.204	4.031	
Sex Ratio (near)	2,372,190	−0.041	0.078	0.200	5.000
Income-Quantile	2,372,190	2.499	1.118	1	4
Education	2,372,190	2.395	0.756	1	3

Statistic	N	Mean	St. Dev.	Min	Max
Childlessness	52,469	0.320	0.466	0	1
Cohort	52,469	1972.156	1.964	1968	1975
Availability Ratio (near)	52,469	0.202	0.165	−0.713	0.706
Preference Ratio (near)	52,469	−0.003	0.069	−1.599	0.248
Sex Ratio (near)	52,469	−0.029	0.067	−0.938	0.358
First born	52,469	0.308	0.461	0	1
Income	52,469	2.737	1.074	1	4
Education	52,469	2.346	0.734	1	3
Duration unemployment	52,469	2.497	3.664	0	27
% Unemployed	276,230	11.067	2.56	2.09	23.017

Table C.7: Summary statistics of indicators in cumulative data.

C.2 Correlation Tables

Correlation	sr (near)	pr (near)	ar (near)	sr	pr	ar
sr (near)	1	0.689	0.241	0.694	0.512	0.165
pr (near)	0.689	1	0.191	0.489	0.760	0.244
ar (near)	0.241	0.191	1	0.177	0.168	0.738
sr	0.694	0.489	0.177	1	0.726	0.280
pr	0.512	0.760	0.168	0.489	1	0.353
ar	0.165	0.244	0.738	0.280	0.353	1

Table C.8: Correlations between availability indicators in fixed effects data. sr = sex ratio; pr = preference ratio, ar = availability ratio.

C.3 Regression Tables

Table C.9: Linear probability model on childlessness using the main indicator as predictor variable.

	Dependent variable:			
	Childless at age 45			
	(1)	(2)	(3)	(4)
log ar (near)	-0.514^{***}	-0.499^{***}	-0.990^{***}	-1.119^{***}
	(-0.527,-0.502)	(-0.513,-0.486)	(-1.003,-0.977)	(-1.147,-1.091)
Cohort: 1972-1976		-0.062^{***}	-0.041^{***}	-0.041^{***}
		(-0.066,-0.058)	(-0.045,-0.038)	(-0.045,-0.037)
Income Q2		-0.094^{***}	-0.091^{***}	-0.100^{***}
		(-0.100,-0.087)	(-0.097,-0.085)	(-0.109,-0.091)
Income Q3		-0.142^{***}	-0.120^{***}	-0.150^{***}
		(-0.148,-0.136)	(-0.126,-0.114)	(-0.159,-0.141)
Income Q4		-0.135^{***}	-0.153^{***}	-0.203^{***}
		(-0.142,-0.129)	(-0.159,-0.147)	(-0.212,-0.193)
Duration unemployed		0.036^{***}	0.030^{***}	0.030^{***}
		(0.035,0.036)	(0.030,0.031)	(0.029,0.030)
Education: high		-0.042^{***}	-0.136^{***}	-0.135^{***}
		(-0.048,-0.035)	(-0.142,-0.130)	(-0.141,-0.129)
Education: medium		-0.014^{***}	-0.032^{***}	-0.033^{***}
		(-0.020,-0.008)	(-0.037,-0.027)	(-0.038,-0.028)
% tertiary: high			0.197^{***}	0.198^{***}
			(0.193,0.202)	(0.193,0.203)
Unemployment rate			-0.054^{***}	-0.054^{***}
			(-0.055,-0.053)	(-0.055,-0.053)
Urban		0.089^{***}	-0.020^{***}	-0.019^{***}
		(0.084,0.095)	(-0.025,-0.015)	(-0.024,-0.014)
log ar (near):Income Q2				0.041^{**}
				(0.006,0.077)
log ar (near):Income Q3				0.147^{***}
				(0.115,0.180)
log ar (near):Income Q4				0.236^{***}
				(0.203,0.269)
Constant	0.431^{***}	0.442^{***}	1.139^{***}	1.164^{***}
	(0.428,0.434)	(0.434,0.450)	(1.126,1.152)	(1.150,1.178)
Observed (% childless)	32.61	32.61	32.61	32.61
Counterfactual (% childless)	32.21	32.22	31.84	31.83
Population level effect	−0.401	−0.389	−0.772	−0.776
Observations	194,080	194,080	194,080	194,080
R^2	0.033	0.161	0.295	0.296
Adjusted R^2	0.033	0.161	0.295	0.296
Note:				*p<0.1; **p<0.05; ***p<0.01

Table C.10: Cumulative logistic regression singlehood at age 45 on partner log ar (near) using.

	Dependent variable:			
	Single at age 45			
	(1)	(2)	(3)	(4)
log ar (near)	-0.633^{***}	-0.543^{***}	-0.946^{***}	-1.445^{***}
	(-0.688,-0.577)	(-0.605,-0.481)	(-1.020,-0.873)	(-1.598,-1.293)
Cohort: 1972-1976		-0.103^{***}	-0.059^{***}	-0.056^{***}
		(-0.123,-0.083)	(-0.081,-0.038)	(-0.077,-0.035)
Income Q2		-0.667^{***}	-0.672^{***}	-0.769^{***}
		(-0.698,-0.637)	(-0.703,-0.641)	(-0.818,-0.721)
Income Q3		-0.915^{***}	-0.904^{***}	-1.088^{***}
		(-0.945,-0.885)	(-0.934,-0.874)	(-1.136,-1.040)
Income Q4		-1.123^{***}	-1.152^{***}	-1.215^{***}
		(-1.154,-1.091)	(-1.184,-1.120)	(-1.266,-1.165)
Duration unemployed		0.099^{***}	0.095^{***}	0.095^{***}
		(0.096,0.102)	(0.092,0.099)	(0.091,0.098)
Education: high		-0.609^{***}	-0.678^{***}	-0.673^{***}
		(-0.641,-0.576)	(-0.712,-0.644)	(-0.706,-0.639)
Education: medium		-0.334^{***}	-0.349^{***}	-0.344^{***}
		(-0.362,-0.305)	(-0.378,-0.321)	(-0.373,-0.316)
% tertiary: high			0.258^{***}	0.263^{***}
			(0.232,0.284)	(0.238,0.289)
Unemployment rate			-0.070^{***}	-0.071^{***}
			(-0.075,-0.066)	(-0.076,-0.066)
Urban			-0.357^{***}	-0.355^{***}
			(-0.384,-0.329)	(-0.383,-0.327)
log ar (near):Income Q2				0.479^{***}
				(0.288,0.670)
log ar (near):Income Q3				0.880^{***}
				(0.702,1.057)
log ar (near):Income Q4				0.305^{***}
				(0.120,0.490)
Constant	-0.320^{***}	0.599^{***}	1.552^{***}	1.652^{***}
	(-0.334,-0.305)	(0.558,0.640)	(1.480,1.624)	(1.575,1.729)
Natural course (% childless)	39.00	39.00	39.00	39.00
Counterfactual (% childless)	38.87	38.90	38.84	38.84
Population level effect	-0.12	-0.10	-0.15	-0.16
Observations	194,080	194,080	194,080	194,080
Akaike Inf. Crit.	259,075.900	237,861.200	235,554.900	235,450.300
Note:				*p<0.1; **p<0.05; ***p<0.01

Table C.11: Discrete-time survival regression model on giving birth using time lag of 1 .

	Dependent variable:			
	First birth			
	(1)	(2)	(3)	(4)
log ar(near)	0.161*	0.041	0.119	0.071
	(0.009,0.313)	(-0.130,0.212)	(-0.098,0.335)	(-0.305,0.448)
Age	0.227***	0.215***	0.257***	0.256***
	(0.129,0.326)	(0.111,0.319)	(0.134,0.379)	(0.134,0.379)
Age^2	−0.002**	−0.002*	−0.003**	−0.003**
	(-0.004,-0.001)	(-0.004,-0.0003)	(-0.005,-0.001)	(-0.005,-0.001)
Cohort: 1972-1976		0.028	0.049	0.049
		(-0.059,0.114)	(-0.054,0.152)	(-0.054,0.152)
Income Q2		−0.011	−0.019	−0.021
		(-0.131,0.108)	(-0.139,0.101)	(-0.150,0.109)
Income Q3		0.167**	0.160**	0.147*
		(0.041,0.293)	(0.034,0.287)	(0.013,0.282)
Income Q4		0.160*	0.151*	0.147*
		(0.024,0.296)	(0.013,0.289)	(0.003,0.291)
Activity: others		−0.110	−0.118	−0.118
		(-0.295,0.074)	(-0.303,0.067)	(-0.302,0.067)
Activity: student		−0.217**	−0.229**	−0.229**
		(-0.383,-0.052)	(-0.395,-0.063)	(-0.395,-0.063)
Activity: unemployed		0.177***	0.161**	0.160**
		(0.066,0.287)	(0.049,0.273)	(0.049,0.272)
Education: high		−0.385***	−0.360***	−0.359***
		(-0.520,-0.251)	(-0.501,-0.219)	(-0.499,-0.218)
Education: medium		−0.330***	−0.327***	−0.327***
		(-0.422,-0.238)	(-0.420,-0.235)	(-0.419,-0.234)
Urban		−0.009	−0.014	−0.013
		(-0.094,0.075)	(-0.105,0.077)	(-0.104,0.078)
% tertiary			0.005	0.005
			(-0.008,0.017)	(-0.008,0.017)
Unemployment rate			0.019	0.019
			(-0.001,0.038)	(-0.001,0.038)
% in poverty			0.005	0.004
			(-0.019,0.028)	(-0.019,0.027)
log ar(near):Income Q2				0.016
				(-0.434,0.466)
log ar(near):Income Q3				0.135
				(-0.301,0.570)
log ar(near):Income Q4				0.020
				(-0.412,0.452)
Constant	−6.072***	−5.816***	−6.924***	−6.908***
	(-7.499,-4.644)	(-7.366,-4.266)	(-8.819,-5.028)	(-8.808,-5.009)
Observed (% childless)	64.4	64.2	46.1	46.1
Counterfactual (% childless)	64.1	64.1	46.0	46.0
Population level effect	−0.255	−0.066	−0.189	−0.189
Observations	2,372,190	2,372,190	2,372,190	2,372,190
Akaike Inf. Crit.	12,109.940	12,053.250	12,055.780	12,061.410
Note:				*p<0.1; **p<0.05; ***p<0.01

Table C.12: Linear sibling FE regression model on childlessness.

Dependent Variable:	Childless at age 45			
Model:	(1)	(2)	(3)	(4)
Variables				
log ar (near)	-0.9716***	-0.9259***	-1.157***	-0.6797***
	(0.0259)	(0.0280)	(0.0245)	(0.0356)
Income Q2		-0.0622***	-0.0785***	
		(0.0098)	(0.0087)	
Income Q3		-0.0831***	-0.0990***	
		(0.0096)	(0.0086)	
Income Q4		-0.0795***	-0.1405***	
		(0.0102)	(0.0091)	
Unemployed		0.0354***	0.0227***	0.0303***
		(0.0010)	(0.0009)	(0.0008)
First son: Yes		0.0634***	0.0064	-0.0059
		(0.0048)	(0.0048)	(0.0048)
Education: high		-0.0961***	-0.2099***	
		(0.0118)	(0.0105)	
Education: medium		-0.0307***	-0.0683***	
		(0.0094)	(0.0084)	
% tertiary: high			0.1844***	0.1672***
			(0.0079)	(0.0080)
Unemployment rate			-0.1022***	-0.0951***
			(0.0018)	(0.0019)
log ar (near):Income Q2				-0.2337***
				(0.0356)
log ar (near):Income Q3				-0.2931***
				(0.0324)
log ar (near):Income Q4				-0.4231***
				(0.0337)
Fixed-effects				
sib (31,730)	Yes	Yes	Yes	Yes
Population level effect				
Observed (% childless)	32.0	32.0	32.0	32.0
Counterfactual (% childless)	31.2	31.3	31.3	31.3
Population level effect	-0.768	-0.732	-0.914	-0.748
Fit statistics				
Observations	52,469	52,469	52,469	52,469
R^2	0.67793	0.70962	0.76911	0.76034
AIC	72,894.9	67,474.1	55,449.4	57,402.7

Clustered (sib) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table C.13: Linear regression on matched data for childlessness

	Dependent variable:			
	Childless at age 45			
	(1)	(2)	(3)	(4)
High availability	-0.160^{***}	-0.222^{***}	-0.565^{***}	-1.104^{***}
	(-0.244,-0.076)	(-0.314,-0.130)	(-0.679,-0.451)	(-1.331,-0.878)
Cohort: 1972-1976		-0.272^{***}	-0.276^{***}	-0.264^{***}
		(-0.359,-0.185)	(-0.375,-0.177)	(-0.364,-0.165)
Income Q2	-0.590^{***}	-0.580^{***}	-0.678^{***}	-0.919^{***}
	(-0.715,-0.464)	(-0.706,-0.454)	(-0.820,-0.537)	(-1.120,-0.719)
Income Q3	-0.970^{***}	-0.970^{***}	-1.056^{***}	-1.318^{***}
	(-1.097,-0.843)	(-1.097,-0.843)	(-1.198,-0.914)	(-1.517,-1.120)
Income Q4	-0.976^{***}	-0.994^{***}	-1.147^{***}	-1.665^{***}
	(-1.110,-0.841)	(-1.129,-0.859)	(-1.297,-0.996)	(-1.875,-1.454)
Education: high	-1.226^{***}	-1.239^{***}	-1.509^{***}	-1.529^{***}
	(-1.383,-1.068)	(-1.399,-1.080)	(-1.691,-1.328)	(-1.712,-1.346)
Education: medium	-0.611^{***}	-0.587^{***}	-0.632^{***}	-0.645^{***}
	(-0.767,-0.456)	(-0.743,-0.431)	(-0.809,-0.454)	(-0.824,-0.467)
% tertiary: high			1.232^{***}	1.215^{***}
			(1.103,1.361)	(1.085,1.344)
Poverty: high			2.165^{***}	2.177^{***}
			(2.023,2.307)	(2.035,2.319)
Unemployment rate			-0.361^{***}	-0.367^{***}
			(-0.386,-0.336)	(-0.392,-0.342)
Urban		0.036	-0.201^{***}	-0.193^{***}
		(-0.076,0.147)	(-0.334,-0.068)	(-0.327,-0.059)
High availability:Income Q2				0.473^{***}
				(0.191,0.754)
High availability:Income Q3				0.516^{***}
				(0.239,0.794)
High availability:Income Q4				1.031^{***}
				(0.748,1.315)
Constant	0.995^{***}	1.147^{***}	3.793^{***}	4.135^{***}
	(0.839,1.152)	(0.980,1.313)	(3.456,4.130)	(3.774,4.497)
Observed (% childless)	34.1	34.1	34.1	34.1
Counterfactual (% childless)	32.5	31.9	29.5	29.5
Population level effect	-1.64	-2.25	-4.56	-4.56
Observations	10,632	10,632	10,632	10,632
Akaike Inf. Crit.	12,724.070	12,690.550	10,737.690	10,691.030
Note:				*p<0.1; **p<0.05; ***p<0.01