# FERTILITY AND FAMILY TYPE IN THE UNITED STATES: A HISTORICAL ANALYSIS

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# Fertility and Family Type in the United States: a Historical Analysis*

Luca Pensieroso† Alessandro Sommacal‡
Gaia Spolverini§

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**Abstract**

We provide a historical decomposition of fertility in the United States by family type. We find that intergenerational coresidence was systematically associated with lower fertility than nuclear families, with the difference shrinking over time. This pattern is robust to controlling for several demographic and socioeconomic confounders. We build a simple, analytical model and show that a theory featuring both endogenous fertility and endogenous coresidence can rationalise the observed cross-family fertility difference. Simulations from a calibrated dynamic general equilibrium version of the model show that the model has the right qualitative behaviour, and is quantitatively meaningful. Using individual data, we discuss (and dismiss) several potential alternative explanations.

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†IRES/LIDAM, Université catholique de Louvain. Email: luca.pensieroso@uclouvain.be

‡Department of Economics, University of Verona. Email: alessandro.sommacal@univr.it

§IRES/LIDAM and FNRS, Université catholique de Louvain. Email: gaia.spolverini@uclouvain.be

# 1 Introduction

In this research, we highlight a fact that has been overlooked in the economic literature so far: in the 19th and 20th century United States, completed fertility for women living in extended vertical households – *i.e.* households characterised by intergenerational coresidence – has been systematically lower than that for women living in nuclear families. We show that this fertility differential has been shrinking over time, and cannot be easily rationalised by existing theories. We propose a novel theory of intergenerational coresidence and endogenous fertility that can explain this fact. We build a dynamic general equilibrium model based on our new theory and show that our proposed mechanism can account for about 60% of the overall reduction over time of the cross-family-type differential fertility.

Following the seminal work of Becker (1960) and Becker and Lewis (1973), the literature on the economics of the family has been burgeoining (Becker (1991), Browning et al. (2014)). This literature focuses on the importance of taking within-household heterogeneity into account, for this affects the outcome of many economic decisions, and, most importantly, the efficacy of economic policies. This has been an important step forward in economics, pointing to the limitations of what is otherwise a useful abstraction, namely the representative household construct.

Family economists, however, have in turn framed the household's decision-making process mainly in the context of nuclear families only, *i.e.* families formed by a couple of parents and their non-adults children. While nuclear families have been predominant in Western societies, other types of families (*e.g.* adults living with their parents, adults living with their siblings and/or other relatives . . . ) were widespread in the past, and still are in today's developing economies (Baudin et al. (2021), Laslett (1972), Todd (1983)). Furthermore, evidence suggests that, even in Western societies, sudden dramatic events, like pervasive economic crises, might induce a return *in auge* of extended families (Kaplan (2012)). There is wide acceptance in the literature that family types are related to cultural attitudes and institutions (Anderson and Bidner (2022), Bau and Fernández (2021)), and the intensity of family ties might well affect economic outcomes (Alesina and Giuliano (2014)). Thus, studying the impact of different family types on socio-economic outcomes is an important undertaking. In this paper, we focus on the impact of family type on one specific outcome: fertility.

Taking a historical perspective like in Jones and Tertilt (2008), we investigate how different types of family structure have influenced the completed fertility of married women during the 19th and 20th century.

Thanks to the richness of American Census micro-data (Ruggles et al. (2021)), we are able to reconstruct married women's family structures and distinguish between nuclear and extended families. We perform a thorough descriptive analysis of these families, by detailing their geographic, demographic and socio-economic characteristics. We provide extensive evidence of a puzzling fact about the American fertility decline: women living in extended vertical families, *i.e.* those characterised by intergenerational coresidence, experience systematically lower fertility rates than those living in nuclear ones. This difference is wider at the beginning of our time window, and shrinks over time. This finding is puzzling, for a copious literature exists in development economics arguing that extended family arrangements typically act as providers of several services, such as insurance and childcare (see, for instance, Cox and Fafchamps (2007)). To corroborate our findings, we carry out a complete heterogeneity analysis, first by repeatedly splitting the sample along different dimensions of heterogeneity, second by including them as controls in a regression analysis (one by one, and all together). We show that the cross-family differential fertility cannot be explained by race, rural status, migration status (first and second-generation migrants), wealth, income, female labour force participation, age at first marriage. In addition, the differential fertility remains sizeable even when excluding childless married women from the sample, or when running the analysis on the subsample for which we have data on surviving children.

We discuss several potential explanations for this phenomenon, and establish that at the light of the data none but two resists closer scrutiny. The two surviving explanations are the 'inverted Caldwell hypothesis' – old parents were a liability in the past, due to their health status, and are now an asset, helping with grandchildren; and the 'relative income hypothesis' – intergenerational coresidence depends on cultural factors and the relative income of the young, and both affect the fertility choice, which turns out to be dependent on family structure. We show that, while the two may complement each other, only the latter – the relative income hypothesis – is necessary, once taking into account that both family structure and fertility are endogenous variables.

We build an analytical model in which both intergenerational coresidence and fertility are endogenous. We show under what conditions the interplay of cultural factors and relative income delivers a positive differential fertility in favour of nuclear families. We then build a dynamic general equilibrium model of the aggregate economy and calibrate it on the actual data. We simulate the model under different hypothesis on the causes of the fertility transition (increase in income *versus* increase in the returns on human capital) and show that independently of the latter, the model reproduces well the time-series behaviour of the fertility pattern for both family types, and can account for a good 60% of the cumulative change in the cross-family differential fertility.

A distinctive element of our theory is that the way in which resources are allocated within vertical families is crucial to understand the existence and the extent of a differential fertility across family types. Given the young's preference for coresidence, how many resources they bring to the common pot under coresidence, compared to how many resources they extract from it, is what determines whether they will have more or fewer children than they would have had in a nuclear family. In particular, if they bring more resources to coresidence than they extract from it, they will have fewer children, and *vice versa*. In other words, the staple of the relative income hypothesis is that the differential fertility between nuclear and vertical families hinges on an income effect, one that, however, is not apparent in the data, if the empirical analysis focuses only on the husband's (occupational) income. Beyond bringing a new fact to the fore, then, and providing a theoretical explanation with a good quantitative performance for it, an additional contribution of this work is to suggest that the empirical analysis of family related outcomes should look at a family-wide concept of income, possibly encompassing the allocation of resources within households.

The nature of the model, together with the result that the income-fertility relationship is mediated by the family structure, links our contribution to the literature on the demographic transition and its impact on economic growth (Galor (2012)). This literature typically argues that changes in the incentives to have children, mostly due to income-related factors, are the drivers behind the fertility transition occurred in major Western countries, and the secret behind their early takeoff. While the first to theorise the quantity-quality trade-off applied to fertility decisions were Becker and Lewis (1973), the idea that returns to education increased in the past two centuries to the extent that parents started to prefer having fewer, but more educated, children – quality, as opposed to quantity – is a staple of what is nowadays known as Unified Growth Theory (Galor (2011)).[1] This literature has traditionally relied on a unitary representation

[1]Major theoretical contributions in this field are Galor and Weil (1996, 2000), Galor and Moav (2002) and Galor and Michalopoulos (2012), among others. Several studies have tested the theory, either empirically (Becker et al. (2010), Bleakley and Lange (2009), Ager and Cinnirella (2020), Madsen and Strulik (2023)), or in quantitative models (Doepke (2004), Lagerlöf (2006)). Others have used it to explain cross-sectional fertility differentials (de la Croix and Doepke (2003)).

of the household, or theorised households' decision making in the context of nuclear families. Our analysis, instead, suggests that integrating other family types in unified growth theory is likely to be important, for the income-fertility relationship depends on the family structure. This way, facts that *prima facie* might look beyond the reach of unified growth theory, such as the existence of a differential fertility across family types that is apparently unrelated to income, may instead find their place within the framework.

This article brings an hitherto overlooked fact, the differential fertility across family type, to the fore. We document this fact, and assess its robustness with an extensive empirical analysis. No attempt is done to uncover a causal link from the family structure to fertility in the empirical analysis alone, although we do control for several possible omitted variables, and explore several alternative mechanisms. Having dismissed most of them through the data, we call the theory for help and unveil a new possible mechanism, the relative income hypothesis. We then build a novel quantitative macroeconomic model, and show that such a mechanism may indeed account for a sizeable part of the actual behaviour in the data. We are currently working on testing specific implications of the model on the data. More in general, the relationship between intergenerational coresidence and fertility is complex, and most likely bi-directional. The presence of grand-parents in the household at time $t$ might indeed affect fertility choices in $t$ for a number of reasons: a stronger or weaker bargaining position of the young may affect the resources they enjoy under coresidence; caring for the elderly might be costly in terms of time and resources; the elderly may on the other hand help parents by sharing the cost of children (again, both in terms of time and resources); this might affect the labour supply (of women in particular), both in terms of hours worked and in terms of location of the family; coresidence might induce huge savings on housing and other public goods *et cetera*. On the other hand, fertility choices by the young at time $t$ might affect their probability of coresidence when old at time $t + 1$. Mechanically, having more kids might imply a higher probability of living with one of them when old. In this paper, we tackle this reverse causality through economic theory. While we focus mostly on the first channel, from coresidence to fertility, in the Appendix we discuss the second one, and concludes that it is most likely negligible from a quantitative perspective.

The rest of the paper is organised as follows. In Section 2, we present our benchmark fact – the differential fertility across family types – and discuss its determinants and whereabouts. Having dismissed all alternative explanations, in Section 3 we develop a novel, fully microfounded, analytical model of endogenous fertility and coresidence. We explore the dynamics of the model in Section 4, where we also simulate an aggregate partial equilibrium version of model. Section 5 builds a dynamic general equilibrium version of the model that is calibrated on the actual data. Simulations from the model show that the relative income mechanism can account for about 60% of the observed drop in the cross-family differential fertility. Several robustness exercises are discussed. Section 6 concludes.

# 2 Empirical analysis

In this Section, we explore the evolution of fertility by family type in the United States across different cohorts between the 19th and the 20th century. Each cohort covers five (birth) years and, in the rest of the paper, it is labeled with its midpoint: for instance the 1851-1855 cohort is labeled the 1853 cohort. For our analysis, we use the 1% sample of the U.S. census data from IPUMS (Ruggles et al. (2021)), consisting of individual data registered at the household level.

## 2.1 Fertility

Following Jones and Tertilt (2008), we use the variable Children Ever Born (CEB) to reconstruct a measure of completed fertility. CEB indicates how many children a woman had throughout her life at the moment of the Census interview. To interpret CEB as a measure of completed fertility, we focus on women aged 40-49. These women were at the end of their fertile life (the median age of menopause oscillates between 48 and 50 in developed countries (Davis et al. (2015)), and yet not too old to incur into selection issues due to survival bias. Accordingly, we generally use CEB of women in the age range 40-49 to measure completed fertility of women born 40-49 years before. For instance, to get a measure of completed fertility for the 1853 cohort, we look at the CEB of women aged 40-44 in the 1900 census.

Although our reference age to measure completed fertility is 40-49, in some instances we are forced to use different age ranges. Indeed, the variable CEB is available only in the decennial censuses between 1900 and 1990, with a gap for the census years 1920 and 1930. To fill this gap, and have data for the 1873-1888 cohorts, we use women aged between 50 and 69 from the 1940 Census. Relaxing the age restriction can also be useful to extend the time series before the 1853 cohort and after the 1948 one. To retrieve information on the 1833-to-1848 cohorts, we use women aged from 50 to 69 in the 1900 Census. By the same token, we use information on women aged between 30 and 39 to reconstruct fertility for the 1953 and the 1958 cohorts. Fertility figures computed using age ranges different from 40-49, however, must be interpreted with some caution: older cohorts might suffer from a survival bias, while younger cohorts might not have completed their fertility yet. To signal the different quality of the fertility data, in the following Figures and Tables we highlight in grey the cohorts whose CEB was observed in the 40-49 age range; in other terms, the highlighted grey areas indicate the cohorts whose data are more reliable.

Finally, we restrict the analysis to those women who are married, and whose husband holds a valid occupation, according to its Census definition. We limit the analysis to marital fertility since the Census reports CEB for unmarried women only after 1960. To grasp the extent of the approximation so introduced, notice that in our data births out of the wedlock are 5% of total birth in 1920, and 10% in 1970 (see Greenwood and Guner (2010)). We consider women whose husband held a valid occupation, because we want to include household income in the analysis.[2]

## 2.2 Families

Thanks to the detailed household and person-level information available in IPUMS, we are able to reconstruct the woman's family structure from the family relationships registered in the Census. We exclude persons living in group quarters. Since our focus is on family relationships and fertility, we also exclude households with multiple families, *i.e.* situations of coresidence among unrelated individuals.[3]

To classify families along some meaningful dimension, we start with the canonical Le Play's definition, singling out three main types of family: the 'nuclear', the 'stem' and the 'complex' family (Le Play (1871)). The nuclear family consists of a couple of parents and their children. The stem family adds the presence of grandparents to it. Complex families are a somewhat residual category that includes all other possible configurations involving parents' siblings and/or other relatives. We use the same temporal structure as in the analysis of fertility. So, for instance, for the 1853 birth cohort, we first attach the family structure to each woman, and then we average fertility rates by family structure.

[2]We have performed our analysis also on the sample including all married women. Results are unaffected, and are available upon request.

[3]In other words, we restrict the analysis only to household in which only the householder's family is present.

Doing so for all the women in the sample, we obtain a time series of CEB by family structure and by cohort, which we report in Figure 1. The graph shows that the three types of families share a similar time-series pattern. We can clearly witness the fertility transition, with completed fertility rates declining over time, from 4-to-6 children per woman among earlier cohorts to roughly 2 among last cohorts, depending on the family structure. We also see the post WWII baby-boom, with fertility rates abruptly increasing to up to 4 children among women born in the late 1920s/early 1930s. On the contrary, there is evidence of cross-type differences in fertility levels: women living in complex families have the highest level of fertility (up to 6 children in earliest cohorts), followed by those living in nuclear families. Somewhat surprisingly, however, stem families have the lowest level of fertility (up to a difference of 2 children for earlier cohorts).

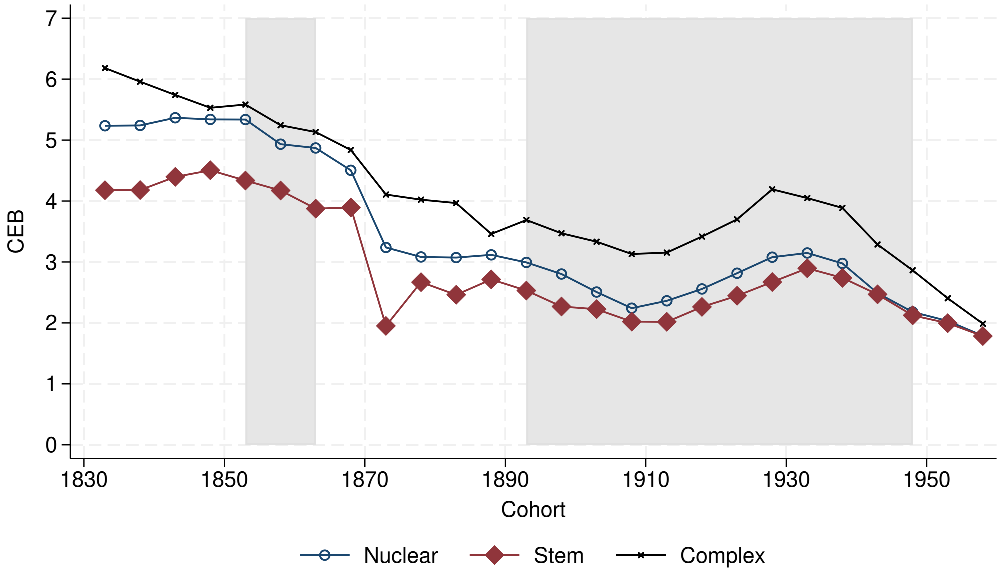



Figure 1: CEB by family type. Married women (various age) with employed husbands.

To understand the latter unexpected result, we zoom in on complex families, looking for the presence of grandparents. We call 'patriarchal' those complex families in which there is at least one coresiding grandparent, and 'other' the rest. The results of this decomposition on the CEB figures by cohort and family structure are shown in Figure 2.

As evident from the graph, fertility in patriarchal complex families turns out to be remarkably similar to that in stem families. This suggests a

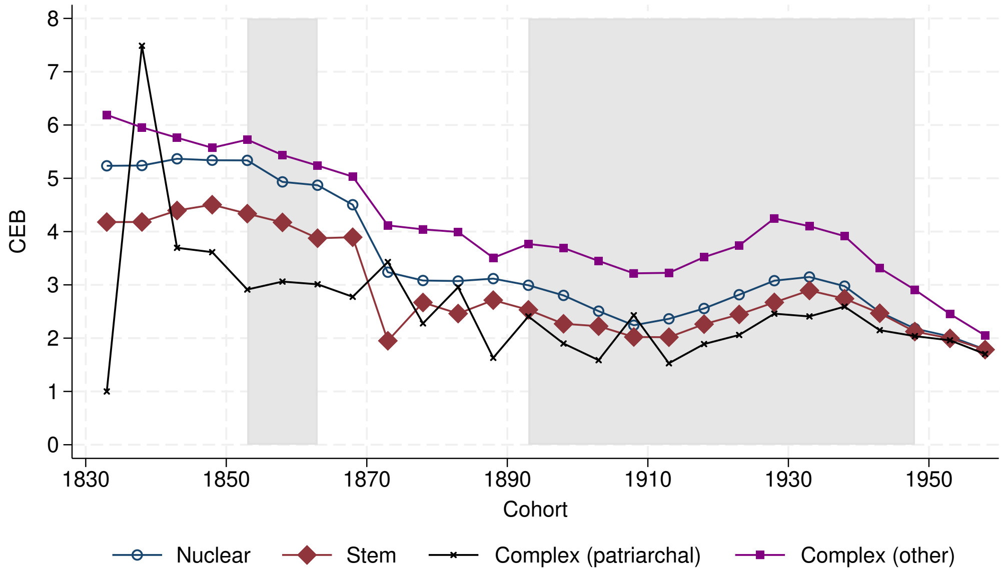



Figure 2: CEB by family type. Married women (various age) with employed husbands.

leading role for the presence of grandparents, and calls for a re-definition of family types with a focus on intergenerational coresidence. Accordingly, we define family types as follows:

- Nuclear families, those characterised by the presence of parents and their children;
- Extended vertical families, those characterised by intergenerational coresidence between grandparents, parents and their children;
- Extended horizontal families: other forms of complex families not involving intergenerational coresidence, typically parents, their siblings and their children.[4]

Figure 3 shows the completed fertility rates by family structure, according to this last classification. The same information on fertility rates by family types are reported in Table 1, which also adds the distribution across family types of women belonging to the different cohorts and the fertility of each cohort averaged across family types.

[4]Notice that the defining feature of extended vertical families is intergenerational coresidence, *i.e.* it the presence of at least one grandparent in the household. This does

| Birth Year | | Label | Age | | Census Year | $\overline{CEB}$ | $CEB^N$ | $CEB^V$ | $CEB^H$ | % N | % V | % H |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1831 | 1835 | **1833** | 65 | 69 | 1900 | 5.58 | 5.31 | 4.00 | 6.29 | 70.88 | 0.45 | 28.67 |
| 1836 | 1840 | **1838** | 60 | 64 | 1900 | 5.57 | 5.37 | 4.59 | 6.19 | 73.14 | 1.19 | 25.67 |
| 1841 | 1845 | **1843** | 55 | 59 | 1900 | 5.55 | 5.50 | 4.53 | 5.91 | 76.65 | 2.69 | 20.66 |
| 1846 | 1850 | **1848** | 50 | 54 | 1900 | 5.53 | 5.50 | 4.75 | 5.84 | 79.63 | 3.80 | 16.57 |
| 1851 | 1855 | **1853** | 45 | 49 | 1900 | 5.52 | 5.53 | 4.39 | 5.95 | 81.41 | 5.71 | 12.89 |
| 1856 | 1860 | **1858** | 40 | 44 | 1900 | 5.14 | 5.13 | 4.29 | 5.77 | 82.84 | 7.05 | 10.11 |
| 1861 | 1865 | **1863** | 45 | 49 | 1910 | 5.01 | 5.03 | 3.93 | 5.44 | 81.67 | 5.88 | 12.45 |
| 1866 | 1870 | **1868** | 40 | 44 | 1910 | 4.67 | 4.66 | 3.92 | 5.22 | 82.04 | 7.51 | 10.45 |
| 1871 | 1875 | **1873** | 65 | 69 | 1940 | 3.52 | 3.35 | 2.37 | 4.22 | 76.82 | 1.46 | 21.71 |
| 1876 | 1880 | **1878** | 60 | 64 | 1940 | 3.31 | 3.13 | 2.69 | 4.12 | 78.61 | 2.67 | 18.72 |
| 1881 | 1885 | **1883** | 55 | 59 | 1940 | 3.28 | 3.13 | 2.35 | 4.09 | 78.36 | 3.63 | 18.01 |
| 1886 | 1890 | **1888** | 50 | 54 | 1940 | 3.20 | 3.18 | 2.66 | 3.51 | 80.31 | 4.80 | 14.89 |
| 1891 | 1895 | **1893** | 45 | 49 | 1940 | 3.09 | 3.04 | 2.53 | 3.79 | 80.51 | 7.44 | 12.05 |
| 1896 | 1900 | **1898** | 40 | 44 | 1940 | 2.88 | 2.87 | 2.23 | 3.75 | 82.92 | 8.77 | 8.30 |
| 1901 | 1905 | **1903** | 45 | 49 | 1950 | 2.60 | 2.52 | 2.18 | 3.48 | 80.82 | 8.02 | 11.16 |
| 1906 | 1910 | **1908** | 40 | 44 | 1950 | 2.31 | 2.25 | 2.06 | 3.24 | 82.62 | 9.44 | 7.94 |
| 1911 | 1915 | **1913** | 45 | 49 | 1960 | 2.41 | 2.36 | 1.99 | 3.23 | 85.38 | 6.84 | 7.78 |
| 1916 | 1920 | **1918** | 40 | 44 | 1960 | 2.60 | 2.56 | 2.24 | 3.54 | 86.74 | 7.13 | 6.14 |
| 1921 | 1925 | **1923** | 45 | 49 | 1970 | 2.85 | 2.81 | 2.45 | 3.66 | 89.00 | 5.10 | 6.21 |
| 1926 | 1930 | **1928** | 40 | 44 | 1970 | 3.11 | 3.07 | 2.68 | 4.16 | 90.29 | 4.72 | 5.29 |
| 1931 | 1935 | **1933** | 45 | 49 | 1980 | 3.19 | 3.14 | 2.90 | 4.12 | 90.23 | 3.96 | 5.81 |
| 1936 | 1940 | **1938** | 40 | 44 | 1980 | 3.01 | 2.97 | 2.68 | 3.88 | 91.61 | 3.36 | 5.03 |
| 1941 | 1945 | **1943** | 45 | 49 | 1990 | 2.54 | 2.48 | 2.43 | 3.30 | 90.48 | 2.86 | 6.66 |
| 1946 | 1950 | **1948** | 40 | 44 | 1990 | 2.21 | 2.17 | 2.10 | 2.90 | 92.21 | 2.72 | 5.07 |
| 1951 | 1955 | **1953** | 35 | 39 | 1990 | 2.04 | 2.03 | 1.99 | 2.44 | 93.71 | 2.74 | 3.55 |
| 1956 | 1960 | **1958** | 30 | 34 | 1990 | 1.79 | 1.79 | 1.75 | 2.03 | 93.67 | 2.94 | 3.39 |

Table 1: CEB and distribution of women by family type for different cohorts.

$\overline{CEB}$ is average CEB over family types. $CEB^N$ is average CEB for nuclear families. $CEB^V$ is average CEB for extended vertical families. $CEB^H$ is average CEB for extended horizontal families. % N is the fraction of women belonging to a nuclear family. % V is the fraction of women belonging to an extended vertical family. % H is the fraction of women belonging to an extended horizontal family.

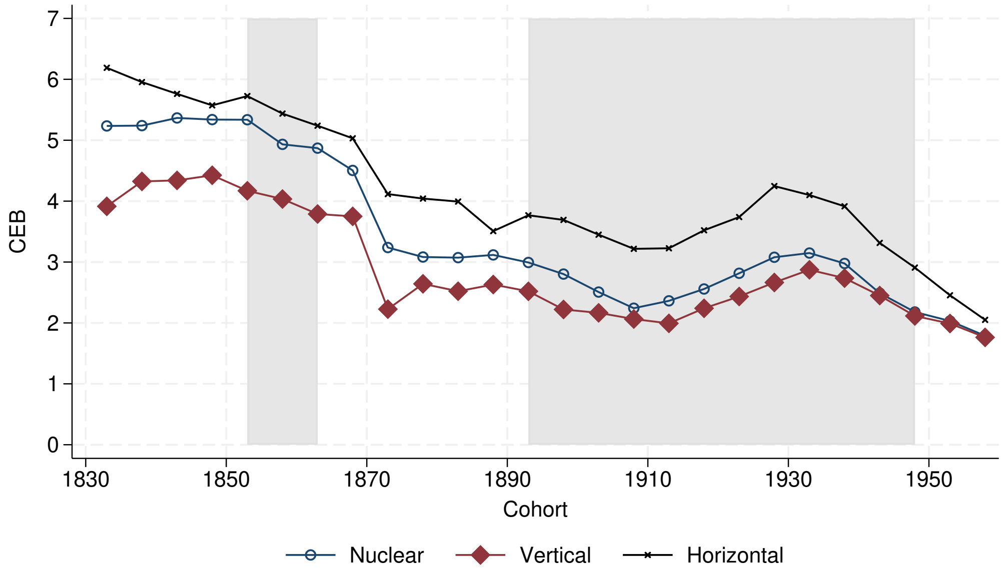



Figure 3: CEB by family type. Married women (various age) with employed husbands. 95% CI.

The fact that emerges from this preliminary investigation is that intergenerational coresidence is systematically associated with lower fertility than the nuclear family (and *a fortiori* than the more prolific horizontal family). Such a difference is sizeable at the beginning of the sample, but tends to shrink over time. Establishing and explaining this fact constitutes the core of this paper.

## 2.3 Family type and fertility: some caveat

One might wonder whether the fact that we uncovered – the differential fertility by family type, cross section and over time – is somewhat an artefact due to the approximations induced by the way we measure both completed fertility and intergenerational coresidence.

Interestingly, in an independent work on the U.S. fertility transition, Hacker and Roberts (2019) find a similar result, namely a negative correlation between the presence of mothers/mothers-in-law and other females in the household, and fertility rates. Their study differs from ours under several respects. They cover a more limited span of time, using full-count

not exclude the possibility of the presence of a horizontal component in these vertical families as well.

U.S. census data for 1850, 1880, 1910 and 1930 only. They impose none of our structure – completed fertility and a specific taxonomy for family types.[5] They focus instead on married women aged between 20-49 who are living with their husband, and measure fertility rates from the number of co-resident own children aged 5 or below. They are not interested in coresidence *per se*, but rather in kin proximity as a potential co-determinant of fertility. To measure kin proximity, they use coresiding mothers, mothers in law, and other females aged at least 11 who may contribute to childrearing. Outside the household, they rely on surnames to identify women as potential mothers in laws, and the census enumeration system to indirectly infer patrilineal kin, using up to 10 nearby households. Aside from the obvious numerous differences between our analysis and theirs,[6] what is relevant here is that the analysis by Hacker and Roberts (2019) is a strong, if indirect proof that our fact is not a by-product of our definition of family types, nor of the class of age we consider in order to have completed fertility.

Having established that our stylised fact is not a purely statistical artefact, but rather an empirical finding in need of an explanation, let us consider some possible caveat to the specific way in which we measure it.

A first possible issue is that longevity increased over the time period we cover. Life expectancy at birth was 49.2 years in 1900-1901 and 69.9 in 1959-1961 (Arias et al. (2017)). Since people tends to live longer in more recent cohorts, the possibility of coresiding with an elderly parents as well as the average age of the latter should mechanically increase over time. Hence, the cross-family-type differential fertility and its shrinking pattern over time might at least partially reflect a measurement bias. To see whether this is the case, we have checked the average age of the coresiding elderly for each cohort. As shown in Table 2, it turns out that this oscillates around

[5]As it is will appear clear in Section 2.6, our taxonomy of family types is quite useful when it comes to explain the observed negative association between fertility and intergenerational coresidence. Besides, we stand by the choice of using CEB instead of the number of coresiding small-age children as a measure of fertility, because in micro-founded economic models what matters is total planned fertility.

[6]On top of the major differences already highlighted in the main text, we also correct for cohort fixed effects, to exploit variation within the same cohort of birth, and state fixed effects, to control for specific geographic patterns. Furthermore, the larger time span of our analysis allows us to uncover the shrinking pattern over time of the differential fertility by family type. More crucially, we delve deeper into the search of an explanation of this new empirical findings, by using data and our taxonomy to scrutinise existing possible mechanisms, including those advanced by Hacker and Roberts (2019), and proposing a novel economic theory, encapsulated in an analytical, quantitative model, to rationalise them.

75 for the whole period, suggesting that the average age gap between our unit of observation – the woman aged 40-49 – and the coresiding parent/inlaw was stable during the period covered by our analysis. This should assuage the longevity-related concerns. Notice also that we include cohort fixed effects in our regression analysis below, which should wash away variations over time that, like longevity, are common to the whole cohort.

| Cohort | Parents/inlaw's age | Age gap |
|---|---|---|
| 1853 | 76.29 | 29.55 |
| 1913 | 75.19 | 28.33 |
| 1948 | 72.36 | 30.47 |

Table 2: Age of *coresiding* elderly, and age gap between the woman and the coresiding elderly. Selected cohorts.

More in general, measuring intergenerational coresidence between the 19th and the 20th century raises several measurement issues related to the important changes in demographic patterns observed in the same period, which may make observing coresidence more or less possible: increasing longevity, declining fertility, increasing education, later age at marriage, later age at first birth *et cetera*. This was discussed at some length in Pensieroso and Sommacal (2019), who proposed a different measure of intergenerational coresidence, one that corrects for the mechanic effect of demographic changes. This measure is the percentage of the elderly who, at a given point in time, coreside with at least one young adult son/daughter (Figure 4). As discussed in Pensieroso and Sommacal (2019), this measure is better apt to catch the behavioural choices of the young and the old, independently of the pattern of other demographic variables. As such, this is the measure we shall use to discipline our model of endogenous coresidence and fertility. Notice that both the pattern and the magnitude of the incidence of intergenerational coresidence depends heavily on the way it is measured. To witness it, consider numbers from Table 1, column 11 (%$V$), and Figure 4. The percentage of women born in 1853 who in 1900 were living in an extended vertical family was 5.71%. The percentage of the elderly living in 1900 with at least one young adult kid, however, was 61%. The time pattern of the incidence of the vertical family among women aged 40-to-49 is first increasing to touch 9% the 1908 cohort and then decreasing to 2.7% for the 1948 cohort. Whereas the time patterns of the percentage of the elderly living with at least one young adult kid is decreasing from 61% in 1900 to about 17% in 1990. On top of other things, this shows that intergenerational coresidence was certainly not a marginal phenomenon in the period under consideration, quite the contrary. Since we want to

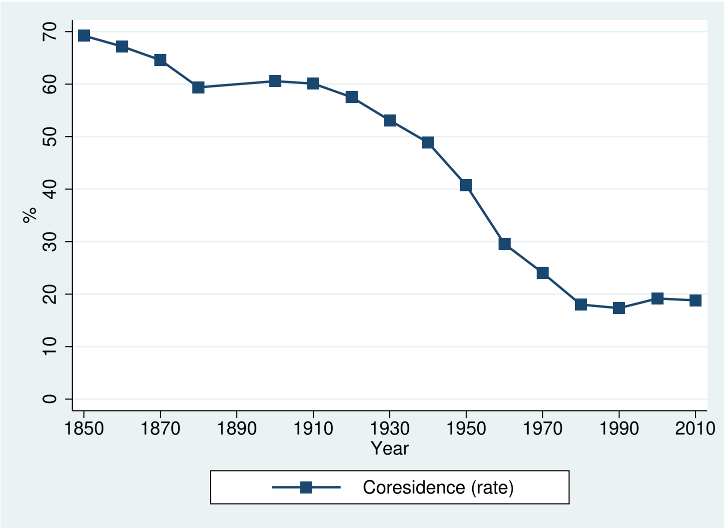



Figure 4: Intergenerational coresidence rate, United States, 1850-2010. Source: Pensieroso and Sommacal (2019).

measure completed fertility, however, our unit of observation is a woman in the 40-49 class age. Accordingly, in our empirical analysis we measure intergenerational coresidence by looking at her family relationships at the moment in which these are recorded in the Census.

A third possible concern is that we are measuring an entirely spurious correlation between fertility and family type. Suppose, for example, that in an unspecified ethnolinguistic group the coresidence rate is 100% for cultural reasons (no elderly live in a nuclear family), and women tend to have very high fertility rates. Every woman will have a lot of siblings, who, like her, will have many children. Since coresidence in vertical family typically involves only one of the siblings, this produces a lot of nuclear families with high fertility. Now think of a second ethnolinguistic group, in which the coresidence rate is still 100% for cultural reason, but in which women tend to have low fertility rates. Every woman will have few siblings (one if population in the group is stationary), who, like her, will have few children. If the society is composed of these two groups, we shall observe that nuclear families are on average associated with higher fertility than vertical ones, without any obvious influence of family structure on fertility. While we cannot completely rule out this possibility, we view it as unlikely. Vogl (2020) shows convincingly that intergenerational autocorrelation in fertility was low during and after the demographic transition, which corresponds by and large to the period covered by our sample. Furthermore, we can show that our fact is consistently observed within more homogenous cultural groups. In fact, in Section 2.5 we repeatedly split the sample along several cultural dimensions (race, migration status of the woman and of her parent), and find that fertility among nuclear families is higher than fertility in vertical families, even among white women only, foreign born women only and second-generation immigrant women only. We are currently checking whether we observe a differential fertility by family type for women with common ancestry.

A fourth concern is that our reconstruction of family types implicitly assume a high degree of stability of family structure along the woman's reproductive life. We measure, indeed, completed fertility and family links when the woman is 40-to-49, which implies that the woman was living in the same family type when she was actually having children, *i.e.* when she was in her 20-to-40. This, however, might not have always been the case. Of particular relevance for our story is the possibility that at least part of those women we identify as coresiding were actually living in nuclear families when they were young – before taking at home, at some later point in their fertility life, an elderly widow. In this case, we would be overestimating the incidence of vertical families. To assuage this concern, we have performed the following exercise. For each Census Year $t$, we averaged among women aged 40-to-49 and computed the aggregate incidence of each family type. Then, we went to the Census Year $t-1$ ($t-2$), averaged among women aged 30-to-39 (20-to-29) and computed the aggregate incidence of each family type, and compare it with the computation in $t$. For our story to hold good, we should observe that the percentage of women living in vertical families in each cohort is stable, or at least not increasing in their age range. Results, reported in in the Appendix (Table 16), are rather reassuring in this respect. The percentage of women living in vertical families in each cohort is decreasing in their age range, which suggests that they were coresiding more in their most fertile period, and less at the end of it, possibly a result of mortality among the elderly. Accordingly, far from overestimating the incidence of vertical families among women during their fertile life, we are actually underestimating it. Furthermore, since we know that intergenerational coresidence is in any case associated with less fertility, by imposing our taxonomy and measuring completed fertility we are actually underestimating the extent of the cross-family-type differential fertility.

## 2.4 Family types: descriptive analysis

The starting point to unravel the determinants of differential fertility across family types and its pattern over time must be a throughout characterisation of those family types in socio-economic and demographic terms. For the sake of readability, in this section we report descriptive statistics for three selected cohorts only, 1853, 1913 and 1948. The first and the last corresponds to the first and last cohorts with the right age range for the woman; 1913, was chosen so as to have a pre-World War mid point between the two. We have also grouped variables depending on their availability along the sample. When variables were not available for our selected cohorts, we chose the closest cohort to the missing one. The complete analysis for all the cohorts is presented in the Appendix.

Table 3 details the percentage of women living in each family type who: 1) were white (as opposed to black); 2) lived in urban area (as opposed to rural area); 3 lived in a dwelling that was owned by the household (as opposed to rented); 4) were in the labour force; 5) were childless; 6) had a husband with high (*i.e.* above median) income.[7]

| | | White | Urban | Owner | Active | Childless | High income |
|---|---|---|---|---|---|---|---|
| | Nuclear | 91.6 | 37.6 | 57.7 | 3.4 | 8.4 | 41.7 |
| 1853 | Vertical | 92.7 | 33.1 | 65.4 | 2.9 | 14.8 | 42.2 |
| | Horizontal | 79.1 | 33.1 | 54.3 | 6.2 | 8.4 | 36.1 |
| | Nuclear | 94.0 | 70.2 | 75.0 | 40.8 | 17.1 | 51.1 |
| 1913 | Vertical | 92.1 | 74.1 | 83.9 | 45.1 | 21.5 | 53.0 |
| | Horizontal | 76.7 | 64.1 | 70.4 | 36.9 | 14.3 | 39.4 |
| | Nuclear | 87.8 | 69.5 | 86.0 | 76.0 | 10.4 | 57.9 |
| 1948 | Vertical | 74.9 | 77.7 | 87.3 | 75.6 | 12.7 | 51.3 |
| | Horizontal | 65.2 | 73.5 | 75.3 | 71.5 | 5.0 | 43.2 |
| | Nuclear | 91.3 | 65.9 | 75.8 | 46.7 | 12.1 | 52.4 |
| Pooled sample | Vertical | 88.5 | 68.4 | 78.2 | 41.0 | 16.7 | 52.0 |
| | Horizontal | 76.9 | 58.5 | 65.7 | 32.9 | 9.6 | 40.7 |

Table 3: Descriptive statistics (Selected cohorts and pooled sample), variables: White, Urban, Owner, Active, Childless, High income.

It turns out that, especially in the early cohorts, vertical families were more likely than nuclear families to own their own dwelling and to be childless. Early cohorts of vertical families were living more in urban areas, but this pattern reverted soon, and mid-to-late cohorts were more rural (than nuclear families). For most of the period, there was no obvious racial or income gap between vertical and nuclear families. Starting from the 1948 cohort, however, vertical families tended to be slightly poorer and less widespread among white persons.

[7] As explained in Section 2.5, individual income data are not available for the Censuses before 1940. Hence, we follow Jones and Tertilt (2008) and use the occupational income score in its stead. We provide more details on this variable in Section 2.5.

Horizontal families, on the other hand, were more likely to be black and poor than nuclear families. Women in horizontal families participated slightly more in the labour market at the beginning of the sample, but this patterns reverted in the mid-to-late cohorts. They were also less likely to be childless.

| | | Origin | | |
|---|---|---|---|---|
| | | Native | 2nd gen | Foreign |
| 1853 | Nuclear | 60.4 | 13.9 | 25.7 |
| | Vertical | 70.5 | 13.5 | 16.0 |
| | Horizontal | 71.4 | 12.3 | 16.4 |
| 1913 | Nuclear | 68.3 | 25.1 | 6.6 |
| | Vertical | 67.5 | 27.2 | 5.3 |
| | Horizontal | 76.7 | 17.2 | 6.2 |
| 1928 | Nuclear | 75.8 | 17.3 | 6.9 |
| | Vertical | 70.0 | 22.1 | 7.8 |
| | Horizontal | 81.8 | 11.7 | 6.5 |
| Pooled sample | Nuclear | 66.8 | 19.7 | 13.5 |
| | Vertical | 69.3 | 22.3 | 8.3 |
| | Horizontal | 72.0 | 14.5 | 13.5 |

Table 4: Descriptive statistics (selected cohorts and pooled sample), variable: Origin.

Table 4 focuses on the incidence of family types by migration status. Except for the early cohorts, vertical families were more widespread than nuclear families among non-natives, both first- and second-generation migrants. In the early cohorts, instead, nuclear families were more widespread.

Horizontal families were significantly less diffused among second generation migrants than nuclear (and *a fortiori* vertical) families. They were more frequent among natives.

| | | Education | | | |
|---|---|---|---|---|---|
| | | up to grade 4 | grade 5-8 | grade 9-12 | some college |
| 1893 | Nuclear | 12.8 | 51.6 | 28.0 | 7.7 |
| | Vertical | 6.8 | 46.3 | 37.0 | 10.0 |
| | Horizontal | 19.4 | 53.7 | 22.5 | 4.3 |
| 1913 | Nuclear | 3.4 | 30.0 | 51.3 | 15.4 |
| | Vertical | 3.3 | 26.1 | 54.8 | 15.8 |
| | Horizontal | 9.8 | 42.8 | 40.4 | 7.0 |
| 1948 | Nuclear | 0.8 | 2.3 | 40.6 | 56.3 |
| | Vertical | 2.1 | 4.0 | 47.4 | 46.5 |
| | Horizontal | 4.3 | 7.3 | 54.1 | 34.4 |
| Pooled sample | Nuclear | 3.5 | 17.5 | 47.3 | 31.8 |
| | Vertical | 3.5 | 23.0 | 51.1 | 22.3 |
| | Horizontal | 11.1 | 34.7 | 40.8 | 13.5 |

Table 5: Descriptive statistics (selected cohorts and pooled sample), variable: Education.

Table 5 shows the percentage of women reaching a given level of education by family arrangement. At the beginning of the sample, vertical families had an edge over nuclear and, especially, horizontal families in terms of women's education. However, the situation reverted by the end of the sample, when women in nuclear families tended to reach higher grades more frequently. Women in horizontal families were systematically less educated than the others.

| | | Mean |
|---|---|---|
| 1893 | Nuclear | 22.1 |
| | Vertical | 23.2 |
| | Horizontal | 21.1 |
| 1913 | Nuclear | 22.7 |
| | Vertical | 23.6 |
| | Horizontal | 21.4 |
| 1938 | Nuclear | 20.9 |
| | Vertical | 21.8 |
| | Horizontal | 19.9 |
| Pooled sample | Nuclear | 21.8 |
| | Vertical | 22.6 |
| | Horizontal | 20.9 |

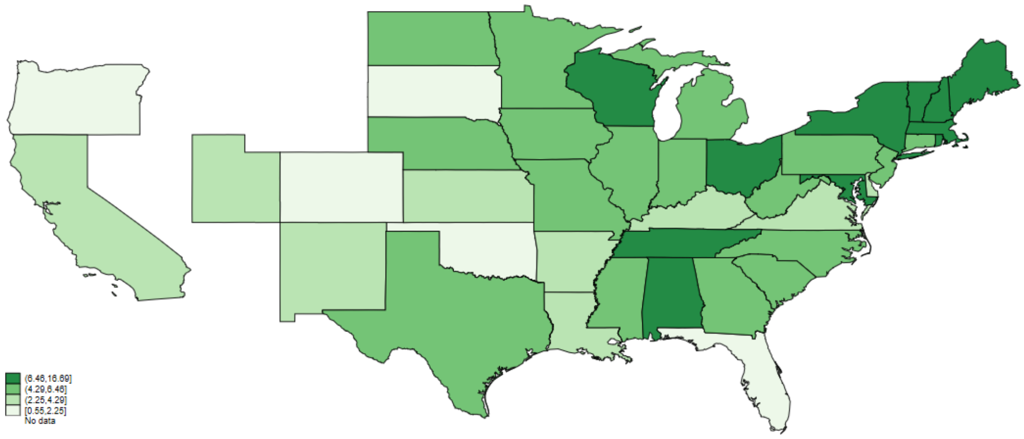
Table 6: Descriptive statistics (selected cohorts and pooled sample), variable: Age at marriage.

Finally, Table 6 reports the average age at marriage for women belonging to different family types. The numbers show that women living in vertical families married about one (two) year(s) later than women in nuclear (horizontal) families.

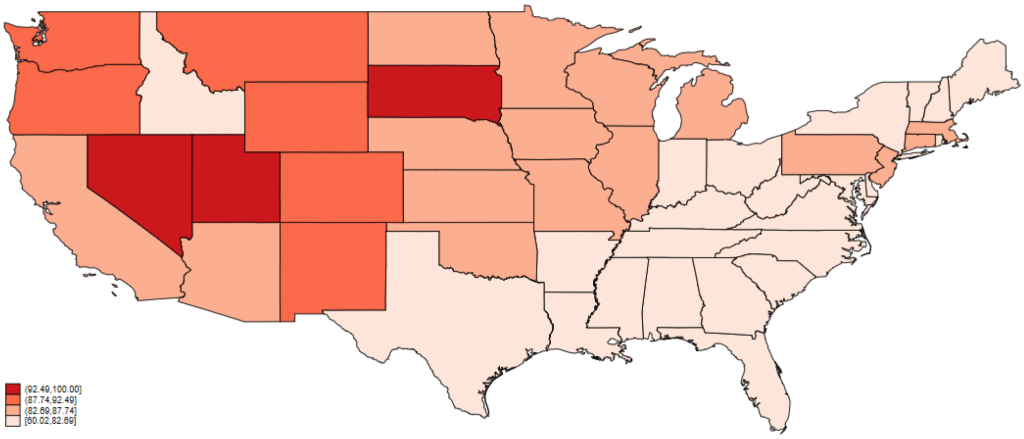
Another possible way to characterise the family structure is to study its geographic dimension. Are different types of family more concentrated in specific areas of the United States? Did this concentration change over time? Figures 5-to-7 provides an answer to these questions. They show convincingly that vertical families were an East, North-East phenomenon, Nuclear families a West, North-West phenomenon, and Horizontal families mostly a South, South-East phenomenon. Also evident from the graphs is the non-monotonic pattern of the incidence of vertical families, which was first increasing and then decreasing in our sample.

In synthesis, the descriptive analysis suggests that vertical and nuclear families were not very different under most socio-economic and demographic factors. The more systematic differences were in terms of geographic location, degree of dwelling ownership and childlessness, and age at first marriage. Differences in terms of education in favour of vertical families reversed over time.

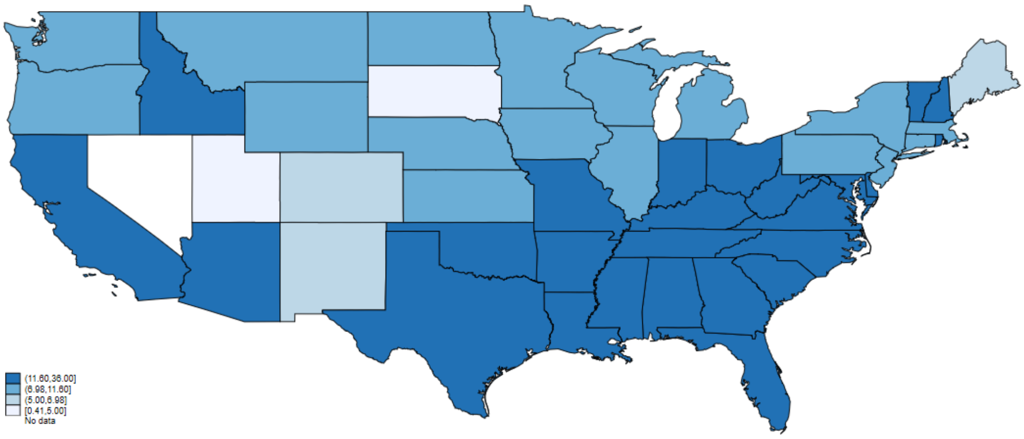
Horizontal families, on the other hand, were wholly distinct from the other two. They tended to be poorer, more widespread among black persons, with less childless and/or educated women.




(a) Vertical

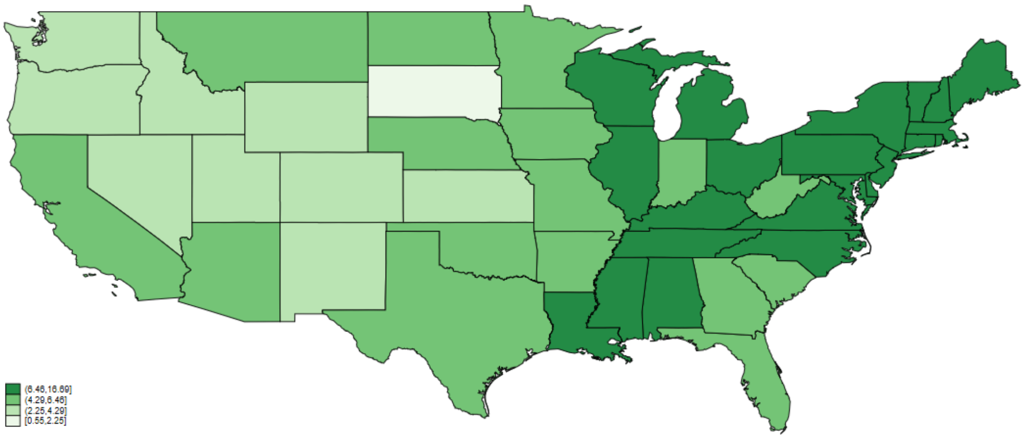



(b) Nuclear

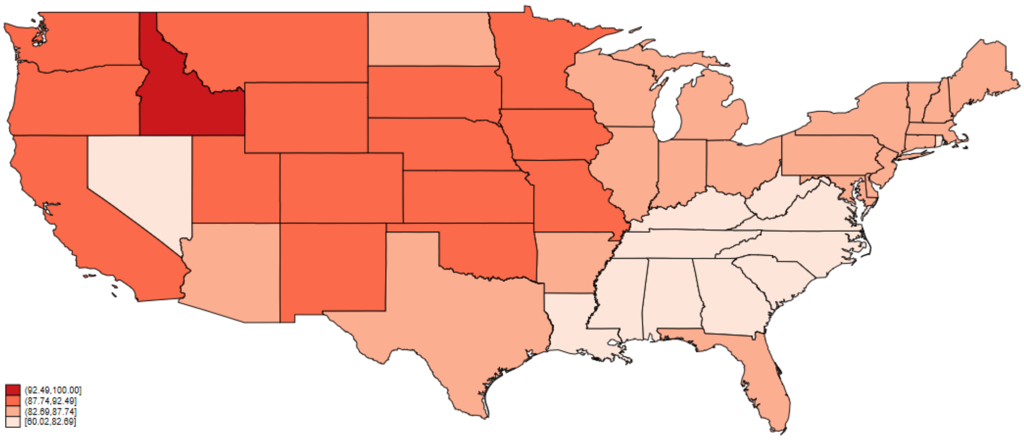



(c) Horizontal

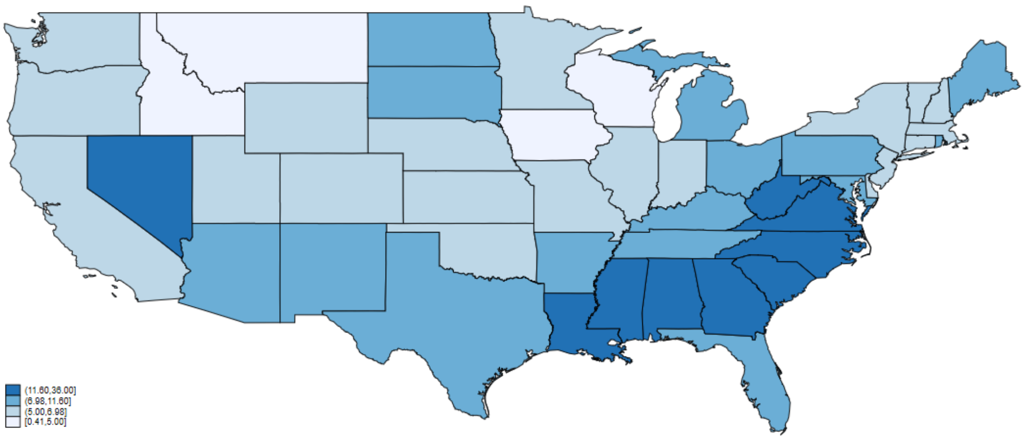
Figure 5: Incidence of family types by U.S. State, 1853




(a) Vertical

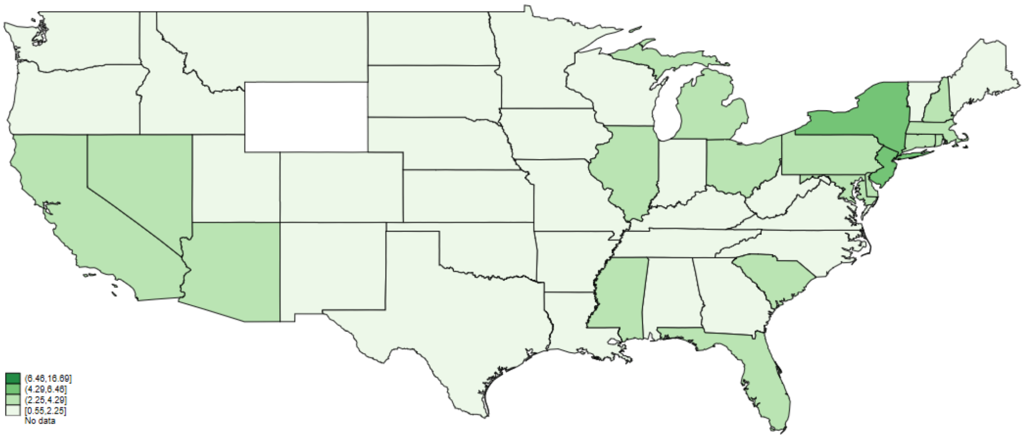



(b) Nuclear

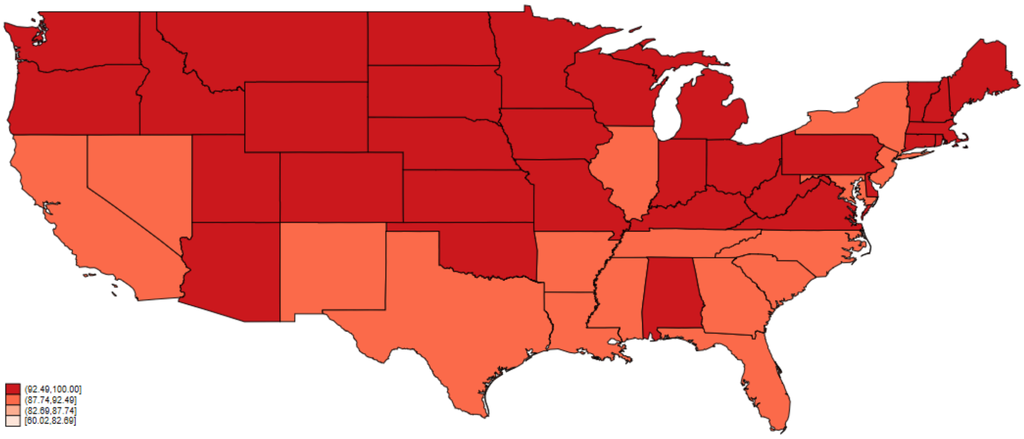



(c) Horizontal

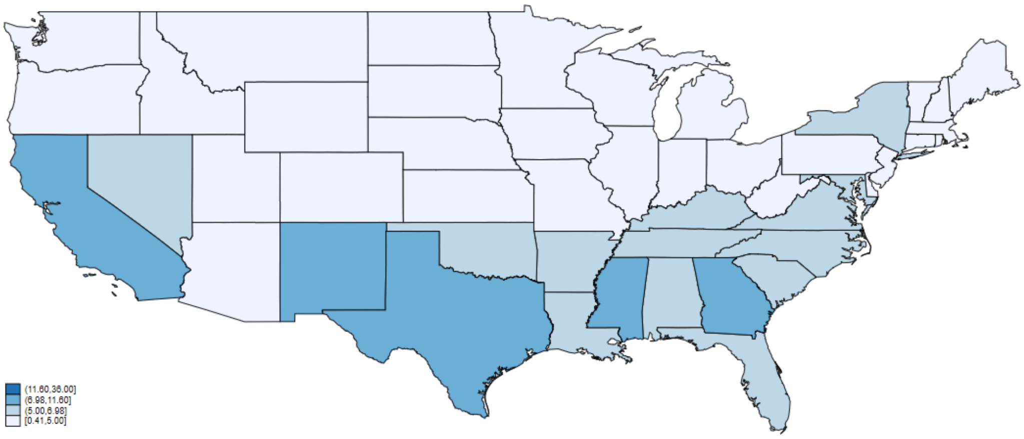
Figure 6: Incidence of family types by U.S. State, 1913




(a) Vertical




(b) Nuclear




(c) Horizontal

Figure 7: Incidence of family types by U.S. State, 1948

In the rest of this paper we are going to focus exclusively on the differential fertility between vertical and nuclear families, and refer only occasionally to the horizontal family. It goes without saying that the latter would deserve a proper analysis of its own that we leave to future research.

## 2.5 Family type and fertility: regression analysis

In this Section, we control for several possible dimensions of heterogeneity among family types, in order to assess the robustness of our fact, subject, of course, to data availability.

We do so in a twofold way. First, by repeatedly splitting the sample along a given dimension of heterogeneity, and checking whether the differential fertility between vertical and horizontal families holds true in the more homogenous two subsamples. Second, by including all dimensions of heterogeneity, one-by-one and all together as controls in a regression analysis, where completed fertility is regressed on family types.

In the interest of brevity, we report the graphical analysis done by splitting the sample along several heterogeneity dimensions in the Appendix. Here we limit to comment on the results, and then shift to the regression analysis.

Since more (married) women in vertical families are childless, considering the intensive *vs* the extensive margin of fertility is worth the while. We find that our fact holds also at the intensive margin, meaning that among the women who had at least one child, the fertility of those living in a nuclear families was higher than that of those living in a vertical one.

Splitting the sample by the urban/rural location, or by whether the household was owning or renting its dwelling confirms the robustness of our fact in those more homogeneous subsamples. In other words, among the women living in an urban (rural) area, the fertility of those living in a nuclear families was higher than that of those living in a vertical one. The same holds true for those women whose family owns (rent) its dwelling.

When it comes to heterogeneity along more cultural dimensions, things change slightly, subject to the caveat that we have (sometimes significantly) less data for those variables. The positive differential fertility in favour of nuclear family holds good for white women, and for women of native background. It also holds good for families with migration background, although to a lesser extent. It does not hold, however, for black women, meaning that black women living in vertical families had fertility rates similar to black women living in nuclear families.

To verify the solidity of the retrieved historical association between fertility and family structure, we are now going to use a regression analysis. This allows us to control simultaneously for all dimensions of heterogeneity for which we have data, and hence deliver a more robust correlation.

We estimate the following equation using Ordinary Least Square (OLS) estimation:

$$CEB_i = \beta_0 + \beta_1 V_i + \beta_2 H_i + \mathbf{X_i'b} + \theta_c + \gamma_s + \epsilon_i. \quad (1)$$

The unit of observation is woman $i$, belonging to cohort $c$, observed in Census year $y$ and living in state $s$. Our outcome of interest is completed fertility, measured by the Census entry "Children Ever Born" (CEB), as explained in Section 2.1. Our main explanatory variables are the $V$ dummy, which is equal to 1 if the woman lives in an extended vertical family, and 0 if she lives in a nuclear family; and the $H$ dummy, which is equal to 1 if the woman lives in an extended horizontal family, and 0 if she lives in a nuclear family.

The vector $\mathbf{X}$ includes all the variables we have analysed in the descriptive sections here above, for all of them are potential confounders that may simultaneously affect fertility and family structure. In particular, we have: a dummy equal to 1 if the woman is white, and 0 otherwise; a dummy equal to 1 if the household's location is urban, 0 otherwise; a dummy equal to 1 if the woman's spouse is a dwelling owner, and 0 if he is a renter; a dummy equal to one if the spouse's occupational income score (OIS) exceeds the median for that cohort; a dummy equal to 1 if the woman is active, *i.e.* in the labor force, and 0 otherwise; age at first marriage; a dummy equal to 1 if the woman is foreign born; a dummy equal to 1 if the woman is a second-generation immigrant (she has at least one foreign parent); education. $\theta_c$ and $\gamma_s$ stand for cohort and state fixed effects, respectively, to control for cohort-specific, state-specific, time-invariant unobservable characteristics. This takes on board sample wide trend evolution of longevity, morbidity and the like, as well as specific geographic patterns at the state level. Our standard errors are robust to heteroskedasticity. In the Appendix, we show that our results are remarkably robust to running the same regressions with standard errors adjusted for multiway clustering at the state-cohort level.

In Table 7, we report the results from the regression analysis, adding the above-mentioned controls first one by one, and then including all of them in Column (11).[8]. The coefficient $\beta_1$ is the fertility differential between women who live in extended vertical families and those who live in nuclear ones. This coefficient is negative, sizeable, robust to all the potential confounders.

[8]The sample shrinks significantly when adding information on nativity, since this variable is available only until 1970 in the US Census.

| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extended vertical | -0.34*** | -0.36*** | -0.35*** | -0.35*** | -0.34*** | -0.33*** | -0.32*** | -0.44*** | -0.46*** | -0.28*** | -0.25*** | -0.35*** | -0.26*** | -0.28*** |
| | (0.017) | (0.017) | (0.017) | (0.017) | (0.017) | (0.017) | (0.022) | (0.022) | (0.022) | (0.017) | (0.034) | (0.017) | (0.034) | (0.018) |
| Extended horizontal | 0.74*** | 0.67*** | 0.72*** | 0.71*** | 0.70*** | 0.74*** | 0.73*** | 0.72*** | 0.71*** | 0.65*** | 0.48*** | 0.60*** | 0.52*** | 0.57*** |
| | (0.020) | (0.020) | (0.021) | (0.021) | (0.020) | (0.020) | (0.031) | (0.028) | (0.028) | (0.022) | (0.045) | (0.021) | (0.045) | (0.023) |
| White | | -0.48*** | | | | | | | | | -0.28*** | -0.49*** | -0.37*** | -0.38*** |
| | | (0.014) | | | | | | | | | (0.052) | (0.013) | (0.052) | (0.013) |
| Urban | | | -0.46*** | | | | | | | | -0.60*** | -0.42*** | -0.63*** | -0.35*** |
| | | | (0.008) | | | | | | | | (0.023) | (0.008) | (0.023) | (0.009) |
| Owner | | | | -0.17*** | | | | | | | -0.13*** | -0.13*** | -0.16*** | -0.04*** |
| | | | | (0.010) | | | | | | | (0.023) | (0.010) | (0.023) | (0.011) |
| High income | | | | | -0.43*** | | | | | | -0.31*** | -0.33*** | -0.38*** | -0.16*** |
| | | | | | (0.007) | | | | | | (0.020) | (0.007) | (0.019) | (0.007) |
| Active | | | | | | -0.47*** | | | | | -0.58*** | -0.46*** | -0.61*** | -0.40*** |
| | | | | | | (0.007) | | | | | (0.017) | (0.006) | (0.017) | (0.006) |
| Age at first marriage | | | | | | | -0.11*** | | | | -0.12*** | | -0.12*** | |
| | | | | | | | (0.001) | | | | (0.002) | | (0.002) | |
| Foreign born | | | | | | | | 0.48*** | | | 0.50*** | | 0.63*** | |
| | | | | | | | | (0.021) | | | (0.039) | | (0.038) | |
| Foreign parent | | | | | | | | | -0.13*** | | 0.08*** | | 0.13*** | |
| | | | | | | | | | (0.014) | | (0.023) | | (0.023) | |
| Education | | | | | | | | | | -0.16*** | -0.09*** | | | -0.13*** |
| | | | | | | | | | | (0.001) | (0.004) | | | (0.002) |
| Constant | 5.77*** | 6.18*** | 5.78*** | 5.84*** | 5.95*** | 5.78*** | 6.28*** | 5.97*** | 6.06*** | 4.02*** | 7.42*** | 6.42*** | 7.50*** | 4.41*** |
| | (0.095) | (0.096) | (0.095) | (0.095) | (0.095) | (0.095) | (0.104) | (0.104) | (0.104) | (0.095) | (0.140) | (0.096) | (0.140) | (0.096) |
| Observations | 634,682 | 634,682 | 609,608 | 613,911 | 634,682 | 634,682 | 297,496 | 298,605 | 298,605 | 566,511 | 113,367 | 609,608 | 113,367 | 541,437 |
| R-squared | 0.161 | 0.165 | 0.179 | 0.172 | 0.169 | 0.168 | 0.104 | 0.150 | 0.148 | 0.107 | 0.174 | 0.196 | 0.169 | 0.131 |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Dependent variable: children ever born.

In our preferred specification, columns (1) and (11), it amounts to -0.34 and-0.25, respectively, and is significant at the 1% level. This means that according to our regression moving a married women from a nuclear to a vertical family would imply a decrease of her fertility by 0.34 or 0.25 children, respectively. All controls are significant and have the expected sign. Columns (12)-to-(14) are intended for robustness, showing results for the set of controls for which we have many observations (Column (12)) as opposed to those for which we have fewer observations (Column (14) and, especially, (13)). The stability of the coefficient suggests that the results in Column (11) are not driven by the reduction of the sample. Overall, this analysis reinforces our previous findings pointing to systematic lower fertility rates among women residing in extended vertical families.

Our regression analysis also confirms that women living in extended horizontal families had systematically higher fertility than the others, both in absolute and conditional to the many potential confounders considered here. In fact, the coefficient $\beta_2$, or the fertility differential between women who live in extended horizontal families and those who live in nuclear ones, is positive, sizeable, and robust to all the controls.

Since we have already shown that childlessness differs among family types (see Table 3), we now investigate whether the differential fertility between vertical and nuclear families persists also when we limit to the

| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extended vertical | -0.27*** | -0.29*** | -0.28*** | -0.27*** | -0.27*** | -0.26*** | -0.27*** | -0.36*** | -0.38*** | -0.21*** | -0.22*** | -0.28*** | -0.23*** | -0.23*** |
| | (0.017) | (0.017) | (0.017) | (0.017) | (0.017) | (0.017) | (0.023) | (0.023) | (0.023) | (0.017) | (0.037) | (0.017) | (0.037) | (0.018) |
| Extended horizontal | 0.72*** | 0.62*** | 0.69*** | 0.68*** | 0.67*** | 0.71*** | 0.73*** | 0.70*** | 0.69*** | 0.63*** | 0.42*** | 0.55*** | 0.46*** | 0.52*** |
| | (0.020) | (0.020) | (0.021) | (0.021) | (0.020) | (0.020) | (0.032) | (0.028) | (0.028) | (0.023) | (0.047) | (0.021) | (0.047) | (0.023) |
| White | | -0.65*** | | | | | | | | | -0.68*** | -0.61*** | -0.79*** | -0.50*** |
| | | (0.014) | | | | | | | | | (0.059) | (0.014) | (0.059) | (0.014) |
| Urban | | | -0.40*** | | | | | | | | -0.56*** | -0.38*** | -0.59*** | -0.32*** |
| | | | (0.008) | | | | | | | | (0.024) | (0.008) | (0.024) | (0.009) |
| Owner | | | | -0.26*** | | | | | | | -0.18*** | -0.20*** | -0.22*** | -0.13*** |
| | | | | (0.010) | | | | | | | (0.025) | (0.010) | (0.025) | (0.011) |
| High income | | | | | -0.45*** | | | | | | -0.33*** | -0.32*** | -0.41*** | -0.18*** |
| | | | | | (0.007) | | | | | | (0.021) | (0.007) | (0.021) | (0.007) |
| Active | | | | | | -0.34*** | | | | | -0.48*** | -0.35*** | -0.52*** | -0.30*** |
| | | | | | | (0.006) | | | | | (0.018) | (0.006) | (0.018) | (0.006) |
| Age at first marriage | | | | | | | -0.09*** | | | | -0.09*** | | -0.10*** | |
| | | | | | | | (0.001) | | | | (0.003) | | (0.003) | |
| Foreign born | | | | | | | | 0.46*** | | | 0.41*** | | 0.56*** | |
| | | | | | | | | (0.022) | | | (0.042) | | (0.041) | |
| Foreign parent | | | | | | | | | -0.17*** | | 0.01 | | 0.07*** | |
| | | | | | | | | | (0.014) | | (0.025) | | (0.025) | |
| Education | | | | | | | | | | -0.15*** | -0.10*** | | | -0.11*** |
| | | | | | | | | | | (0.001) | (0.004) | | | (0.002) |
| Constant | 6.39*** | 6.94*** | 6.38*** | 6.52*** | 6.56*** | 6.39*** | 6.18*** | 6.61*** | 6.68*** | 4.59*** | 7.65*** | 7.18*** | 7.79*** | 5.13*** |
| | (0.093) | (0.094) | (0.093) | (0.093) | (0.093) | (0.093) | (0.112) | (0.102) | (0.102) | (0.101) | (0.153) | (0.093) | (0.153) | (0.101) |
| Observations | 561,911 | 561,911 | 541,230 | 545,094 | 561,911 | 561,911 | 263,757 | 261,183 | 261,183 | 499,831 | 94,406 | 541,230 | 94,406 | 479,150 |
| R-squared | 0.196 | 0.203 | 0.217 | 0.212 | 0.206 | 0.201 | 0.078 | 0.172 | 0.170 | 0.123 | 0.160 | 0.236 | 0.151 | 0.149 |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Dependent variable: children ever born, women with at least 1 child.

intensive margin of fertility only. In order to do so, we exclude the sample of childless women from our analysis and run Equation (1) on the modified sample. Results are shown in Table 8. The coefficients associated with the vertical dummy diminish, but remain sizeable and significant: -0.27 in Column (1), -0.22 in Column (11). This suggests that, although the observed differential childlessness across family types may contribute to explain the observed differential fertility, its role is most likely to be quantitatively minor.

In view of the importance that is commonly attributed to income as a determinant of fertility, we are now going to zoom in on its possible role here. As briefly hinted at before, we do not have data for income before 1940. Accordingly, we follow Jones and Tertilt (2008) and use the variable Occupational Income Score (OIS) from the Census as a proxy for lifetime income. OIS is a constructed variable assigning each occupation in all years the median total income – in hundreds of dollars – of each occupation in 1950. By assigning the same score to the same occupations in all years, this variable implicitly assumes that workers in the same occupations are equally rich in relative terms across years. We use the husband's income in view of the low participation rate of women in the labour force in the early cohorts, as visible from Table 3, and under the presumption that the man was the household's main breadwinner in the historical period under consideration.

We have already shown that vertical and nuclear families do not differ much as to median income (see Table 3). We have also shown that including a dummy for high-income households, *i.e.* households with an income higher than the median, does not wash away the differential fertility by family type (see Table 7). As an additional exercise, we now want to study whether the cross-family differential fertility can be observed along the entire distribution of income. To this end, we compute the average completed fertility by family type in each income decile, by cohort. In Figures 8, 9 and 10, we show results for the usual selected cohorts (1853, 1913, 1948).[9] Among all types of families, and for each cohort, we find a strong negative relationship between OIS and CEB, with occasional departures at the very bottom of the distribution for early cohorts. In addition, the relation becomes somewhat flatter as we approach the top decile, for the majority of cohorts. This pattern is in accordance with the aggregate analysis by Jones and Tertilt (2008), and suggests that the income fertility-relationship was already negative at the beginning of the sample, implying that the United States had already completed the demographic transition by then.

More interestingly in view of our research focus, we observe in most cohorts a fertility differential across family types per income decile, with the now familiar pattern of horizontal families having more children, followed by nuclear first, and then vertical families.

The joint consideration of our regression results and this descriptive analysis by income decile leads to conclude that income as typically measured in the literature is not the obvious main determinant of the observed cross-family-type differential fertility.

## 2.6 Possible explanations

The analysis worked out so far has no pretension to detect a formal causal link from family structure, and in particular intergenerational coresidence, to fertility. Nonetheless, we claim that our findings suggest a robust statistical association that deserves an explanation. Why was it the case that extended vertical families had less children than nuclear ones? Building on economic intuition and a copious literature, we are now going to explore several possible mechanisms, and to assess them at the light of the data.

[9] The Figures for all the cohorts are available upon request.

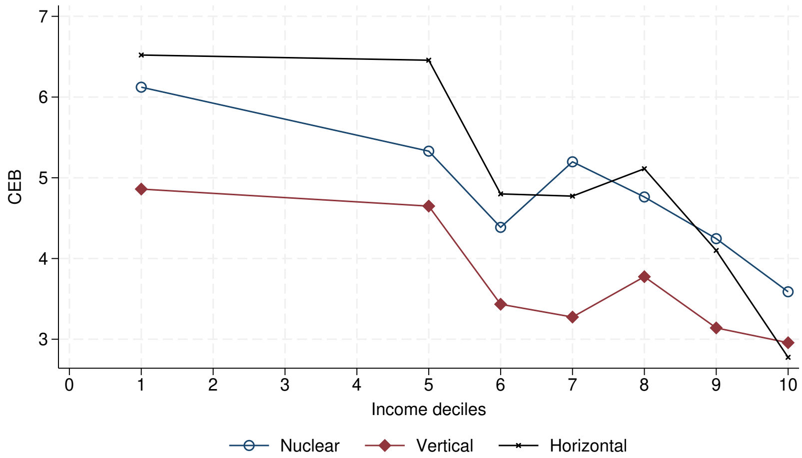



Figure 8: CEB by family type and income decile. Married women belonging to the 1853 cohort.

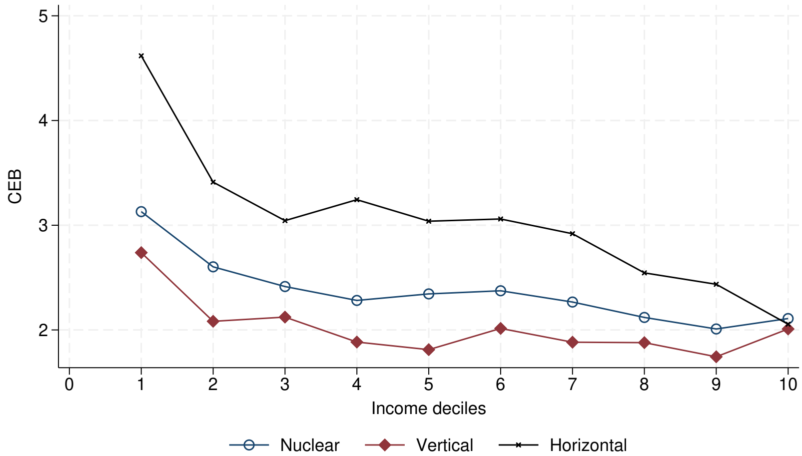



Figure 9: CEB by family type and income decile. Married women belonging to the 1913 cohort.

### 2.6.1 The old maid hypothesis

The first possible explanation is that one kid, most likely a daughter, remained unmarried and took care of the elderly parent. While this is a documented practice in the past, it cannot be an explanation of our findings, since our unit of observation are married women.

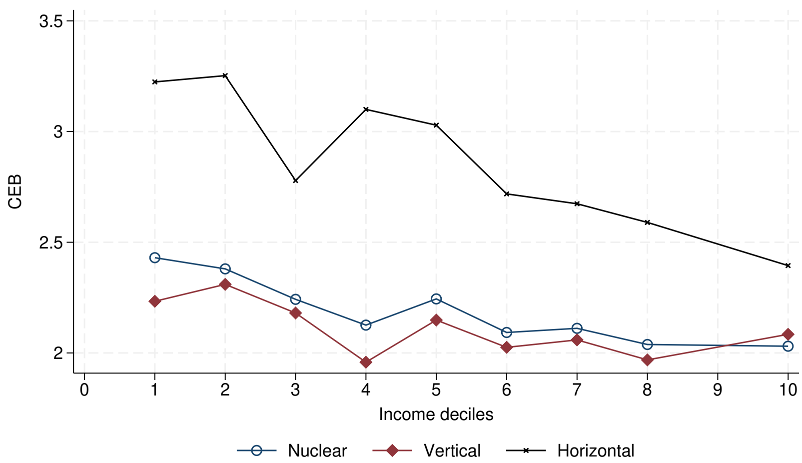



Figure 10: CEB by family type and income decile. Married women belonging to the 1948 cohort.

### 2.6.2 The congestion hypothesis

Alternatively, one may think that vertical families were more affected than nuclear families by congestion problems, with lack of privacy and room at home acting as a limit to fertility. This mechanism is suggested for instance by Hacker and Roberts (2019). However, this does not square well with vertical families being as rich as nuclear families, possibly wealthier in the early cohorts. Furthermore, if congestion ought to be thought as a limit to fertility, one would expect to see such a mechanism at work also in horizontal families, which were, moreover, sensibly poorer on average. But this seems not to be the case, since horizontal families had instead the highest fertility. So, we can conclude that the logic of the congestion hypothesis is at odds with our data.

### 2.6.3 The child labour hypothesis

According to the well-known Caldwell hypothesis (Caldwell (1976, 1978)), in the past children were an asset to parents, not only when the latter were in their old age, but also in their prime, for child work was an important source of family income. Accordingly, one might think that nuclear families had more children to compensate the fact that they had no working elderly. In this explanation, the differential fertility in favour of nuclear families emerges because nuclear families would substitute working children for working elderly. This argument, however, implies that the same differential fertility should be observed between nuclear and horizontal families. The latter too have working adults other than the parents (siblings, cousins). So, one would expect nuclear families to have more children that horizontal families, which is at odds with the data.

### 2.6.4 The grandmother hypothesis

A hotly debated issue in Anthropology and Biology, the "grandmother hypothesis" conjectures that in humans, females survive long after the end of their reproductive life, because this enhances the survival probability of their nephews (see Kim et al. (2014), Watkins (2021) and the references therein). In our context, this might be an explanation of the cross-family-type differential fertility. If, thanks to the presence of grandmothers, the survival probability of children is higher in vertical than in nuclear families, it follows that we should observe less children ever born (and more surviving children) in vertical than in nuclear families. To verify whether this is the case, we have used the (little) information we have in the Census on the surviving number of children. Following Jones and Tertilt (2008), we use the variable Surviving Children Ever Born, reconstructed from information on surviving children asked to married women in the Census years 1900 and 1910. Figure 11 plot the surviving CEB for each available

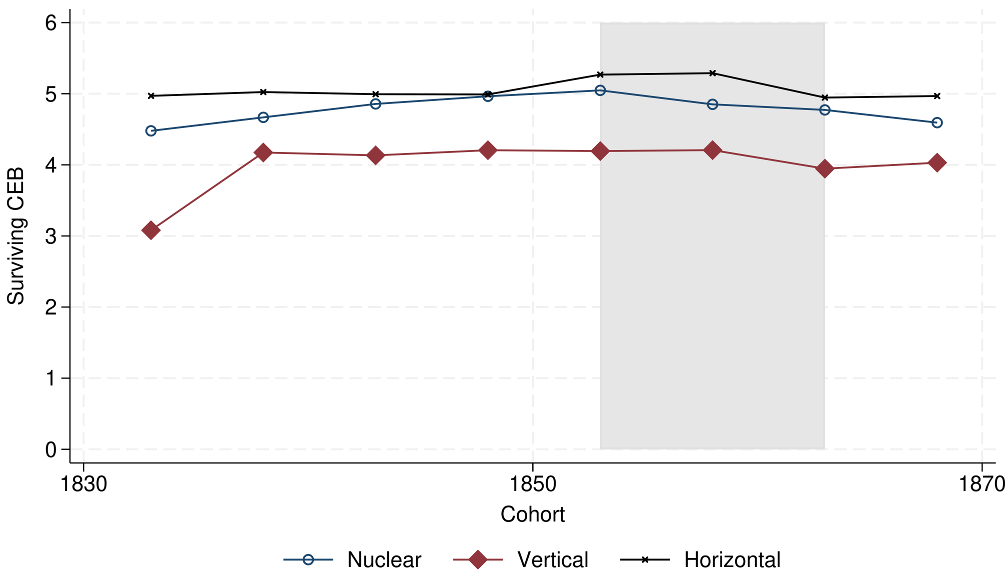



Figure 11: Surviving children ever born by family type. Married women (various age) with employed husbands.

cohort of women, by family type. Although the sample is reduced, we observe that, contrary to what the grandmother hypothesis would suggest, nuclear families had more surviving children that vertical ones.

### 2.6.5 The female emancipation hypothesis

While the effect of fertility on women's participation to the labour force were possibly negligible before WWII (Aaronson et al. (2020)), there is evidence that higher female employment reduces fertility, even in the short run (Coskun and Dalgic (2024)). Furthermore, Borderías and Ferrer-Alòs (2017) find that that in early 20th century Catalonia, stem families increased the labour force participation of women, accelerating the diffusion of the factory production system. Accordingly, one might formulate a 'female emancipation hypothesis' to explain the differential fertility by family type. Under this hypothesis, the presence of grandmothers in vertical families would free women from some domestic chores and provide some child care. This would increase women's participation to the labour market, and hence their employment, which would in turn reduce their completed fertility. Two arguments run against this hypothesis. First, there exists

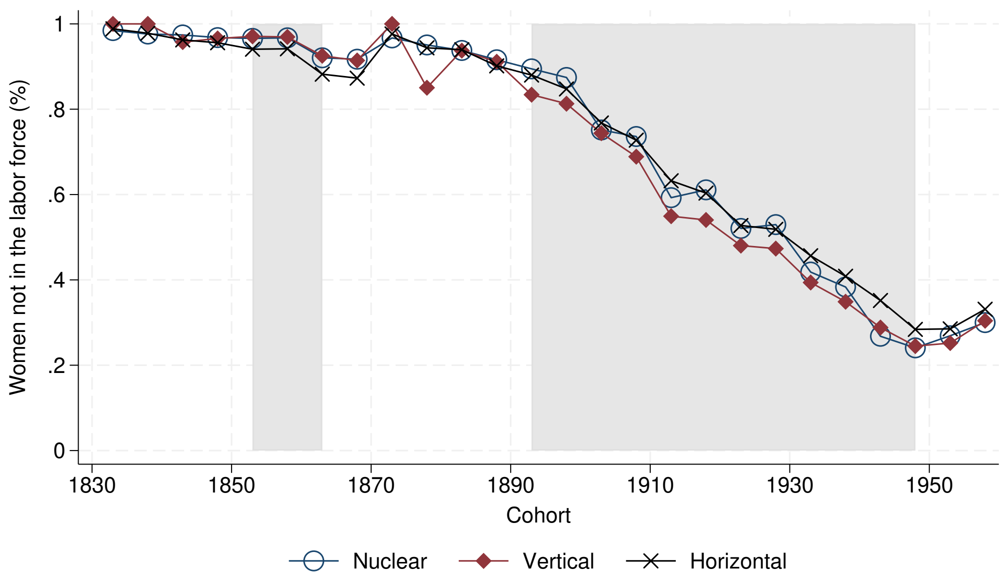



Figure 12: Female labour force non-participation. Married women (various age) with employed husbands.

also another possibility, namely that women in vertical families had to care for the coresiding elderly, thereby reducing their labour supply (see Ettner (1995), for instance). Second, we control for female labour force participation at the individual level in our regressions, and while this reduces fertility, it does not affect the differential fertility by family type. Moreover, as shown in Figure 12, there was little difference in female labour force participation by family type. Finally, and more crucially, even among women who did not participate in the labour market, those living in vertical families had significantly less children than those living in nuclear families, as shown in Figure 13.

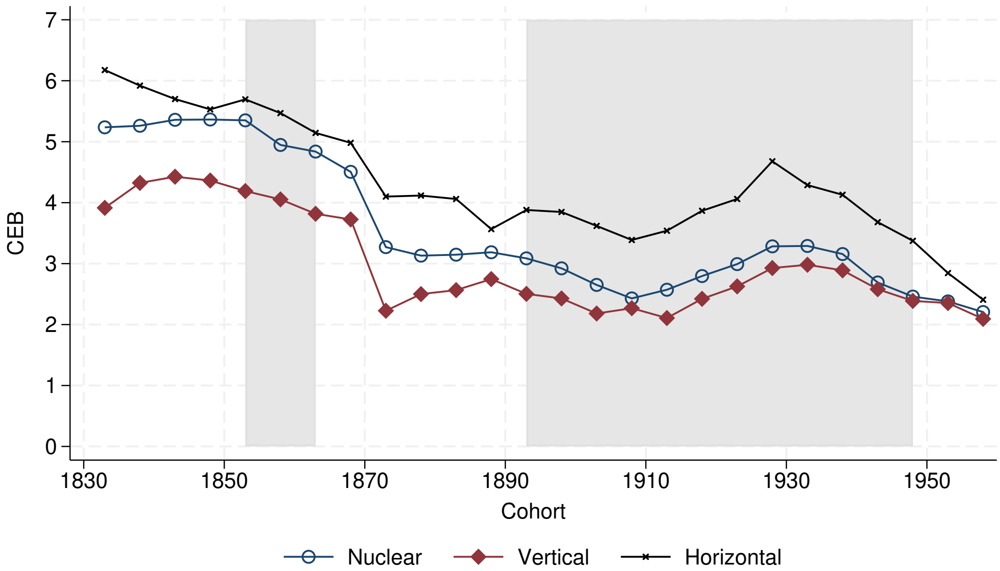



Figure 13: CEB by family type. Married women (various age) who are not in the labour force, with employed husbands.

### 2.6.6 The inverted Caldwell hypothesis

An intriguing possibility that we advance in this paper to explain the cross-family differential fertility is what we call the "inverted Caldwell hypothesis". According to this hypothesis, over the time span that we consider here, changes in medicine and public health, as well as the advent of the welfare state, changed the status of coresiding elderly from being a liability to their adult children, to being an asset. The idea is that for earlier cohorts, women living in extended vertical families had to take care of the old, possibly sick parents/in-laws. This took time and resources away from child rearing. For more recent cohorts, instead, grandparents were in relatively good health and enjoyed pension benefits. Hence, they may add time and resources to child rearing, leaving more time to the parents to work and, possibly, have more children.

In the Appendix, we show that the inverted Caldwell hypothesis can easily rationalise our empirical findings in a model with exogenous coresidence. When we turn to a more general model with endogenous coresidence, however, the inverted Caldwell hypothesis is not necessary to explain the cross-family differential fertility. As we show in the rest of this paper, a more general theory can explain this fact, the relative income hypothesis, which encompasses the Caldwell hypothesis as a specific modification of the relative income of the young.

# 3 Model

In this Section, we propose a novel model in which both the coresidence and the fertility choices are endogenous. The aim is to discipline our thoughts on the various facts we have highlighted in the empirical analysis. In particular there are several facts we wold like the model to rationalise.

1. There exists a cross family differential fertility: nuclear families have systematically more children that extended vertical families (Fact I).

2. The cross-section income-fertility relationship is non-increasing or decreasing in the data (Fact II).

3. This cross family differential fertility shrinks over time (Fact III).

4. The fertility of all types of family decreases over time (Fact IV).

As a further disciplining element, we would like the model to reproduce the time series properties of intergenerational coresidence, *i.e.* its decreasing pattern over time (Fact V).

Our model builds on Kotlikoff and Morris (1990) and Pensieroso and Sommacal (2014), enriched with an endogenous fertility choice featuring a quantity-quality trade off à la Becker and Barro (1988). In this model, income plays a major role, although, as it will be clear momentarily, the theoretically relevant concept of income turns out to be different from the husband's income we have used in our empirical analysis. In this sense, the model also serves the purpose of guiding further empirical analysis.

## 3.1 The logic of the model

Before delving into the technicalities of the model, let us briefly recall its building blocks and main mechanisms.

The coresidence choice is modelled as the efficient outcome of a cooperative game: agents (young-adult children, and old parents) coreside if doing so is Pareto improving with respect to the outside option "living alone". This depends on i) preferences (cultural factors); and ii) the amount of resources enjoyed when alone compared to those enjoyed under coresidence. The latter is influenced by the bargaining power that each member holds within the extended family, which in turn is a function of agents' relative income. Thus, the coresidence choice eventually depends on relative income and preferences.[10] If the young like coresidence, they will be ready to accept a relatively low share of resources within the extended family. On the contrary, if the young do not like coresidence, they will need a high share of resource to be bribed into coresidence by the old. As shown by Pensieroso and Sommacal (2014), *ceteris paribus* the higher the relative income of the young, the higher its bargaining power and the less likely coresidence, provided the young don't like coresidence "too much", so to speak.

The fertility choice depends on income in a non-trivial way. In nuclear families, what matters is parents' income. Since children are supposed to be a normal good, the demand for children is likely to be increasing in parents' income. This is an income effect. On the other hand, raising children takes time off the labour supply of parents. Hence, labour income is also the opportunity cost of children. This induces a substitution effect: raising labour income should decrease the demand for children. The dominance of one effect on the other depends on how parents' preferences are modelled. Under the assumption that parents care not only for the number of children they have, but also for the human capital they can grant them via education, and using standard preferences, the substitution effect dominates when the expenditure on education is positive.[11] In extended vertical families, all this keeps on holding with one additional complication: grandparents' income matters as well, which brings in an additional income effect (under the assumption that grandparents do not devote time to raise their grandchildren).

[10]This approach being quite general, it could be adapted to both the extended horizontal and vertical families. Here, we focus on the latter only, for the fertility differential between nuclear and extended vertical family is the core of our research question.

[11]See de la Croix (2013) for a general treatment of models of endogenous fertility and a literature review.

Bringing the two building blocks together, if the young like coresidence, for a given relative income they will have a lower bargaining power. So, they might extract fewer resources from coresidence than they would have by living alone. Because of an income effect, then, the young living in extended vertical families might end up having fewer children. Hence, the differential fertility between nuclear and extended vertical family turns out to be a by-product of the coresidence choice. If the relative income of the young increases, for given cultural factors, intergenerational coresidence becomes less likely, because the outside option of living alone becomes more and more compelling. At the same time, the fertility differential shrinks, because the bargaining power of the young increases, leading the remaining young under coresidence in a better position to extract resources from the old.

## 3.2 Preferences and constraints

The economy is populated by three overlapping generations of individuals; the young, denoted by a superscript $y$; the old, denoted by a superscript $o$; and the children, who do not make any decisions, but only accumulate human capital as chosen by the young. There are two possible living arrangements, coresidence – the extended vertical family, denoted by a subscript $c$ – or living alone – the nuclear family, denoted by a subscript $a$.

Both types of agents work,[12] may like or dislike coresidence – a stand in for cultural factors – and have preferences defined over private consumption, $c$, and housing services, $x$. The latter are private goods in the nuclear family, but are shared under coresidence.

Preferences are age-dependent. In particular, we assume that the young care also for the number of children they have, $n$, and their future human capital, $h$, while the old do not. Accordingly, for any coresidence status $i = a, c$, the utility function of a young agent at time $t$ reads:

$$U_i^y = (1 - \gamma - \zeta) \ln c_t^y + \zeta \ln x_t^y + \gamma \ln(n_t h_{t+1}) + \delta_i \ln \kappa^y, \tag{2}$$

with $\zeta \in (0, 1)$ and $\gamma \in (0, 1)$ standing for the relative weight in the utility function of the housing services, and the number of children and their human capital, respectively; $\kappa^y$ representing the young's (positive or negative) taste for coresidence; and $\delta_i$ being a dummy variable that depends on the living arrangement, such that $\delta_i = 0$ for $i = a$ and $\delta_i = 1$ for $i = c$.

By the same token, the utility function of an old agent at time $t$ reads:

$$U_i^o = (1 - \zeta) \ln c_t^o + \zeta \ln x_t^o + \delta_i \ln \kappa^o. \tag{3}$$

[12]The model can be extended to a richer setup including retirement and pensions.

For analytical purposes, we set $\kappa^o = 1$.[13] Also, we do not consider heterogeneity along the gender dimension. Accordingly, our agents must be understood as a couple.[14]

Young parents pay a time cost $\phi \in (0,1)$ for raising each child, and a good cost $e$ for educating them. Education builds up the child's human capital according to the following production function:[15]

$$h^y_{t+1} = (1 + e_t)^\beta. \tag{4}$$

The budget constraint of each agent differs along the age and family dimension. Calling $w$ the wage per efficiency unit and $p^x$ the price of housing services, the budget constraints of the young and the old living alone read:

$$w_t(1 - \phi n_t)h^y_t = c^y_t + e_t n_t + p^x_t x^y_t, \tag{5}$$

and

$$w_t h^o_t = c^o_t + p^x_t x^o_t, \tag{6}$$

respectively.

Maximising (2) and (3) subject to (5) and (6), respectively, gives the

[13] In the Appendix, with discuss the case in which $\kappa^o = \kappa^y$, and show that results hold substantially unchanged. More in general this model of endogenous coresidence is compatible with any positive value of $\kappa^j$ (see Pensieroso and Sommacal (2014)).

[14] This assumption might be questionable when it comes to the analysis of the fertility choice by the young, since, especially in the past, mothers would bear most of the brunt of child raising, without participating much in the labour market. See Galor and Weil (1996) for a model explicitly taking this dimension on board. In our model, instead, the young couple works, and the opportunity cost of children hits the couple. This is an acceptable approximation from a historical perspective under the presumption that children implied some time cost also for the bread-winning husbands. By the same token, the model does not allow to discriminate extended families where the old are both alive, from those where only one is; nor who is the widow, the husband or the wife. Finally, the model is silent about the distinction between natural parents and in laws. As a consequence, the model does not speak to the demographic literature suggesting that the gender dimension of old parents and their being natural parents or in-laws may contribute to explain the fertility differential between family types (see Hacker and Roberts (2019)). The mechanism we stress – relative income – is, however, quite general, and may be seen as complementary to that analysis. Furthermore, although we do not want to push this argument too far, the specificities underlined by the demographic literature (gender of the widow, in-laws) may find a suitable, if incomplete representation through the $\kappa^i$ variables in our model.

[15] Equation (4) is an overly simplified version of the typical human capital accumulation in the literature (see for instance de la Croix and Doepke (2003)). We use it here for the sake of analytical clarity, but, as will be clear in Section 5, our argument holds good for more general forms.

optimal choices when living alone:

$$c^{y,*}_{t,a} = (1-\gamma-\zeta)h^y_t w_t; \qquad c^{o,*}_{t,a} = (1-\zeta)h^o_t w_t; \tag{7}$$

$$x^{y,*}_{t,a} = \zeta\frac{h^y_t w_t}{p^x_t}; \qquad x^{o,*}_{t,a} = \zeta\frac{h^o_t w_t}{p^x_t}; \tag{8}$$

$$n^*_{a,t} = \begin{cases} \frac{\gamma}{\phi} & \text{if } w_t h^y_t \leq \frac{1}{\beta\phi} \\ \frac{\gamma(1-\beta)h^y_t w_t}{\phi h^y_t w_t - 1} & \text{if } w_t h^y_t > \frac{1}{\beta\phi} \end{cases}; \qquad e^*_{t,a} = \begin{cases} 0 & \text{if } w_t h^y_t \leq \frac{1}{\beta\phi} \\ \frac{\beta h^y_t w_t \phi - 1}{1-\beta} & \text{if } w_t h^y_t > \frac{1}{\beta\phi} \end{cases}. \tag{9}$$

We impose $\phi > 1/(h^y_t w_t)$ and $\gamma + \zeta < 1$, so that $c^{y,*}_{t,a} > 0$ and $n^*_{t,a} > 0$.

Notice that $e^*_{t,a} \geq 0$ if $w_t h^y_t \geq \frac{1}{\beta\phi}$. Hence, this model admits two education regimes, depending on the wage rate. The first, which we shall label the 'Post-Malthusian' regime, is characterised by low income and zero education. In the second, or 'Modern' regime, education is instead positive and income higher.

We now turn to the optimal solution under coresidence.

We assume that coresidence only happens between one young and one old agent. While this may seem restrictive from a theoretical perspective, the empirical evidence suggests this was actually the case for the United States in the period under consideration (see Ruggles (2007)).

Sticking to a widespread literature on collective models (Chiappori (1992)), we shall assume that agents under coresidence pool resources together and maximise a family-wide utility function that is a weighted average of the utility of the young and the utility of the old. The parameter $\theta$ represents the weight of the young in the maximisation problem, which holds a natural interpretation as the young's bargaining power, as noticed by Pensieroso and Sommacal (2019). The problem of the extended vertical family then reads:

$$\max \theta U^y_c + (1-\theta)U^o_c \tag{10}$$

$$\text{sub}$$

$$w_t\{h^o_t + h^y_t(1-\phi n_t)\} = c^o_t + c^y_t + e_t n_t + p^x_t x_t. \tag{11}$$

In this formulation, the young and the old plays a cooperative game over the allocation of resources within the family. The only restriction this imposes on the outcome of the game is that it should be efficient, that is, no other allocation could represent a Pareto improvement over it (see Browning et al. (2014) for an extended treatment of this class of models). Notice that housing services are a public good under coresidence.

Solving the maximisation problem, optimal choices under coresidence are:

$$c_{t,c}^{y,*} = \theta(1-\gamma-\zeta)w_t(h_t^o + h_t^y); \qquad c_{t,c}^{o,*} = (1-\theta)(1-\zeta)w_t(h_t^o + h_t^y); \tag{12}$$

$$x_{t,c}^{*} = \frac{\zeta w_t(h_t^o + h_t^y)}{p_t^x}; \tag{13}$$

$$n_{c,t}^{*} = \begin{cases} \frac{\gamma\theta(h_t^o+h_t^y)}{h_t^y\phi} & \text{if } w_t h_t^y \leq \frac{1}{\beta\phi} \\ \frac{(1-\beta)\gamma\theta w_t(h_t^o+h_t^y)}{h_t^y w_t\phi - 1} & \text{if } w_t h_t^y > \frac{1}{\beta\phi} \end{cases}; \quad e_{t,c}^{*} = \begin{cases} 0 & \text{if } w_t h_t^y \leq \frac{1}{\beta\phi} \\ \frac{\beta h_t^y w_t \phi - 1}{1-\beta} & \text{if } w_t h_t^y > \frac{1}{\beta\phi} \end{cases}. \tag{14}$$

The first interesting result that emerges comparing Equations (14) and (9) is that $e_{t,c}^{*} = e_{t,a}^{*}$. This implies that the level of income for which there is shift in the education regime is overall independent of the family structure.

## 3.3 The coresidence choice in the Modern regime

In our model, the family structure is endogenous. The young and the old compare the utility they can get under coresidence with what they can get by living alone. Only if the former exceeds the latter, coresidence will be chosen. In terms of the model, this means comparing the indirect utility functions, $V$, under both living arrangements.

$$V_a^y = U_a^y(c_{t,a}^{y,*}, x_{t,a}^{y,*}, n_{t,a}^{*}, e_{t,a}^{*}), \tag{15}$$

$$V_c^y = U_c^y(c_{t,c}^{y,*}, x_{t,c}^{y,*}, n_{t,c}^{*}, e_{t,c}^{*}), \tag{16}$$

$$V_a^o = U_a^o(c_{t,a}^{o,*}, x_{t,a}^{o,*}), \tag{17}$$

$$V_c^o = U_c^o(c_{t,c}^{o,*}, x_{t,c}^{o,*}). \tag{18}$$

This allows us to define the threshold levels of the bargaining power of the young such that coresidence is Pareto improving. In particular, we define $\theta_{min}$ as the value of $\theta$ such that $V_a^y = V_c^y$:

$$\theta_{min} = \left[ \frac{1}{\kappa^y} \left( \frac{\frac{h_t^y}{h_t^o}}{1 + \frac{h_t^y}{h_t^o}} \right) \right]^{\frac{1}{1-\zeta}}. \tag{19}$$

In other words, $\theta_{min}$ is the minimum value of the bargaining power of the young such that the young is indifferent between living alone (nuclear family) or with the old (intergenerational coresidence – extended vertical family). Since $\frac{\partial V_c^y}{\partial \theta} > 0$, then $\forall \theta > \theta_{min}$, the young prefers coresidence. By the same token, we define $\theta_{max}$ as the value of $\theta$ such that: $V_a^o = V_c^o$:

$$\theta_{max} = 1 - \left[\left(\frac{1}{1+\frac{h_t^y}{h_t^o}}\right)\right]^{\frac{1}{1-\zeta}}. \tag{20}$$

In other words, $\theta_{max}$ is the value of the bargaining power of the young such that the old is indifferent between living alone or with the young. Since $\frac{\partial V_c^o}{\partial \theta} < 0$, then $\forall \theta < \theta_{max}$, the old prefers coresidence.

We can can then parametrise the possibility of coresidence to the difference $\Delta_\theta \equiv \theta_{max} - \theta_{min}$:

- if $\Delta_\theta > 0 \; \exists \; \theta$ such that coresidence is attractive for both the young and the old.
- if $\Delta_\theta = 0$, both the young and the old are indifferent between coresidence and living alone.
- if $\Delta_\theta < 0 \; \nexists \; \theta$ such that coresidence is attractive for both the young and the old.

In this article, we assume that, whenever $\Delta_\theta > 0$, coresidence is actually chosen, for agents do not leave the possibility of a Pareto improvement unexploited. Under this assumption, and using Equations (19) and (20), it is possible to characterise the "coresidence frontier", $\Phi_c$, or the geometric locus of the combinations of $\kappa^y$ and $h^y/h^o$ delimiting the region in which coresidence is Pareto efficient.

**Proposition 1** *Given the coresidence frontier*

$$\Phi_c \equiv \frac{\frac{h_t^y}{h_t^o}\left(\frac{1}{1+\frac{h_t^y}{h_t^o}}\right)^{\frac{1}{1-\zeta}}\left(\left(1+\frac{h_t^y}{h_t^o}\right)^{\frac{1}{1-\zeta}}-1\right)^{\zeta}}{1-\left(\frac{1}{1+\frac{h_t^y}{h_t^o}}\right)^{\frac{1}{1-\zeta}}}, \tag{21}$$

*if $\kappa^y > \Phi_c$, then $\Delta_\theta > 0$: coresidence is Pareto efficient.*

*Proof*

Solving $\Delta_\theta = 0$ for $\kappa^y$ gives $\kappa^y = \Phi_c$. The Proposition then follows from the fact that $\Delta_\theta$ is increasing in $\kappa^y$. ■

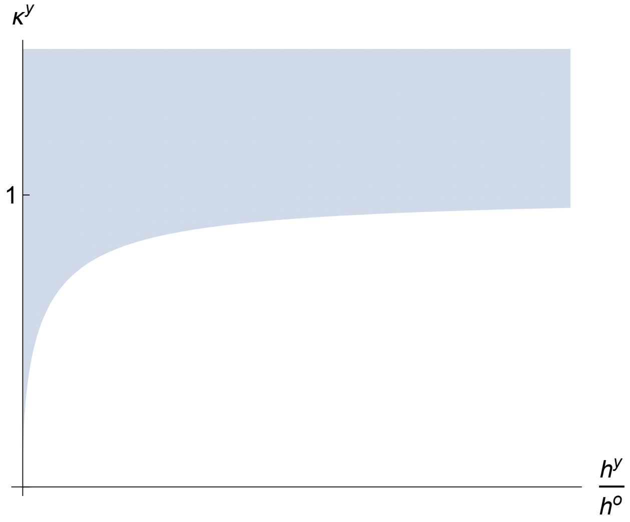



Figure 14: The coresidence frontier. In the shaded area, $\Delta_\theta > 0$: coresidence is optimal.

Proposition 1 lends itself to a graphical representation in the $(\kappa^y, h^y/h^o)$ space, Figure 14, which offers an intuitive representation of the working of the model as to the determinants of coresidence. In this model, coresidence depends on cultural factors and the relative income of the young. For a given $h^y/h^o$, higher values of $\kappa^y$ implies 'more' coresidence. For a given $\kappa^y$, instead, higher values of $h^y/h^o$ implies 'less' coresidence. It is possible to prove that if $\kappa^y < (h^y/h^o)^\zeta$, then $\Delta_\theta$ always decreases with $h^y/h^o$, making coresidence less attractive as the relative income increases. Finally, the figure was drawn for a given $\zeta$. An increase in $\zeta$ within the range of admissible values will push the coresidence frontier downwards: as the public good becomes more relevant in the utility of both agents, *ceteris paribus* the region for which coresidence is Pareto improving becomes larger.

### 3.4 The coresidence choice in the Post-Malthusian regime

So far, we have studied family formation under the assumption that optimal education is at the interior solution. If the young's income is too low, however, optimal education might fall to the zero corner solution, what we have called the Post-Malthusian regime. As shown in Equations (9) and (14), this affects the fertility choice, while leaving the optimal solutions for the other variables unaltered. The question arises, then, whether the education regime also affects the coresidence choice. Quite interestingly, it turns out of computations that this is not the case. In this model, Equations (19) and (20) characterise the region for which coresidence is Pareto efficient both when education is positive and when it is zero, meaning that the coresidence choice is unaffected by the education regime.[16]

## 3.5 Fertility, income and coresidence

While the education regime does not affect the coresidence choice, it does affect the fertility one, and it does so in a way that depends on the family structure, as shown by Equations (9) and (14).

We shall now compare the qualitative predictions of the model with the empirical facts on fertility and family structure highlighted in Section 2.

### Fact I

We start by Fact I: in the data, fertility differs by family type. In particular, intergenerational coresidence (extended vertical families) is systematically associated with lower fertility than nuclear families. Consistent with the empirical evidence, equations (9) and (14) show that in the model fertility differs by family type. In particular, rearranging terms we shall have that, for both education regimes,

$$n_{c,t} = \theta \frac{(h_t^o + h_t^y)}{h_t^y} n_{a,t}. \tag{22}$$

To understand the sign of the differential fertility, then, we need to know the value of $\theta$, or the allocation of resources within the family, and the "relative family income", $(h^y)/(h^y + h^o)$, or the share of the family income represented by the income of the young. Since our theory is silent with respect to the determinants of the actual bargaining power of the young, we shall take an agnostic stance by assuming

$$\theta = \lambda\theta_{min} + (1 - \lambda)\theta_{max}. \tag{23}$$

This simply means that whenever coresidence is Pareto efficient ($\Delta_\theta > 0$), it will be chosen, and the actual $\theta$ will fall within the interval $[\theta_{min}\theta_{max}]$ according to a parameter $\lambda \in [0, 1]$. The higher $\lambda$, the nearer $\theta$ to $\theta_{min}$. So, $\lambda$ gives a sense of the relative bargaining position of the young under

[16]To prove the statement, it suffices to compare the indirect utility functions when living alone or in coresidence, under the post-Malthusian regime. Solving for $\theta_{min}$ and $\theta_{max}$ one retrieves Equations (19) and (20).

coresidence, it is a reduced form for the determinants of their actual bargaining power. Under this assumption, and using Equations (9) and (14), it is possible to characterise the "differential fertility frontier", $\Phi^n$, or the geometric locus of the combinations of $\kappa^y$ and $h^y/h^o$ delimiting the region in which $n_a > n_c$.

**Proposition 2** *Given the differential fertility frontier*

$$\Phi_n \equiv \frac{\frac{h^y}{h^o}\lambda^{1-\zeta}\left((1-\lambda)\left(\frac{1}{1+\frac{h^y}{h^o}}\right)^{\frac{1}{1-\zeta}} + \frac{\frac{h^y}{h^o}}{1+\frac{h^y}{h^o}} - (1-\lambda)\right)^{\zeta}}{(1-\lambda)\left(\frac{1}{1+\frac{h^y}{h^o}}\right)^{\frac{\zeta}{1-\zeta}} + \lambda(1+\frac{h^y}{h^o}) - 1}. \tag{24}$$

*If $\kappa^y > \Phi_n$, then $n_a > n_c$: nuclear families have more children than extended vertical families.*

*Proof*
Consider Equation (22). Since $(\partial n_c/\partial\theta > 0)$, then $n_a > n_c$ if $\theta < (h^y)/(h^y + h^o)$. Using Equation (23) it turns out that $\theta < (h^y)/(h^y + h^o)$ if $\kappa^y > \Phi^n$. ■

Proposition 2 lends itself to a graphical representation in the $(\kappa^y, h^y/h^o)$ space, Figure 15, which offers an intuitive representation of the working of the model as to the determinants of a positive differential fertility between nuclear and extended vertical families.

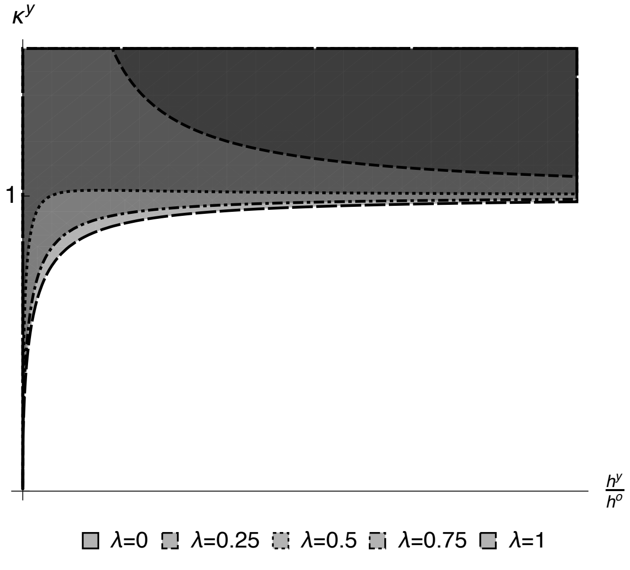



Figure 15: In the shaded area, $\theta < \frac{h^y}{h^y+h^o}$ and $n_a > n_c$.

In this model, $n_a > n_c$ if $\theta < \frac{h^y}{h^y+h^o}$. There is an income effect at work. If the young reap fewer (more) resources from coresidence than they would have reaped by living alone, then they will have fewer (more) children under coresidence. The prevalence and strength of this income effect depends on the relative income of the young, and the parameters $\lambda$, $\kappa^y$ and $\zeta$. Higher $\lambda$ means lower actual bargaining power of the young. Hence, *ceteris paribus* the differential fertility frontier shifts downwards as $\lambda$ increases.[17] For a given relative income, a higher taste for coresidence on the young's part is sufficient for them to accept a lower share of resources than they would have enjoyed in the nuclear family. This reduces their fertility. By the same token, a lower $\kappa^y$ means the young dislike coresiding. *Ceteris paribus*, they will ask for more resources under coresidence, and hence have more children. Finally, a higher weight of housing services in the utility function (higher $\zeta$) makes coresidence more attractive – for these are shared under coresidence – thereby increasing $\Delta_\theta$ for any $\lambda$. Accordingly, the differential fertility frontier will shift downwards.

To visualise the working of the model, in Figure 16 we represent the coresidence and differential fertility frontiers in the same graph, for $\lambda$ and $\zeta$ equal to the values calibrated in Section 5. In the figure, for low levels of relative income, if the young have a high enough taste for coresidence, they will end up in an extended vertical family and have fewer children. As the relative income increases, however, the bargaining position of the young improves, so that, if their taste for coresidence is not too high, they might cross the differential fertility frontier, and have more children that they would have had in the nuclear family. Eventually, for even higher levels of the the relative income, the coresidence frontier is crossed, and the extended vertical family dissolves.

**Fact II**

Let us now consider Fact II: in the cross-section individual data, fertility is non-increasing with income. In the model, the young's income may change because of a change in either the wage per efficiency unit or their

[17] As shown in the graph, for $\lambda$ sufficiently low, the differential fertility frontier is decreasing in the relative income. This is because for a low $\lambda$, $\theta$ tends to $\theta_{max}$, and the latter is much less sensible than $\theta_{min}$ to variations in the relative income. Accordingly, when the relative income increases, $\theta$ changes little, to the extent that the young, although enjoying a relatively strong bargaining position, would still grab more resources, and hence have more children, in the nuclear family. This case can be discarded as unlikely to be empirically relevant. In the quantitative exercise, the calibrated value of $\lambda$ is next to 1, its upper bound.

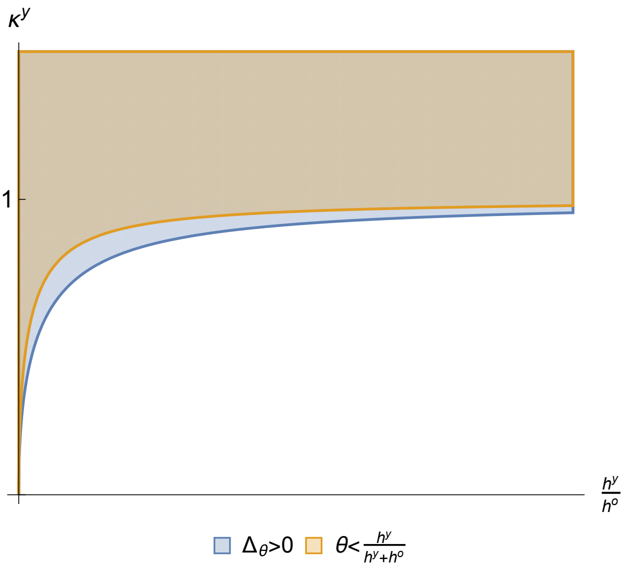



Figure 16: When the two areas overlaps, coresidence is Pareto improving and $n_a > n_c$.

human capital (or both). If income changes because of a change in $w_t$, then

$$\frac{\partial n_a^*}{\partial w_t} = \frac{\partial n_c^*}{\partial w_t} = 0, \quad \text{if } w_t h_t^y \leq \frac{1}{\beta\phi}; \tag{25}$$

$$\frac{\partial n_a^*}{\partial w_t} < 0 \quad \text{and} \quad \frac{\partial n_c^*}{\partial w_t} < 0 \quad \text{if } w_t h_t^y > \frac{1}{\beta\phi}. \tag{26}$$

In this case, the education regime maps one-to-one into a fertility regime, *i.e.* into a specific income-fertility relationship. In the post-Malthusian world, education is zero, fertility is at the maximum biological level, and is not affected by income; whereas in the Modern regime, education is positive, the quantity-quality trade-off kicks in, and fertility decreases with income. Interestingly, changes in $w$ affect nuclear and extended vertical families in the same way, from a qualitative point of view.

If income changes because of a change in $h_t^y$, instead, a difference between nuclear and vertical families emerges. In particular, while nuclear families behave as in the previous case, extended vertical families do not. The following Proposition fully characterises the relationship between the young's human capital and fertility under coresidence in the model.

**Proposition 3** *Given the income-fertility frontier at coresidence,*

$$\Phi_{h^y} = \frac{1}{1+\frac{h_t^o}{h_t^y}} \left( (1-\lambda) \left( \frac{1-\zeta}{\zeta\lambda} - \left( \frac{1}{1+\frac{h_t^o}{h_t^y}} \right)^{\frac{1}{1-\zeta}} \left( \frac{1-\zeta}{\zeta\lambda} + \frac{1}{\zeta\lambda} \frac{h_t^y}{h_t^o} \right) \right) \right)^{\zeta-1}. \tag{27}$$

1. *In the post-Malthusian regime,* i.e. *when* $w_t h_t^y \leq \frac{1}{\beta\phi}$

$$\frac{\partial n_a^*}{\partial h_t^y} = 0; \tag{28}$$

$$\frac{\partial n_c^*}{\partial h_t^y} \gtreqless 0 \ \ \textit{if}\ \kappa^y \lesseqgtr \Phi_{h^y}. \tag{29}$$

2. *In the Modern regime,* i.e. *when* $w_t h_t^y > \frac{1}{\beta\phi}$*:*

$$\frac{\partial n_a^*}{\partial h_t^y} < 0; \tag{30}$$

$$\frac{\partial n_c^*}{\partial h_t^y} < 0. \tag{31}$$

*Proof*
See Appendix. ■

When the human capital of the young increases, fertility in extended vertical families is always decreasing, *for a given bargaining power*. The latter, however, always increase with $h_t^y$. The overall effect depends on the relative strength of these two forces. In the Modern regime, the direct effect always prevails. In the post-Malthusian regime, instead, the direct effect prevails only when the preference for coresidence is sufficiently high. In this case, the bargaining power of the young does not increase too much with their human capital. If, however, the young have a sufficiently low taste for coresidence, then the positive effect of increases in $h^y$ on $\theta$ will be strong enough to counterbalance the direct negative effect.

Hence, the source of income variation does not matter for nuclear families, for which there is always a perfect mapping between the education and fertility regimes. On the contrary, the income-fertility relationship in the extended vertical family is less straightforward.

To understand the rationale for this result, let us focus on the concept of relative income. Changes in $w_t$ do not affect the relative income of the young with respect to the old at time $t$. Hence, the coresidence choice is unaffected, and we recover the standard non-increasing relationship between fertility and income, independent of the family structure. Changes in $h_t^y$, on the contrary, do affect the relative income of the young at time $t$. This in turns influences both the coresidence and the fertility choice, making the income-fertility relationship dependent on the family structure.

These results have interesting implications for the empirical analysis of the demographic transition. They suggest that the family structure should be explicitly considered, for it might influence the income-fertility relationship.

**Fact III, IV, and V**

When it comes to Fact III – in the data, the difference in fertility by family type shrinks over time – the partial equilibrium analysis developed here above needs to be integrated with the production side, and the explicit dynamics underpinning the demographic transition. This will allow the model to speak also to Fact IV – the decreasing fertility pattern over time in the United States – and Fact V – the change of the family structure over time.

To illustrate the compliance of the model with these facts, we shall resort to numerical simulations.

# 4 A numerical exercise

In this Section, we propose a stripped-down, partial equilibrium version of the dynamic model, which has the merit of illustrating how a simple dynamic extension of the analytical model of Section 3 can match Fact III, IV and V in a reasonable way, both qualitatively and quantitatively. This will also allows us to discuss how we tackled the issue of aggregation. In Section 5, we shall then propose a general equilibrium version of the dynamic model that can be calibrated and simulated to match the actual data.

The human capital of the young accumulates according to Equation (4). The old keep the human capital they had when young, but for a depreciation $\alpha$ meant to catch knowledge obsolescence and age-related lost of memory and other brain capacities. Hence,

$$h_{t+1}^y = (1 + e_t)^\beta; \tag{32}$$

$$h_{t+1}^o = (h_t^y)^\alpha. \tag{33}$$

In this stripped-down version of the model, we assume that exogenous technical change is the force driving the dynamics of the economy, with wages per unit of efficiency growing at a constant rate $\mu$:

$$w_t = (1 + \mu)w_{t-1}. \tag{34}$$

In order to simulate the model, we first need to assign numerical value to its structural parameters. We fix $\phi$ as in de la Croix and Doepke (2003). Knowing $\phi$, and assuming that the maximum fertility in the post-Malthusian regime is $n_a = 5$ (see Mariani et al. (2023)), we derive $\gamma$ from Equation (9), when $e = 0$. Assuming that over time the economy converges to a final steady state in the Modern regime, in which all families are nuclear, and population is constant, we retrieve $\beta$ from imposing that the limit of $n_a$ (Equation 9) for $w$ the goes to infinity is equal to one. The parameter $\zeta$ is obtained by computing the share of housing services over private consumption in the nuclear family, and setting it equal to 1.8. This corresponds to the share of public to private consumption for U.S. households in 1929, as computed by Salcedo et al. (2012). The (20-year) growth rate of wages is fixed so as to match the secular growth rate of TFP in Mariani et al. (2023).

The parameters $\kappa^y$, $\lambda$ and $\alpha$ are not disciplined either by the theory or the data. They are completely free, and we have fixed them in a way that facilitates the illustrative purpose of the exercise. The same holds true for the initial value of $w$.

| Parameter | Value | Target |
|---|---|---|
| $\phi$ | 0.075 | de la Croix and Doepke (2003) |
| $\gamma$ | 0.375 | Max (nuclear) fertility in pre-modern regime |
| $\beta$ | 0.8 | Limit (nuclear) fertility in the modern regime |
| $\zeta$ | 0.402 | Share of public to private consumption in the family in 1929 |
| $\mu$ | 0.3 | Secular growth in Europe and the USA |
| $\lambda$ | 0.85 | |
| $\kappa^y$ | 0.9 | |
| $\alpha$ | 0.9 | |

Table 9: Numerical value of the parameters

In Figure 17 we show the dynamic behaviour of a generic household. We assume that the household is in the post-Malthusian regime at the beginning of the period, and we initialise the relative income of the young to one. Under these conditions, coresidence is Pareto improving, and there exists a differential fertility between family arrangements: in the extended vertical family, the young have fewer children than they would have in the nuclear family. As the wage per unit of efficiency increases, education increases as well. Hence, the relative income goes up, and $\Delta_\theta$ decreases, thereby reducing the advantage from coresidence. The increase in income also causes fertility to decline under both living arrangements, while the increase in the relative income of the young makes the differential fertility shrink. So, qualitatively, the model can reproduce Fact III, IV and V for a single, generic household. Can it do so when it comes to the aggregate economy?

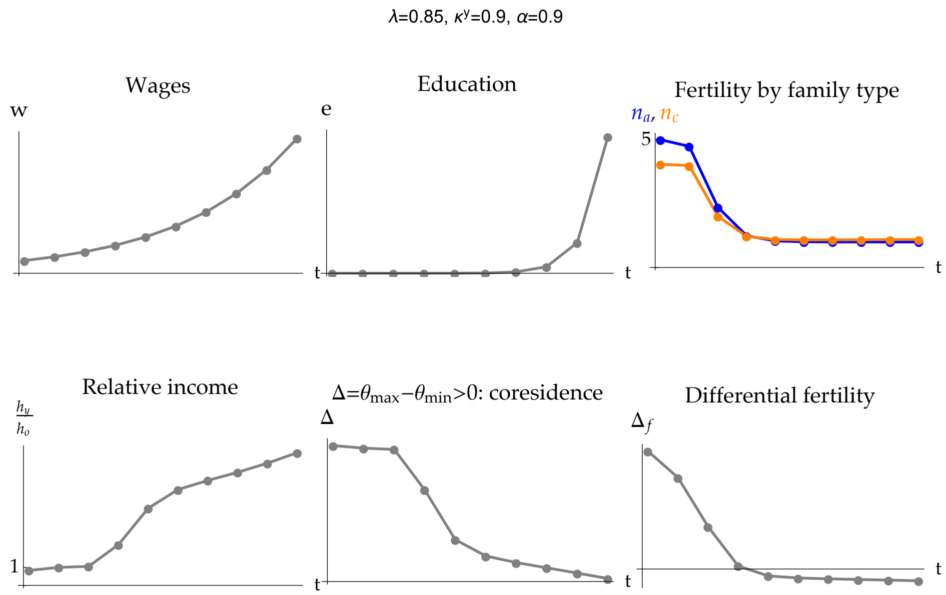



Figure 17: Simulation: a generic household.

To answer this question, we need to overcome the binary nature of the model when it comes to coresidence. At the household level, in fact, coresidence is either optimal, and hence will be chosen, or is not. In order to have heterogeneity at the aggregate level, we follow Pensieroso and Sommacal (2019) and introduce heterogeneity in the young's taste for coresidence. In particular, we assume that siblings share the same cultural trait $\kappa^y$, but these differ from family to family. This is a simplifying assumption that allows us to keep the shape of distribution of $\kappa^y$ constant, even when population increases. More specifically, we assume that $\kappa^y$ follow a truncated normal distribution defined over the interval $(0, \infty)$, with mean (0.79) and standard deviation (0.4) taken from Pensieroso and Sommacal (2019). The other parameters are set as in the previous exercise.

Before getting to the simulations, notice that in this model, aggregation potentially affect both the fertility pattern over time and the cross-family differential fertility for each period. To understand why, suppose $h^y$ (and $h^y/h^o$) increases: the ensuing aggregate fertility will result from adjustments both at the intensive and the"extensive" margin. At the intensive margin, we have already shown that $n_a$ decreases with $h^y$, whereas $n_c$ may decrease or increase, depending on the strength of the positive variations in $\theta$ (see Proposition 3). At the extensive margin, there will be a shift out of coresidence, which has a direct impact on fertility, because the two living arrangements have different implications for fertility. Furthermore, the marginal shifter is the one with the lowest $\kappa^y$, hence the one that had more children under coresidence. In other words, in this model the dynamic effect of a relative income increase on the aggregate fertility by family type is a priori non-obvious. Hence, the additional value added of the aggregate simulations.

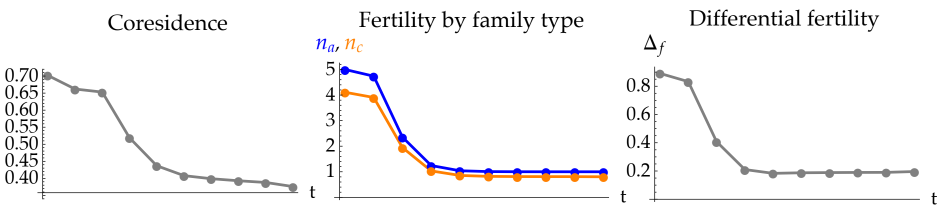



Figure 18: Simulation: the aggregate economy.

Figure 18 shows the results from simulations with the aggregate version of the model. In this version, the coresidence rate is the average relative frequency of the occurrence of coresidence, and the fertility rates are averages by family type. Interestingly, the model reproduces the same pattern of the coresidence rate in Pensieroso and Sommacal (2019), while at the same time witnessing a positive differential fertility in favour of nuclear families, which is moreover shrinking over time.

# 5 A dynamic general equilibrium model with endogenous coresidence and fertility

In the model discussed above, the cost of education is normalised to one and thus constant with respect to the wage rate in efficiency units, which is assumed to increase over time. Accordingly, the demographic transition turns out to be driven by a decrease in the relative price of education with respect to the number of children. There is some discussion in the literature as to whether this is the best way to model the demographic transition. Doepke et al. (2023), for instance, argue that since teachers are the primary input in education – and hence their wage the primary cost – it is not unreasonable to assume that wages and the price of education must have co-moved along the growth pattern, leaving unaffected the relative price of education with respect to the number of children. They suggest an increase in return to education as an alternative mechanism for the demographic transition and the take-off from stagnation to growth. Accordingly, in this Section, we propose a general equilibrium version of the model, in which the demographic transition is triggered by an increase in the return to the parental investment in human capital. Thanks to the general equilibrium environment, we are able to calibrate the model on actual data and to compare the simulated dynamic pattern of the main variables in the model with the historical evolution of their empirical counterpart in the data. Two results stand out. First, qualitatively, our results on differential fertility and family structure are independent of the way in which we model the demographic transition. Second, the model does a fairly good job of reproducing the magnitude of the drop in the intergenerational coresidence rate and in the differential fertility between nuclear and vertical families.

Agents' choices are described by the same model discussed in Section 3, but for the human capital production function and the price of education. The human capital production function is:

$$h^y_{t+1} = (1 + \eta_t e_t)^{\beta} (h^y_t)^{\epsilon}. \tag{35}$$

where $\eta_t > 0$ is a time-varying parameter that will be used to model changes in the return to education; $\epsilon$ is a constant parameter that determines the importance of parents' human capital in the production of children's human capital. When $\epsilon = 1$ ($\epsilon < 1$), the production function (35) has constant (decreasing) returns in parents' human capital. The price of education is denoted by $p_e$. Accordingly, the budget constraint of the young when living alone is given by:

$$w_t h^y_t = c^y_t + \phi w_t h^y_t n_t + p^e_t e_t n_t + p^x_t x^y_t. \tag{36}$$

and the budget constraint of a vertical family reads as:

$$w_t (h^o_t + h^y_t) = c^o_t + c^y_t + \phi w_t h^y_t n_t + p^e_t e_t n_t + p^x_t x_t. \tag{37}$$

We then insert the model of Section 3, with the just presented modifications, into a fully-fledged general equilibrium model. To this aim, we need to specify the source of intragenerational heterogeneity, the population dynamics, and the production side. As in Section 4, the taste for coresidence $\kappa^y$ represents the only source of intragenerational heterogeneity. Accordingly, heterogeneity is represented by the distribution $f_t(\kappa^y)$, which is assumed to be constant over time, i.e. $f_t(\kappa^y) = f(\kappa^y) \quad \forall t$.

As to population, we need to distinguish between young and old agents. We use $N_t^i$ to denote the number of active agents of type $i$ at time t, with $i = y, o$. Since we assume that no mortality occurs between young age and old age, it turns out that:

$$N_t^o = N_{t-1}^y \tag{38}$$

The number of children generated by a young agent $j$ at time $t$ is denoted by $n_t(j)$. Accordingly, average fertility at time $t$ is given by:

$$\bar{n}_t = \frac{\int_{N^y} n_t(j)dj}{N_t^y} \tag{39}$$

and:

$$N_t^y = \bar{n}_{t-1} N_{t-1}^y \tag{40}$$

that is the number of young at $t$ is equal to the number of children born at $t-1$, since child mortality is excluded from the model.

Then, we need to specify how education, the final good, and housing services are produced. We assume perfect competition in all markets as well as perfect labour mobility. The latter assumption implies that the wage is the same regardless of the sector in which labour supply is utilised.

We assume that education is produced using only the labour supply of young agents. The production function is $E_t = \psi L_t^{ye}$, where $E_t$ is the aggregate output of the education sector, $L_t^{ye}$ denotes aggregate hours of work used in this sector and $\psi \geq 1$ is a productivity parameter. This means that 1 hour of work produces $\psi$ units of education or, equivalently, that to produce 1 unit of education, $\frac{1}{\psi}$ hours of work are needed.[18] Perfect competition implies

$$p_t^e = \frac{w_t h_t^y}{\psi} \tag{41}$$

The final good is produced using the following production function:

$$Y_t = A\left[h_t^y N_t^y \left(1 - \phi \bar{n}_t - \frac{L_t^{y,e}}{N_t^y}\right) + h_t^o N_t^o\right]. \tag{42}$$

[18]Note that the production function of education per child is $e_t \equiv E_t/N_{t+1}^y = \psi L_t^{y,e}/N_{t+1}^y$. Accordingly, $\psi$ could also be interpreted as the pupils/staff ratio, since for $e = 1$ we get $\psi = N_{t+1}^y/L_t^{y,e}$.

where $L^{y,e}/N^y$ represents the fraction of hours devoted to the production of education. The price of the final good is chosen as the *numeraire* and, accordingly, perfect competition implies $w_t = A$.

The final good can be used for consumption purposes as well as for the production of housing services $x$, through the linear technology $X = zY^x$, where $Y^x$ are the units of the final good $Y$ used to produce x, and z is a productivity parameter. Thus, perfect competition gives $p_x = 1/z$.

Agents' choices, once we consider the human capital production function (35) and we replace $p_e$ by equation (41), can be written as:

$$e_t = \begin{cases} 0 & \text{if } \beta \le \frac{1}{\eta_t \psi \phi} \\ \frac{\beta\phi - \frac{1}{\eta_t \psi}}{(1-\beta)\frac{1}{\psi}} & \text{otherwise} \end{cases} \tag{43}$$

$$n_{a,t} = \begin{cases} \frac{\gamma}{\phi} & \text{if } \beta \le \frac{1}{\eta_t \psi \phi} \\ \frac{\gamma(1-\beta)}{\phi - \frac{1}{\eta_t \psi}} & \text{otherwise} \end{cases} \tag{44}$$

$$n_{c,t} = n_t^a \theta \frac{1 + \iota_t}{\iota_t} \tag{45}$$

with:

$$\iota_t \equiv \frac{h_t^y}{h_t^o}; \tag{46}$$

$$\theta = \lambda \theta_{min} + (1 - \lambda)\theta_{max}; \tag{47}$$

$$\theta_{min} = \left( \frac{\iota_t}{1 + \iota_t} \frac{1}{\kappa^y} \right)^{\frac{1}{1-\zeta}}; \tag{48}$$

$$\theta_{max} = 1 - \left( \frac{1}{1 + \iota_t} \right)^{\frac{1}{1-\zeta}}. \tag{49}$$

From equations (44) and (45), we can see that, while the fertility of nuclear families is homogeneous within a generation, the fertility of vertical families depends on the taste for coresidence, and thus, it is heterogeneous within each cohort. Average fertility within vertical families is given by:

$$\bar{n}_{c,t} = \int_K n_{c,t} dF(\kappa^y) \quad \text{with} \quad K = \{\kappa^y : \kappa^y > \Phi_c\} \tag{50}$$

where $\Phi_c$ is the coresidence frontier defined in Proposition 1.

When $\eta$ is constant, fertility and education are also constant. As to relative income $\iota_{t+1} \equiv h_{t+1}^y / h_{t+1}^o$, we assume that $h_{t+1}^o = h_t^y$. The dynamics of relative income turns out to depend on the value of the parameter $\epsilon$

in equation Equation (35). When $\epsilon = 1$, the model delivers endogenous growth, and relative income is given by:

$$\iota^y_{t+1} \equiv \frac{h^y_{t+1}}{h^o_{t+1}} = (1 + \eta_t e_t)^\beta . \tag{51}$$

Using Equation (43), Equation (51) can be re-written as:

$$\iota_{t+1} = \begin{cases} 1 & \text{if } \beta \leq \frac{1}{\eta_t \psi \phi} \\ \left(1 + \eta_t \frac{\beta\phi - \frac{1}{\eta_t \psi}}{(1-\beta)\frac{1}{\psi}}\right)^\beta & \text{otherwise} \end{cases} \tag{52}$$

Thus, a constant $\eta$ would also imply a constant relative income, i.e. $\iota_{t+1} = \iota_t = \iota$. The same holds for the stationarised value of the final output, defined as the ratio between $Y$ and the aggregate working hours in efficiency units of the young; indeed:

$$\hat{y}_t = \frac{Y_t}{h^y_t N^y_t} = A\left[1 - \bar{n}_t\left(\phi + \frac{e_t}{\psi}\right) + (1/\bar{n}_{t-1}) * (1/\iota_t)\right]; \tag{53}$$

which is clearly constant when $n$, $e$ and $\iota$ do not change over time. Thus the economy is on a balanced growth path in which the growth rate of output is equal to the growth rate of $h^y_t N^y_t$, i.e. $\iota n - 1$.

When $\epsilon < 1$, the model features exogenous growth. The dynamics of relative income is given by:

$$\iota_{t+1} = \iota^\epsilon_t \frac{(1 + \eta_t e_t)^\beta}{(1 + \eta_{t-1} e_{t-1})^\beta}; \tag{54}$$

When $\eta$ is constant, the model admits a balanced growth path with $\iota_{t+1} = \iota_t = \iota$ with $\iota = 1$. Along this balanced growth path, output grows at a rate equal to $n$-1.

In our computational exercise, we consider an economy that is initially on a balanced growth path characterised by an education level equal to zero. Then we change the parameter $\eta_t$ to affect the education decision and look at the impact on fertility as well as on coresidence. We now discuss how $\eta_t$ and all the other parameters are set. A model period is set equal to 20 years. We simulate the model for 9 cohorts.

We assume that the first cohort is born in the years 1801-1805; the following cohorts refer to the years 1821-1825, 1841-1845, 1861-1865, 1881-1885, 1901-1905, 1921-1925, 1941-1945, 1961-1965. To calibrate the model, we use several types of data: data on fertility, education, and coresidence. As to fertility, we use cohort-level data presented in Section 2; data are available from the cohort born in 1831-1835 to the cohort born in 1956-1960. For education, we rely on data on the average years of schooling in the workforce provided by Turner et al. (2006); these data are available every 20 years for the period 1840 - 2000 (see Table 10, row 1). For coresidence, we use data from Pensieroso and Sommacal (2014), available every 20 years from 1850 to 2010 (see Table 10, row 2). We stress that, as to education

| Cohort | Schooling$_{(year)}$ | Coresidence$_{(year)}$ |
|---|---|---|
| 1803 | $0.97_{(1840)}$ | $69.18_{(1850)}$ |
| 1823 | $2.04_{(1860)}$ | $64.43_{(1870)}$ |
| 1843 | $3.64_{(1880)}$ | $59.76_{(1890)}$ |
| 1863 | $4.94_{(1900)}$ | $59.91_{(1910)}$ |
| 1883 | $6.28_{(1920)}$ | $52.82_{(1930)}$ |
| 1903 | $8.41_{(1940)}$ | $40.31_{(1950)}$ |
| 1923 | $10.20_{(1960)}$ | $23.24_{(1970)}$ |
| 1943 | $12.00_{(1980)}$ | $16.69_{(1990)}$ |
| 1963 | $13.50_{(2000)}$ | $18.21_{(2010)}$ |

Table 10: Average years of schooling, source: Turner et al. (2006). Coresidence rate of old people, source: Pensieroso and Sommacal (2014).

and coresidence, we use aggregate data that mix up several generations. Accordingly, the mapping between fertility data, on the one hand, and education and coresidence data, on the other hand, is not trivial. We attribute coresidence in a year to the cohort born 50 years before: e.g. the coresidence rate in 1850 is assumed to refer to the cohort born in 1801-1805 and their parents. We think of education in a year as reflecting the parental choices of a generation born 40 years before; for instance, the first data on education we have, i.e. data 1840, is attributed to the choices of parents born in 1801-1805. That's why the latter is the first cohort we consider in our simulation. Unfortunately, for such a cohort, we don't have a measure of fertility; we thus assume that fertility for this cohort (and more generally for all the cohorts born before 1831) is equal to the fertility of the first cohort for which data are available, i.e. the cohort 1831-1835. Moreover, since years of schooling in 1840 are not too different from zero (i.e. 0.97), we approximate this value of education with 0 since we want the initial balanced growth path to be a post-Malthusian economy. Accordingly, the parameter $\eta$ in the first period of the simulation is such that $\eta_1 \leq \frac{1}{\beta\psi\phi}$. Then, in the following periods, we want to choose $\eta_t$ so that education $e_t$ matches the years 1860-2000 data. The implied values of $\eta_t$ from simulation period 2 to simulation period 9 are $4.13, 4.72, 5.34, 6.17, 8.20, 11.33, 18.40, 38.32$. We fix $\phi$ following the same procedure used by de la Croix and Doepke (2003). Accordingly, the opportunity cost of a child is set equal to 15% of the parents' time endowment. Such a cost is assumed to be present for the first 15 years of a child's life. Thus $\phi = 0.1125$ (=$0.15 * \frac{15}{20}$). Knowing $\phi$, we then set $\gamma$ to match the fertility of the nuclear family in the first simulation period. Thus $\gamma = 0.311$. We retrieve $\beta$ from imposing that the limit of $n_a$ for $\eta_t$ that goes to infinity is equal to 1. Thus, we choose $\beta = 0.6382$. The parameter $\lambda$ is chosen to match the average fertility of the vertical family in the first simulation period. Accordingly, we set $\lambda = 0.9945$. The parameter $\zeta$ is calibrated to get a share of housing services over private consumption in the nuclear family equal to 1.8. This value corresponds to the share of public to private consumption for U.S. households in 1929, as computed by Salcedo et al. (2012). Accordingly, we set $\zeta = 0.4429$.

We assume that the distribution of the taste for coresidence is log-normal, with mean $\mu$ and standard deviation $\sigma$. The value of $\mu$ is calibrated to match the U.S. coresidence rate in 1850, which was equal to 69.18%. As to the standard deviation $\sigma$ we follow the same approach as Pensieroso and Sommacal (2019). A priori, we would like to have a small value of $\sigma$, for this would imply that we do not need a high degree of unexplained heterogeneity in unobservables in order to account for the data. We run several simulations of the model with different values of $\sigma$ and choose the one that minimises the average quadratic distance between the intergenerational coresidence rate in the model and the data. It turns out that the value of $\sigma$ that gives the best performance of the model in terms of replicating the coresidence pattern is $\sigma = 0.42$. This is a relatively low value compared to the standard normal distribution, suggesting that for our mechanism to work we effectively only need a small degree of unexplained heterogeneity. For this value of $\sigma$, $\mu$ turns out to be equal to 0.82.

As to the production side, $A$ is a scale parameter normalised to 1. The productivity parameter of the education sector, i.e. $\psi$, is set equal to 4, in order to have a ratio between expenditure on education per student and average earnings consistent with the current data - that is, a ratio equal to 24%. [19]

As to $\epsilon$, we first explore the case $\epsilon = 1$. Then we look at the case $\epsilon < 1$.

Table 11 summarises the calibration procedure. Results for the case $\epsilon = 1$ are reported in Figure 19.

The model has the right qualitative behaviour: an increase in the pro-

[19]Data on expenditure on education per student are taken from OECD (2023) and are available at `https://stat.link/nyek0g`. Data on average earnings come from `https://data.oecd.org/earnwage/average-wages.htm`

| Parameter | Value | Target |
|---|---|---|
| $\phi$ | 0.1125 | de la Croix and Doepke (2003) |
| $\gamma$ | 0.311 | Average fertility of nuclear families in pre-modern regime |
| $\beta$ | 0.6382 | Limit fertility of nuclear families in the modern regime |
| $\lambda$ | 0.9945 | Average fertility of vertical families in pre-modern regime |
| $\zeta$ | 0.4429 | Share of public to private consumption in the family in 1929 |
| $\mu$ | 0.82 | Coresidence rate of the old in 1850 |
| $\sigma$ | 0.42 | Coresidence pattern |
| $\psi$ | 4 | Ratio between expenditure on education per student and average earnings in 2020 |
| $\eta_t$ | Several values | Years of education from 1840 to 2000. |

Table 11: Numerical values of the parameters

ductivity of education - captured by $\eta$ - generates a reduction in coresidence and fertility as well as a shrinkage of the gap between the fertility of nuclear and vertical families. In other terms, we get results that are qualitatively similar to those derived in Section 4, where the demographic transition is triggered by an increase in total factor productivity and not by a rise in the productivity of education. Thus, we conclude that results on differential fertility and family structure seem to be independent of the way in which we model the demographic transition.

From a quantitative perspective, the model accounts for 62% of the observed drop in the intergenerational coresidence rate from 1850 to 2010 and for 59% of the observed reduction in the differential fertility from the 1803 cohort to the 1843 cohort.

In the model, the drop in coresidence and the shrinkage of the differential fertility are both related to the increase in the relative income $\iota_t$, which in turn determines the growth rate of output per capita. Therefore, it is important to compare the growth rate generated by the model with the value computed from the data. The values of $\iota_t$ generated by the simulation imply an average growth rate of output per capita on an annual basis equal to 3.8% (excluding the first two periods, in which the economy is stagnant). This value is higher than the actual growth in the data: Kehoe and Prescott (2007) suggest a value of 2% as an average of the annual growth rates of GDP in the 20th century.

The growth rate generated by the model is clearly related to the value of $\epsilon$, which is assumed equal to 1 in Figure 19. Figure 20 shows the results for the exogenous growth version of the model, namely for a value of $\epsilon = 0.7$. For this value of $\epsilon$ the model produces an average annual growth rate of GDP per capita of 2.3%, which is more in line with the data mentioned above. For this parametrisation, the model accounts for 38% of the observed drop in the intergenerational coresidence rate from 1850 to 2010 and for 62% of the observed reduction in the differential fertility from the 1803 cohort to the 1843 cohort. On the one hand the ability of the model to reproduce the pattern of coresidence over time is reduced, though it still remains sizeable. On the other hand, the model produces a slightly better estimate of the drop in the differential fertility between nuclear and vertical families.

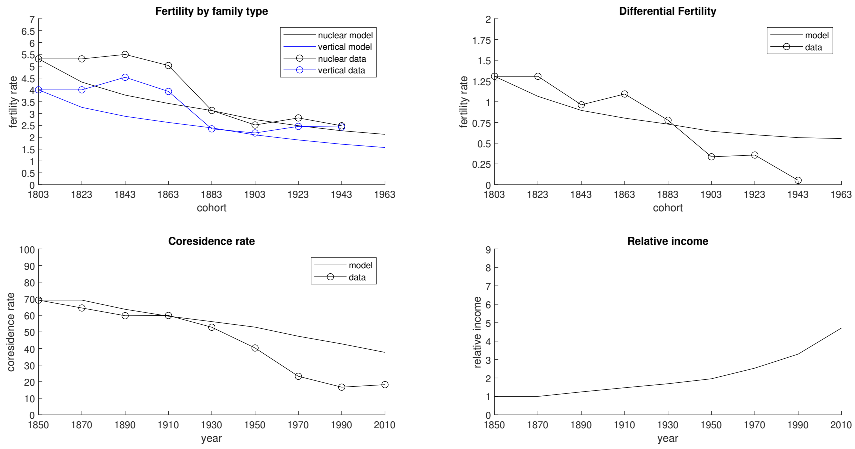



Figure 19: Simulation results. Endogenous growth model: $\epsilon = 1$.

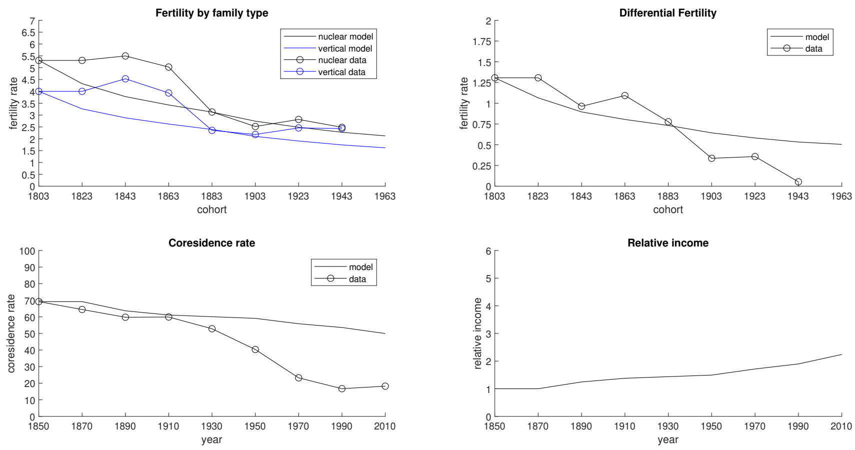



Figure 20: Simulation results. Exogenous growth model: $\epsilon = 0.7$.

# 6 Conclusions

In this paper, we carried out a historical analysis of fertility by family type in the United States between the 19th and 20th century.

Our contribution is twofold. First, we enriched the analysis by Jones and Tertilt (2008) with the family dimension. By doing so, we brought to the fore a hitherto overlooked phenomenon in demographic economics: married women living in extended vertical families tend have less children than those living in nuclear families. This cross-family differential fertility is stronger at the beginning of the observation period and slowly fades away over time.

Second, after dismissing potential alternative mechanisms, we propose a novel theory to rationalise this puzzling new fact. The theory centres on the role of cultural factors and relative income in determining both coresidence and fertility. We show that the emergence of a differential fertility in favour of nuclear families is a possible by-product of the coresidence choice. We present both an analytical model spelling out the theoretical mechanisms in some details, and a full-fledged dynamic general equilibrium model, exploring their quantitative implications. Simulations from a calibrated version of the dynamic general equilibrium model show that, using only variations in economic factors, the model account for *circa* 60% of the drop in the cross-family fertility differential for the cohorts of women born between 1803 and 1943.

Our theoretical analysis offers a guide for further empirical work in family macroeconomics. Instead of focusing on the husband's or the couple's income, as currently done in the literature, the theory developed here above suggests to focus on the family's income and its allocation among family members, when studying contexts in which non-nuclear family arrangements are non-negligible.

This research is limited to the United States, and, while exploiting individual data, has a definite macroeconomic flavour and focus on economic factors. Possible extensions include the explorations of cultural factors, a more in-depth individual level analysis, using for instance the available linked census, and an international comparison on the link between family structure and fertility. These topics are now on our research agenda.

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# A Appendix

## A.1 Descriptive statistics: all cohorts

| | | White | Urban | Owner | Active | Childless | High income |
|---|---|---|---|---|---|---|---|
| | Nuclear | 93.9 | 28.2 | 73.2 | 1.6 | 12.0 | 48.5 |
| 1833 | Vertical | 100.0 | 50.1 | 87.5 | | 12.6 | 87.5 |
| | Horizontal | 88.5 | 27.4 | 73.0 | 1.4 | 6.0 | 41.6 |
| | Nuclear | 93.6 | 31.4 | 72.2 | 2.2 | 10.5 | 50.9 |
| 1838 | Vertical | 97.4 | 25.6 | 74.4 | | 10.3 | 53.8 |
| | Horizontal | 85.0 | 26.5 | 67.7 | 2.3 | 5.8 | 44.8 |
| | Nuclear | 93.7 | 33.4 | 68.0 | 2.6 | 9.4 | 52.3 |
| 1843 | Vertical | 91.1 | 27.4 | 72.6 | 3.7 | 11.8 | 46.7 |
| | Horizontal | 85.2 | 30.7 | 65.8 | 3.9 | 6.6 | 44.5 |
| | Nuclear | 92.2 | 36.8 | 63.3 | 3.1 | 9.1 | 40.1 |
| 1848 | Vertical | 92.3 | 27.5 | 71.8 | 3.5 | 11.5 | 34.5 |
| | Horizontal | 81.9 | 32.9 | 59.6 | 5.1 | 7.6 | 33.5 |
| | Nuclear | 91.6 | 37.6 | 57.7 | 3.4 | 8.4 | 41.7 |
| 1853 | Vertical | 92.7 | 33.1 | 65.4 | 2.9 | 14.8 | 42.2 |
| | Horizontal | 79.1 | 33.1 | 54.3 | 6.2 | 8.4 | 36.1 |
| | Nuclear | 92.3 | 39.4 | 53.2 | 3.2 | 7.9 | 44.5 |
| 1858 | Vertical | 92.2 | 36.2 | 61.4 | 3.4 | 12.0 | 44.8 |
| | Horizontal | 80.9 | 36.5 | 51.4 | 5.8 | 10.6 | 40.3 |
| | Nuclear | 92.8 | 45.6 | 59.0 | 7.9 | 8.3 | 49.0 |
| 1863 | Vertical | 93.2 | 44.4 | 63.7 | 7.6 | 15.3 | 53.7 |
| | Horizontal | 82.5 | 42.9 | 54.5 | 11.9 | 8.4 | 42.9 |
| | Nuclear | 92.4 | 46.3 | 53.6 | 8.2 | 8.8 | 50.4 |
| 1868 | Vertical | 93.5 | 46.1 | 61.4 | 9.1 | 13.3 | 55.3 |
| | Horizontal | 83.5 | 47.9 | 49.3 | 12.8 | 10.8 | 47.3 |
| | Nuclear | 95.0 | 47.0 | 68.9 | 3.0 | 16.9 | 46.9 |
| 1873 | Vertical | 84.7 | 30.5 | 49.2 | | 32.2 | 64.4 |
| | Horizontal | 88.3 | 38.6 | 63.9 | 2.6 | 8.2 | 45.7 |
| | Nuclear | 96.8 | 50.9 | 67.0 | 4.6 | 17.2 | 48.5 |
| 1878 | Vertical | 95.8 | 53.5 | 64.8 | 13.1 | 23.0 | 57.7 |
| | Horizontal | 88.3 | 43.0 | 66.5 | 4.8 | 9.4 | 44.0 |
| | Nuclear | 96.3 | 51.8 | 64.1 | 5.9 | 17.2 | 51.2 |
| 1883 | Vertical | 95.4 | 58.5 | 58.5 | 6.5 | 25.5 | 59.9 |
| | Horizontal | 85.2 | 48.3 | 62.9 | 5.8 | 9.7 | 41.2 |
| | Nuclear | 95.4 | 55.1 | 58.6 | 8.2 | 15.1 | 42.2 |
| 1888 | Vertical | 95.7 | 49.7 | 64.8 | 8.8 | 22.1 | 47.9 |
| | Horizontal | 86.8 | 51.6 | 58.3 | 9.7 | 11.7 | 43.2 |
| | Nuclear | 94.6 | 56.8 | 54.5 | 10.3 | 14.2 | 45.7 |
| 1893 | Vertical | 93.8 | 59.6 | 67.2 | 17.3 | 18.4 | 50.5 |
| | Horizontal | 86.1 | 50.4 | 52.7 | 11.9 | 12.7 | 39.4 |
| | Nuclear | 94.2 | 57.2 | 48.4 | 12.1 | 14.5 | 48.3 |
| 1898 | Vertical | 94.3 | 63.3 | 58.5 | 18.4 | 19.1 | 56.6 |
| | Horizontal | 81.9 | 52.9 | 47.4 | 15.1 | 12.6 | 40.5 |
| | Nuclear | 94.5 | | | 24.6 | 18.2 | 54.8 |
| 1903 | Vertical | 93.1 | | | 25.3 | 24.8 | 59.2 |
| | Horizontal | 81.1 | | | 23.4 | 13.8 | 42.8 |
| | Nuclear | 94.3 | | | 26.2 | 19.6 | 49.3 |
| 1908 | Vertical | 93.0 | | | 31.2 | 24.1 | 51.9 |
| | Horizontal | 79.4 | | | 27.1 | 15.4 | 37.9 |
| | Nuclear | 94.0 | 70.2 | 75.0 | 40.8 | 17.1 | 51.1 |
| 1913 | Vertical | 92.1 | 74.1 | 83.9 | 45.1 | 21.5 | 53.0 |
| | Horizontal | 76.7 | 64.1 | 70.4 | 36.9 | 14.3 | 39.4 |
| | Nuclear | 93.7 | 70.4 | 74.5 | 38.9 | 12.7 | 52.2 |
| 1918 | Vertical | 92.0 | 73.7 | 83.4 | 45.9 | 16.0 | 51.9 |
| | Horizontal | 74.0 | 63.1 | 65.8 | 39.6 | 11.3 | 37.9 |
| | Nuclear | 93.3 | 73.8 | 81.7 | 48.0 | 9.9 | 54.3 |
| 1923 | Vertical | 92.7 | 76.3 | 87.1 | 52.0 | 12.9 | 54.1 |
| | Horizontal | 76.5 | 70.9 | 76.3 | 47.4 | 7.0 | 41.9 |
| | Nuclear | 92.0 | 72.8 | 81.0 | 47.1 | 7.8 | 51.0 |
| 1928 | Vertical | 90.4 | 76.0 | 86.7 | 52.7 | 11.1 | 50.5 |
| | Horizontal | 72.7 | 68.0 | 70.8 | 48.3 | 5.4 | 35.9 |
| | Nuclear | 92.0 | 70.8 | 88.5 | 58.1 | 6.9 | 53.3 |
| 1933 | Vertical | 88.3 | 76.5 | 90.8 | 60.6 | 9.9 | 53.2 |
| | Horizontal | 72.5 | 69.7 | 82.6 | 54.2 | 4.2 | 39.4 |
| | Nuclear | 90.6 | 69.1 | 86.8 | 61.7 | 6.4 | 54.5 |
| 1938 | Vertical | 86.3 | 75.6 | 89.8 | 65.3 | 8.5 | 51.3 |
| | Horizontal | 70.7 | 67.7 | 79.8 | 59.2 | 4.2 | 42.0 |
| | Nuclear | 89.2 | 69.0 | 88.1 | 73.3 | 8.3 | 51.9 |
| 1943 | Vertical | 80.4 | 77.5 | 91.5 | 71.4 | 10.4 | 49.9 |
| | Horizontal | 67.5 | 73.7 | 80.2 | 64.8 | 4.6 | 37.9 |
| | Nuclear | 87.8 | 69.5 | 86.0 | 76.0 | 10.4 | 57.9 |
| 1948 | Vertical | 74.9 | 77.7 | 87.3 | 75.6 | 12.7 | 51.3 |
| | Horizontal | 65.2 | 73.5 | 75.3 | 71.5 | 5.0 | 43.2 |
| | Nuclear | 87.1 | 70.4 | 80.9 | 73.1 | 12.3 | 55.8 |
| 1953 | Vertical | 68.3 | 80.9 | 84.2 | 74.9 | 13.0 | 47.1 |
| | Horizontal | 58.5 | 79.3 | 68.5 | 71.3 | 8.6 | 41.0 |
| | Nuclear | 86.3 | 72.0 | 73.0 | 70.0 | 16.6 | 55.5 |
| 1958 | Vertical | 68.0 | 81.4 | 78.7 | 69.8 | 17.0 | 47.0 |
| | Horizontal | 59.6 | 83.4 | 59.5 | 66.7 | 14.2 | 40.8 |

Table 12: Descriptive statistics (all cohorts), variables: White, Urban, Owner, Active, Childless, High income.

| | | Origin | | |
|---|---|---|---|---|
| | | Native | 2nd gen | Foreign |
| 1833 | Nuclear | 59.9 | 5.6 | 34.5 |
| | Vertical | 62.3 | | 37.7 |
| | Horizontal | 70.5 | 4.7 | 24.9 |
| 1838 | Nuclear | 60.4 | 6.4 | 33.1 |
| | Vertical | 71.8 | 10.2 | 18.0 |
| | Horizontal | 72.0 | 5.8 | 22.2 |
| 1843 | Nuclear | 62.6 | 7.2 | 30.2 |
| | Vertical | 74.8 | 11.8 | 13.3 |
| | Horizontal | 73.5 | 6.9 | 19.6 |
| 1848 | Nuclear | 60.7 | 9.4 | 30.0 |
| | Vertical | 69.0 | 10.5 | 20.6 |
| | Horizontal | 74.8 | 7.6 | 17.6 |
| 1853 | Nuclear | 60.4 | 13.9 | 25.7 |
| | Vertical | 70.5 | 13.5 | 16.0 |
| | Horizontal | 71.4 | 12.3 | 16.4 |
| 1858 | Nuclear | 58.2 | 18.4 | 23.3 |
| | Vertical | 65.7 | 21.4 | 12.9 |
| | Horizontal | 69.1 | 15.6 | 15.3 |
| 1863 | Nuclear | 54.7 | 19.1 | 26.2 |
| | Vertical | 66.8 | 20.1 | 13.1 |
| | Horizontal | 64.8 | 15.5 | 19.7 |
| 1868 | Nuclear | 55.9 | 19.4 | 24.7 |
| | Vertical | 64.1 | 20.2 | 15.7 |
| | Horizontal | 58.8 | 19.0 | 22.2 |
| 1873 | Nuclear | 60.2 | 18.3 | 21.5 |
| | Vertical | 83.0 | 7.5 | 9.4 |
| | Horizontal | 64.8 | 18.9 | 16.3 |
| 1878 | Nuclear | 57.4 | 17.2 | 25.3 |
| | Vertical | 73.1 | 17.9 | 9.0 |
| | Horizontal | 66.7 | 17.3 | 16.0 |
| 1883 | Nuclear | 58.7 | 18.2 | 23.1 |
| | Vertical | 77.7 | 11.6 | 10.7 |
| | Horizontal | 70.9 | 10.4 | 18.7 |
| 1888 | Nuclear | 58.3 | 17.3 | 24.4 |
| | Vertical | 69.6 | 22.1 | 8.3 |
| | Horizontal | 64.3 | 16.1 | 19.7 |
| 1893 | Nuclear | 60.3 | 19.1 | 20.5 |
| | Vertical | 73.1 | 18.0 | 9.0 |
| | Horizontal | 67.2 | 13.3 | 19.5 |
| 1898 | Nuclear | 63.9 | 18.9 | 17.2 |
| | Vertical | 70.4 | 19.6 | 10.1 |
| | Horizontal | 71.7 | 15.1 | 13.2 |
| 1903 | Nuclear | 66.2 | 19.6 | 14.2 |
| | Vertical | 69.6 | 22.5 | 7.9 |
| | Horizontal | 71.3 | 17.4 | 11.3 |
| 1908 | Nuclear | 69.3 | 21.6 | 9.1 |
| | Vertical | 70.3 | 21.9 | 7.8 |
| | Horizontal | 76.1 | 15.1 | 8.8 |
| 1913 | Nuclear | 68.3 | 25.1 | 6.6 |
| | Vertical | 67.5 | 27.2 | 5.3 |
| | Horizontal | 76.7 | 17.2 | 6.2 |
| 1918 | Nuclear | 71.4 | 24.0 | 4.6 |
| | Vertical | 67.8 | 28.8 | 3.4 |
| | Horizontal | 79.2 | 17.0 | 3.7 |
| 1923 | Nuclear | 73.1 | 20.6 | 6.3 |
| | Vertical | 69.1 | 23.9 | 6.9 |
| | Horizontal | 79.1 | 14.3 | 6.6 |
| 1928 | Nuclear | 75.8 | 17.3 | 6.9 |
| | Vertical | 70.0 | 22.1 | 7.8 |
| | Horizontal | 81.8 | 11.7 | 6.5 |

Table 13: Descriptive statistics (all cohorts), variable: Origin.

| | | Education | | | |
|---|---|---|---|---|---|
| | | up to grade 4 | grade 5-8 | grade 9-12 | some college |
| | Nuclear | 16.1 | 58.7 | 19.2 | 6.0 |
| 1873 | Vertical | 5.1 | 84.7 | 10.2 | |
| | Horizontal | 20.5 | 57.4 | 16.5 | 5.7 |
| | Nuclear | 15.7 | 56.9 | 21.4 | 5.9 |
| 1878 | Vertical | 15.5 | 53.1 | 24.9 | 6.6 |
| | Horizontal | 20.0 | 60.1 | 17.0 | 2.9 |
| | Nuclear | 13.2 | 57.1 | 24.1 | 5.6 |
| 1883 | Vertical | 8.6 | 43.8 | 35.7 | 11.9 |
| | Horizontal | 22.7 | 55.6 | 18.0 | 3.7 |
| | Nuclear | 15.5 | 54.1 | 23.9 | 6.5 |
| 1888 | Vertical | 9.1 | 52.9 | 29.0 | 8.9 |
| | Horizontal | 21.5 | 55.3 | 18.4 | 4.8 |
| | Nuclear | 12.8 | 51.6 | 28.0 | 7.7 |
| 1893 | Vertical | 6.8 | 46.3 | 37.0 | 10.0 |
| | Horizontal | 19.4 | 53.7 | 22.5 | 4.3 |
| | Nuclear | 10.5 | 49.6 | 31.2 | 8.7 |
| 1898 | Vertical | 3.7 | 45.3 | 40.6 | 10.4 |
| | Horizontal | 18.8 | 58.1 | 18.9 | 4.3 |
| | Nuclear | 7.7 | 40.4 | 37.9 | 14.0 |
| 1903 | Vertical | 4.7 | 40.5 | 40.6 | 14.2 |
| | Horizontal | 15.5 | 50.9 | 27.2 | 6.3 |
| | Nuclear | 5.2 | 34.7 | 44.8 | 15.3 |
| 1908 | Vertical | 5.1 | 28.9 | 48.5 | 17.5 |
| | Horizontal | 11.2 | 48.0 | 34.6 | 6.3 |
| | Nuclear | 3.4 | 30.0 | 51.3 | 15.4 |
| 1913 | Vertical | 3.3 | 26.1 | 54.8 | 15.8 |
| | Horizontal | 9.8 | 42.8 | 40.4 | 7.0 |
| | Nuclear | 2.7 | 22.3 | 59.2 | 15.9 |
| 1918 | Vertical | 2.6 | 21.0 | 61.9 | 14.5 |
| | Horizontal | 8.1 | 37.9 | 47.5 | 6.6 |
| | Nuclear | 1.9 | 15.0 | 63.8 | 19.3 |
| 1923 | Vertical | 2.1 | 13.4 | 66.4 | 18.1 |
| | Horizontal | 5.4 | 27.1 | 58.1 | 9.3 |
| | Nuclear | 1.8 | 12.4 | 65.5 | 20.4 |
| 1928 | Vertical | 1.8 | 12.8 | 68.5 | 16.9 |
| | Horizontal | 5.5 | 23.9 | 62.1 | 8.5 |
| | Nuclear | 1.6 | 8.5 | 63.7 | 26.2 |
| 1933 | Vertical | 2.2 | 9.2 | 64.4 | 24.3 |
| | Horizontal | 5.2 | 16.5 | 64.3 | 14.1 |
| | Nuclear | 1.2 | 6.2 | 62.7 | 29.9 |
| 1938 | Vertical | 2.0 | 8.2 | 63.7 | 26.1 |
| | Horizontal | 3.7 | 15.7 | 66.7 | 14.0 |
| | Nuclear | 1.0 | 3.0 | 47.9 | 48.1 |
| 1943 | Vertical | 1.6 | 4.6 | 50.9 | 42.9 |
| | Horizontal | 4.4 | 9.3 | 58.8 | 27.6 |
| | Nuclear | 0.8 | 2.3 | 40.6 | 56.3 |
| 1948 | Vertical | 2.1 | 4.0 | 47.4 | 46.5 |
| | Horizontal | 4.3 | 7.3 | 54.1 | 34.4 |
| | Nuclear | 0.7 | 1.9 | 38.3 | 59.1 |
| 1953 | Vertical | 1.6 | 5.2 | 40.6 | 52.6 |
| | Horizontal | 4.4 | 8.1 | 50.4 | 37.1 |
| | Nuclear | 0.7 | 1.8 | 40.0 | 57.5 |
| 1958 | Vertical | 2.6 | 4.3 | 46.8 | 46.3 |
| | Horizontal | 6.5 | 9.2 | 44.0 | 40.3 |

Table 14: Descriptive statistics (all cohorts), variable: Education.

| | | Mean |
|---|---|---|
| | Nuclear | 24.0 |
| 1873 | Vertical | 24.2 |
| | Horizontal | 22.7 |
| | Nuclear | 23.1 |
| 1878 | Vertical | 23.4 |
| | Horizontal | 21.7 |
| | Nuclear | 23.1 |
| 1883 | Vertical | 23.2 |
| | Horizontal | 21.6 |
| | Nuclear | 22.4 |
| 1888 | Vertical | 23.1 |
| | Horizontal | 21.6 |
| | Nuclear | 22.1 |
| 1893 | Vertical | 23.2 |
| | Horizontal | 21.1 |
| | Nuclear | 21.6 |
| 1898 | Vertical | 22.4 |
| | Horizontal | 20.5 |
| | Nuclear | 22.7 |
| 1913 | Vertical | 23.6 |
| | Horizontal | 21.4 |
| | Nuclear | 22.1 |
| 1918 | Vertical | 22.8 |
| | Horizontal | 20.7 |
| | Nuclear | 21.9 |
| 1923 | Vertical | 22.3 |
| | Horizontal | 20.8 |
| | Nuclear | 21.1 |
| 1928 | Vertical | 21.8 |
| | Horizontal | 19.8 |
| | Nuclear | 21.1 |
| 1933 | Vertical | 21.9 |
| | Horizontal | 20.3 |
| | Nuclear | 20.9 |
| 1938 | Vertical | 21.8 |
| | Horizontal | 19.9 |

Table 15: Descriptive statistics (all cohorts), variable: Age at marriage.

## A.2 Stability of the family structure

| | | Nuclear | Vertical | Horizontal |
|---|---|---|---|---|
| 1863 | 35-39 | 83.31 | 8.32 | 8.37 |
| | 45-49 | 81.67 | 5.88 | 12.45 |
| 1868 | 30-34 | 82.85 | 9.06 | 8.09 |
| | 40-44 | 82.04 | 7.51 | 10.45 |
| | 25-29 | 80.49 | 10.40 | 9.11 |
| 1873 | 35-39 | 82.89 | 8.42 | 8.70 |
| | 45-49 | 79.87 | 6.67 | 13.46 |
| | 20-24 | 78.45 | 12.63 | 8.92 |
| 1878 | 30-34 | 82.53 | 9.39 | 8.08 |
| | 40-44 | 81.82 | 7.75 | 10.43 |
| | 25-29 | 80.16 | 10.73 | 9.12 |
| 1883 | 35-39 | 83.02 | 8.74 | 8.24 |
| | 45-49 | 80.40 | 6.46 | 13.14 |
| | 20-24 | 78.35 | 12.38 | 9.27 |
| 1888 | 30-34 | 82.47 | 9.77 | 7.76 |
| | 40-44 | 82.32 | 7.86 | 9.82 |
| | 25-29 | 80.57 | 11.19 | 8.24 |
| 1893 | 35-39 | 82.79 | 9.24 | 7.97 |
| | 45-49 | 80.51 | 7.44 | 12.05 |
| | 20-24 | 77.23 | 14.77 | 8.00 |
| 1898 | 30-34 | 81.92 | 10.46 | 7.62 |
| | 40-44 | 82.92 | 8.77 | 8.30 |
| | 25-29 | 80.23 | 11.43 | 8.34 |
| 1903 | 35-39 | 83.76 | 9.28 | 6.97 |
| | 45-49 | 80.82 | 8.02 | 11.16 |
| | 20-24 | 76.76 | 15.44 | 7.80 |
| 1908 | 30-34 | 82.77 | 11.29 | 5.94 |
| | 40-44 | 82.62 | 9.44 | 7.94 |
| | 25-29 | 81.46 | 11.96 | 6.58 |
| 1913 | 35-39 | 84.69 | 9.80 | 5.51 |
| | 45-49 | 85.38 | 6.84 | 7.78 |
| | 20-24 | 77.65 | 16.71 | 5.64 |
| 1918 | 30-34 | 85.27 | 10.08 | 4.65 |
| | 40-44 | 86.74 | 7.13 | 6.14 |
| | 25-29 | 84.29 | 11.17 | 4.54 |
| 1923 | 35-39 | 89.21 | 6.35 | 4.44 |
| | 45-49 | 89.13 | 5.16 | 5.71 |
| | 20-24 | 80.52 | 14.57 | 4.91 |
| 1928 | 30-34 | 90.54 | 5.88 | 3.58 |
| | 40-44 | 90.58 | 4.70 | 4.72 |
| | 25-29 | 91.00 | 5.17 | 3.83 |
| 1933 | 35-39 | 92.40 | 4.05 | 3.55 |
| | 45-49 | 90.41 | 3.87 | 5.73 |
| | 20-24 | 89.63 | 6.34 | 4.02 |
| 1938 | 30-34 | 93.88 | 3.39 | 2.72 |
| | 40-44 | 91.57 | 3.37 | 5.06 |
| | 25-29 | 94.45 | 2.88 | 2.67 |
| 1943 | 35-39 | 93.39 | 3.14 | 3.47 |
| | 45-49 | 90.48 | 2.86 | 6.66 |
| | 20-24 | 93.04 | 4.23 | 2.73 |
| 1948 | 30-34 | 94.57 | 2.67 | 2.76 |
| | 40-44 | 92.21 | 2.72 | 5.07 |
| 1953 | 25-29 | 94.35 | 2.42 | 3.23 |
| | 35-39 | 93.71 | 2.74 | 3.55 |

Table 16: Family structure by cohort and age (% of women belonging to a specific family type)

## A.3 CEB by family type for different sub-samples

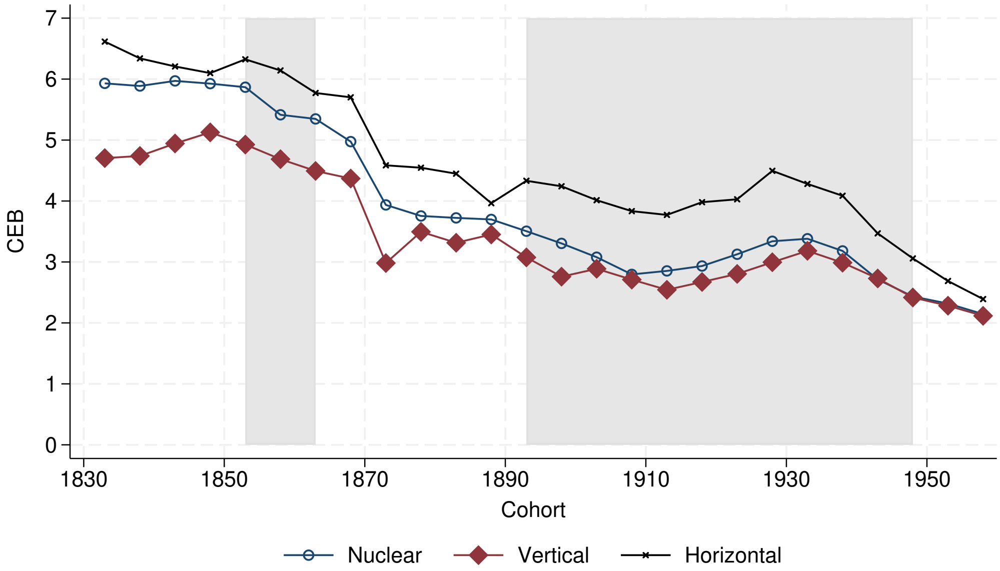


Figure 21: CEB by family type: married women with employed husbands and at least 1 child.

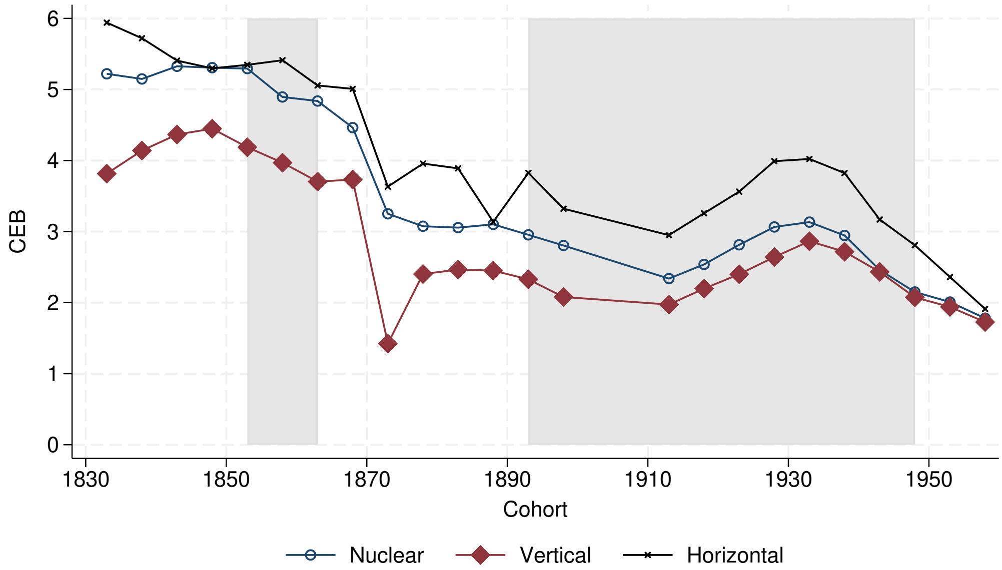


Figure 22: CEB by family type: married women with employed husbands who are dwelling owners.

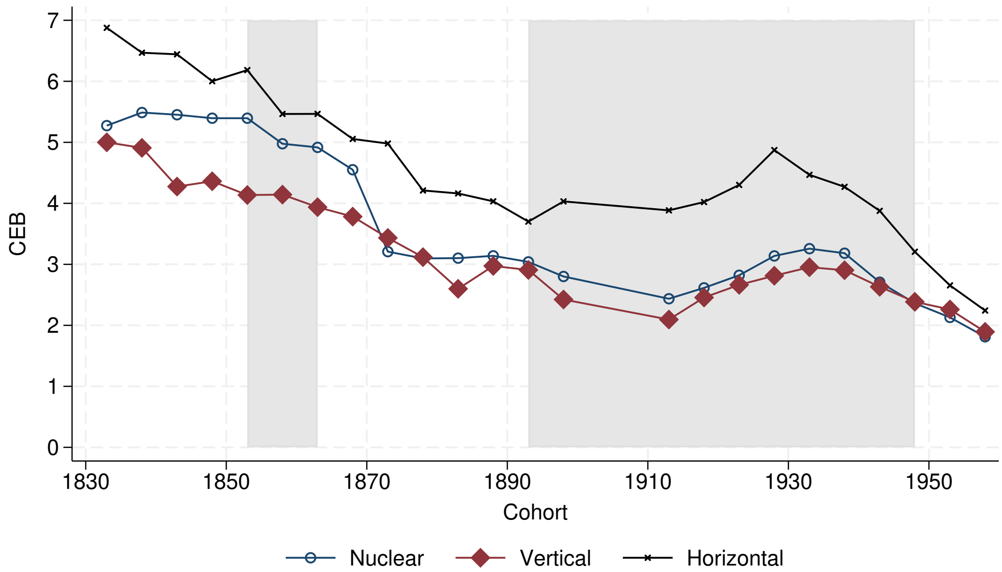


Figure 23: CEB by family type: married women with employed husbands who are renters.

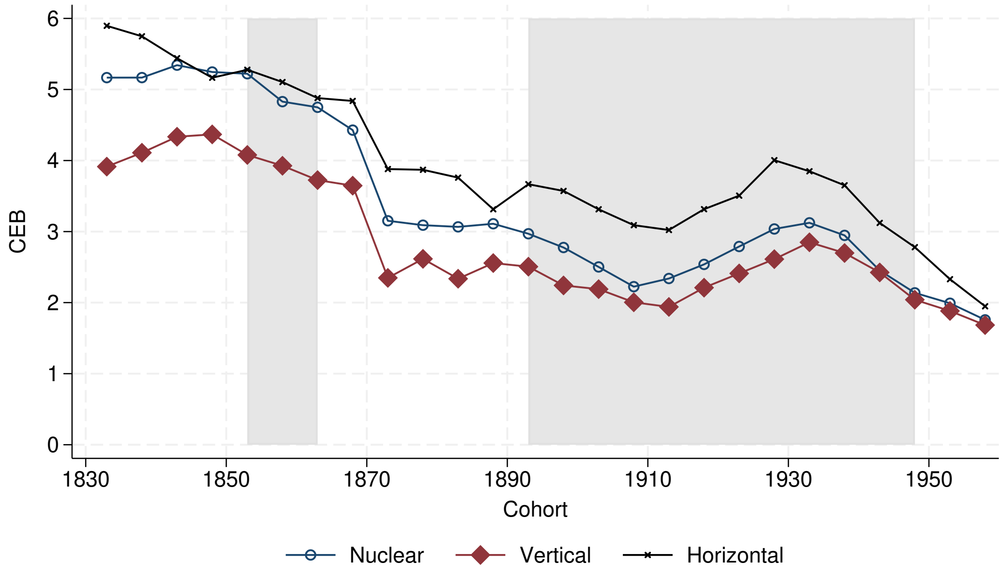


Figure 24: CEB by family type: white married women with employed husbands.

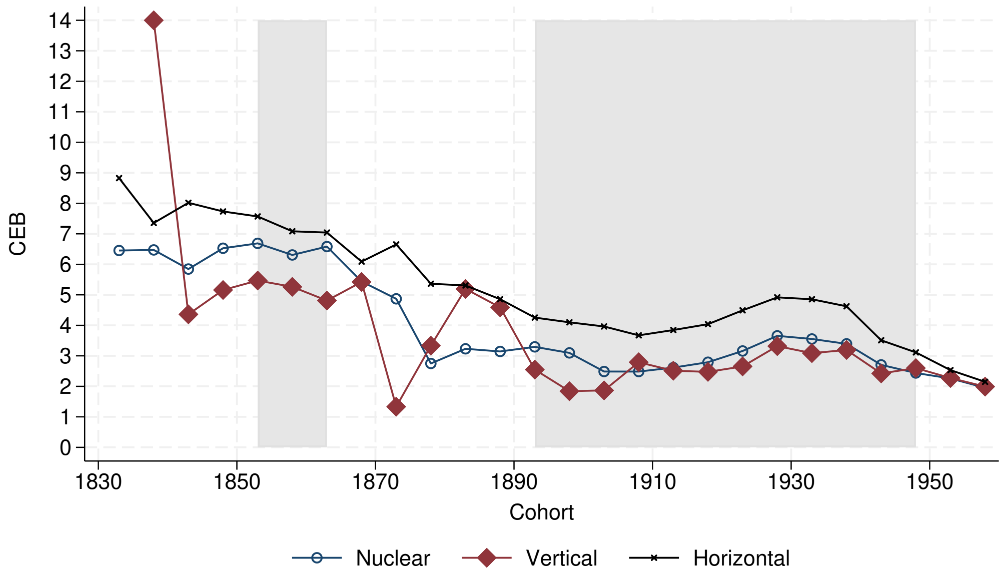


Figure 25: CEB by family type: black married women with employed husbands.

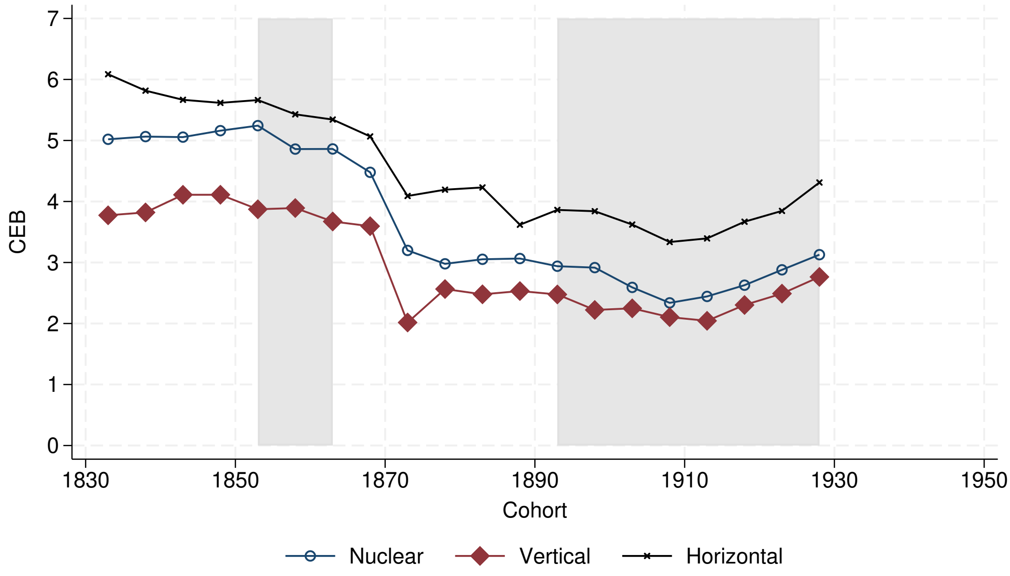


Figure 26: CEB by family type: Native-born married women with both parents native-born and with employed husbands.

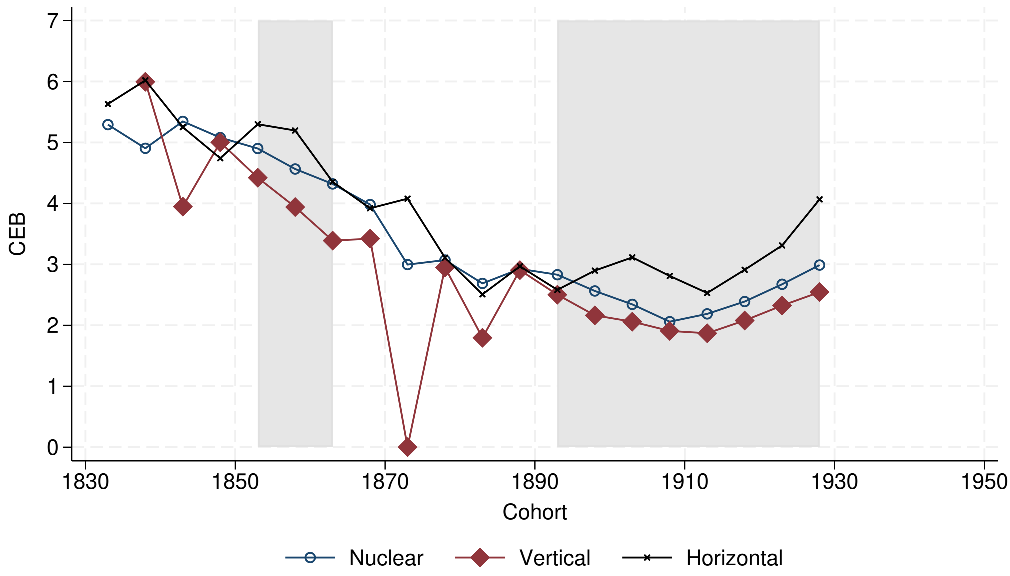


Figure 27: CEB by family type: Native-born married women with at least one parent foreign-born and with employed husbands.

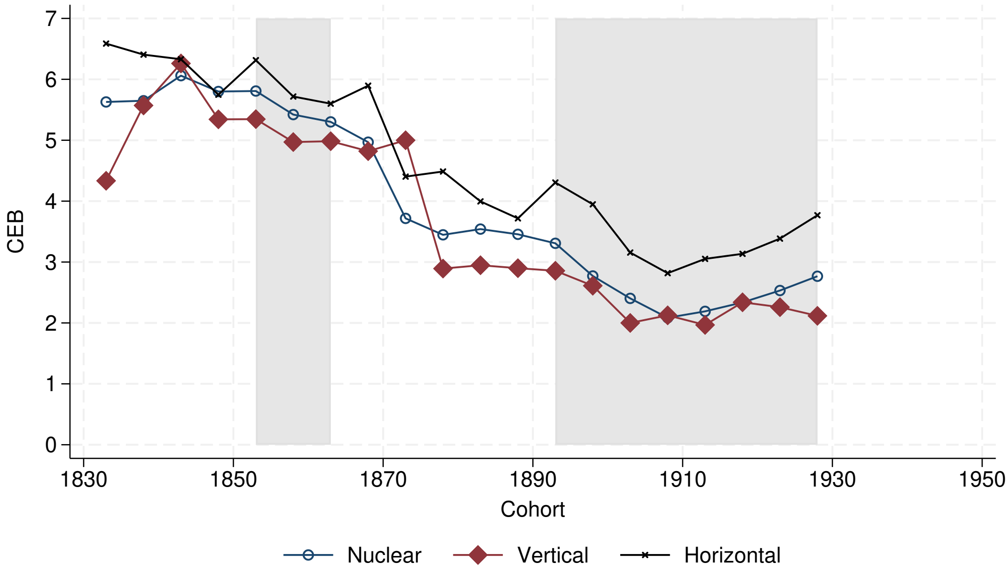


Figure 28: CEB by family type: Foreign-born married women with employed husbands.

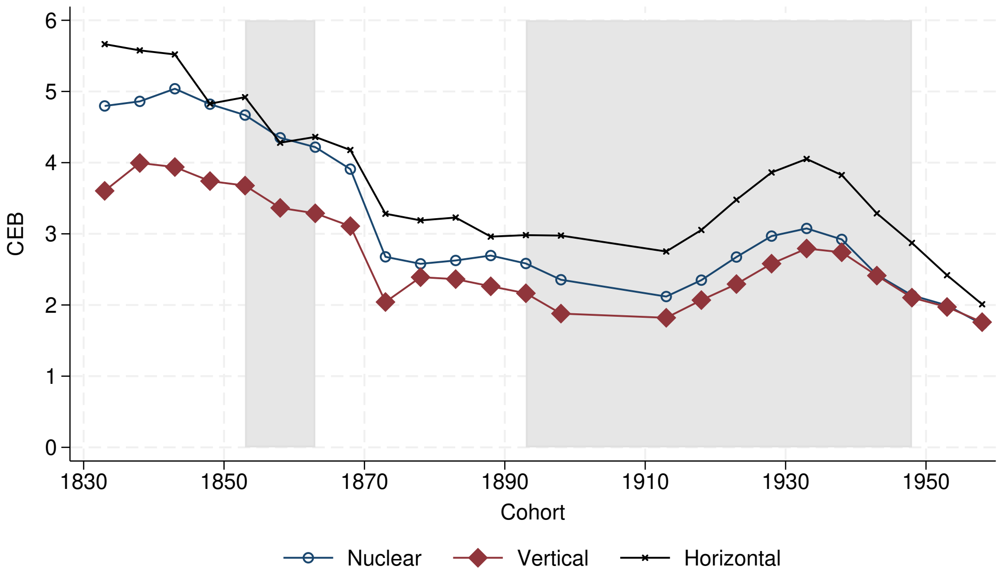


Figure 29: CEB by family type: Married women living in an urban area and with employed husbands.

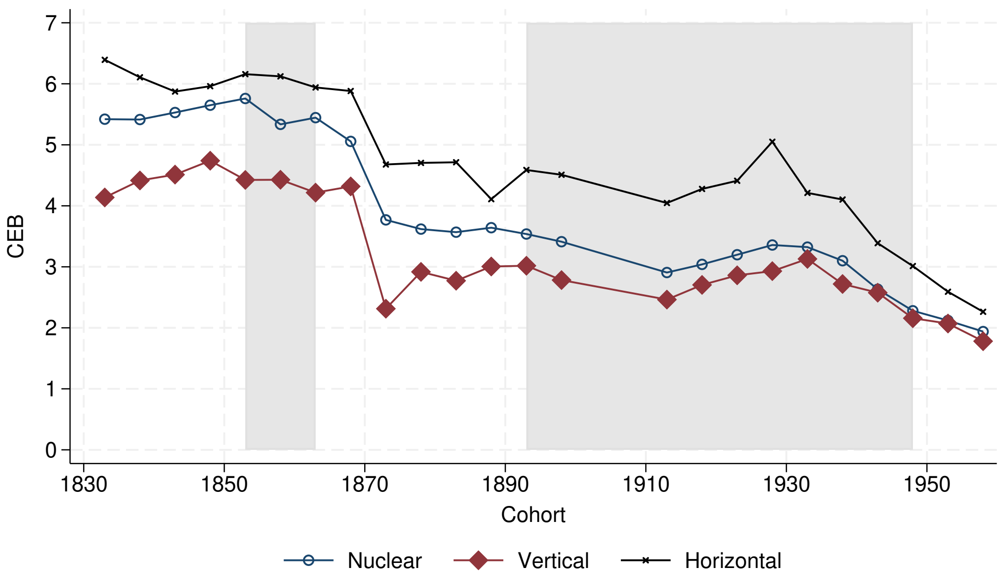


Figure 30: CEB by family type: Married women living in a rural area and with employed husbands.

## A.4 Robustness: regressions

| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extended vertical | -0.34*** | -0.36*** | -0.35*** | -0.35*** | -0.34*** | -0.33*** | -0.32*** | -0.44*** | -0.46*** | -0.28*** | -0.25*** | -0.35*** | -0.26*** | -0.28*** |
| | (0.040) | (0.037) | (0.041) | (0.042) | (0.039) | (0.041) | (0.036) | (0.039) | (0.039) | (0.034) | (0.043) | (0.036) | (0.043) | (0.030) |
| Extended horizontal | 0.74*** | 0.67*** | 0.72*** | 0.71*** | 0.70*** | 0.74*** | 0.73*** | 0.72*** | 0.71*** | 0.65*** | 0.48*** | 0.60*** | 0.52*** | 0.57*** |
| | (0.053) | (0.040) | (0.052) | (0.051) | (0.048) | (0.053) | (0.063) | (0.058) | (0.059) | (0.042) | (0.050) | (0.036) | (0.052) | (0.033) |
| White | | -0.48*** | | | | | | | | | -0.28*** | -0.49*** | -0.37*** | -0.38*** |
| | | (0.060) | | | | | | | | | (0.086) | (0.052) | (0.086) | (0.046) |
| Urban | | | -0.46*** | | | | | | | | -0.60*** | -0.42*** | -0.63*** | -0.35*** |
| | | | (0.033) | | | | | | | | (0.035) | (0.029) | (0.038) | (0.020) |
| Owner | | | | -0.17*** | | | | | | | -0.13** | -0.13*** | -0.16*** | -0.04 |
| | | | | (0.048) | | | | | | | (0.053) | (0.038) | (0.054) | (0.048) |
| High income | | | | | -0.43*** | | | | | | -0.31*** | -0.33*** | -0.38*** | -0.16*** |
| | | | | | (0.034) | | | | | | (0.024) | (0.021) | (0.028) | (0.009) |
| Active | | | | | | -0.47*** | | | | | -0.58*** | -0.46*** | -0.61*** | -0.40*** |
| | | | | | | (0.014) | | | | | (0.025) | (0.012) | (0.024) | (0.013) |
| Age at first marriage | | | | | | | -0.11*** | | | | -0.12*** | | -0.12*** | |
| | | | | | | | (0.003) | | | | (0.004) | | (0.004) | |
| Foreign born | | | | | | | | 0.48*** | | | 0.50*** | | 0.63*** | |
| | | | | | | | | (0.066) | | | (0.087) | | (0.087) | |
| Foreign parent | | | | | | | | | -0.13*** | | 0.08*** | | 0.13*** | |
| | | | | | | | | | (0.030) | | (0.026) | | (0.029) | |
| Education | | | | | | | | | | -0.16*** | -0.09*** | | | -0.13*** |
| | | | | | | | | | | (0.009) | (0.007) | | | (0.007) |
| Constant | 5.77*** | 6.18*** | 5.78*** | 5.84*** | 5.95*** | 5.78*** | 6.28*** | 5.97*** | 6.06*** | 4.02*** | 7.42*** | 6.42*** | 7.50*** | 4.41*** |
| | (0.127) | (0.140) | (0.131) | (0.141) | (0.131) | (0.127) | (0.134) | (0.121) | (0.121) | (0.134) | (0.190) | (0.157) | (0.195) | (0.167) |
| Observations | 634,682 | 634,682 | 609,608 | 613,911 | 634,682 | 634,682 | 297,496 | 298,605 | 298,605 | 566,511 | 113,367 | 609,608 | 113,367 | 541,437 |
| R-squared | 0.161 | 0.165 | 0.179 | 0.172 | 0.169 | 0.168 | 0.104 | 0.150 | 0.148 | 0.107 | 0.174 | 0.196 | 0.169 | 0.131 |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Standard errors clustered by state in parenthesis
*** p<0.01; ** p<0.05; * p<0.1

Table 17: Dependent variable: children ever born. Clustered standard error.

| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extended vertical | -0.27*** | -0.29*** | -0.28*** | -0.27*** | -0.27*** | -0.26*** | -0.27*** | -0.36*** | -0.38*** | -0.21*** | -0.22*** | -0.28*** | -0.23*** | -0.23*** |
| | (0.034) | (0.030) | (0.034) | (0.034) | (0.032) | (0.034) | (0.034) | (0.035) | (0.035) | (0.029) | (0.044) | (0.028) | (0.044) | (0.025) |
| Extended horizontal | 0.72*** | 0.62*** | 0.69*** | 0.68*** | 0.67*** | 0.71*** | 0.73*** | 0.70*** | 0.69*** | 0.63*** | 0.42*** | 0.55*** | 0.46*** | 0.52*** |
| | (0.049) | (0.035) | (0.049) | (0.048) | (0.044) | (0.049) | (0.061) | (0.055) | (0.056) | (0.038) | (0.046) | (0.032) | (0.047) | (0.028) |
| White | | -0.65*** | | | | | | | | | -0.68*** | -0.61*** | -0.79*** | -0.50*** |
| | | (0.064) | | | | | | | | | (0.088) | (0.059) | (0.088) | (0.055) |
| Urban | | | -0.40*** | | | | | | | | -0.56*** | -0.38*** | -0.59*** | -0.32*** |
| | | | (0.030) | | | | | | | | (0.032) | (0.025) | (0.036) | (0.021) |
| Owner | | | | -0.26*** | | | | | | | -0.18*** | -0.20*** | -0.22*** | -0.13*** |
| | | | | (0.045) | | | | | | | (0.050) | (0.034) | (0.052) | (0.044) |
| High income | | | | | -0.45*** | | | | | | -0.33*** | -0.32*** | -0.41*** | -0.18*** |
| | | | | | (0.035) | | | | | | (0.026) | (0.022) | (0.030) | (0.011) |
| Active | | | | | | -0.34*** | | | | | -0.48*** | -0.35*** | -0.52*** | -0.30*** |
| | | | | | | (0.013) | | | | | (0.023) | (0.010) | (0.022) | (0.010) |
| Age at first marriage | | | | | | | -0.09*** | | | | -0.09*** | | -0.10*** | |
| | | | | | | | (0.003) | | | | (0.005) | | (0.005) | |
| Foreign born | | | | | | | | 0.46*** | | | 0.41*** | | 0.56*** | |
| | | | | | | | | (0.066) | | | (0.096) | | (0.097) | |
| Foreign parent | | | | | | | | | -0.17*** | | 0.01 | | 0.07** | |
| | | | | | | | | | (0.030) | | (0.029) | | (0.031) | |
| Education | | | | | | | | | | -0.15*** | -0.10*** | | | -0.11*** |
| | | | | | | | | | | (0.009) | (0.007) | | | (0.007) |
| Constant | 6.39*** | 6.94*** | 6.38*** | 6.52*** | 6.56*** | 6.39*** | 6.18*** | 6.61*** | 6.68*** | 4.59*** | 7.65*** | 7.18*** | 7.79*** | 5.13*** |
| | (0.137) | (0.156) | (0.140) | (0.146) | (0.140) | (0.137) | (0.137) | (0.134) | (0.132) | (0.141) | (0.192) | (0.168) | (0.199) | (0.171) |
| Observations | 561,911 | 561,911 | 541,230 | 545,094 | 561,911 | 561,911 | 263,757 | 261,183 | 261,183 | 499,831 | 94,406 | 541,230 | 94,406 | 479,150 |
| R-squared | 0.196 | 0.203 | 0.217 | 0.212 | 0.206 | 0.201 | 0.078 | 0.172 | 0.170 | 0.123 | 0.160 | 0.236 | 0.151 | 0.149 |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Standard errors clustered by state in parenthesis
*** p<0.01; ** p<0.05; * p<0.1

Table 18: Dependent variable: children ever born, women with at least 1 child. Clustered standard errors.

| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extended vertical | -0.34*** | -0.36*** | -0.35*** | -0.35*** | -0.34*** | -0.33*** | -0.32*** | -0.44*** | -0.46*** | -0.28*** | -0.25*** | -0.35*** | -0.26*** | -0.28*** |
| | (0.070) | (0.065) | (0.078) | (0.079) | (0.066) | (0.070) | (0.053) | (0.058) | (0.066) | (0.052) | (0.045) | (0.066) | (0.049) | (0.045) |
| Extended horizontal | 0.74*** | 0.67*** | 0.72*** | 0.71*** | 0.70*** | 0.74*** | 0.73*** | 0.72*** | 0.71*** | 0.65*** | 0.48*** | 0.60*** | 0.52*** | 0.57*** |
| | (0.076) | (0.068) | (0.081) | (0.080) | (0.073) | (0.075) | (0.103) | (0.092) | (0.095) | (0.072) | (0.085) | (0.068) | (0.084) | (0.070) |
| White | | -0.48*** | | | | | | | | | -0.28* | -0.49*** | -0.37** | -0.38*** |
| | | (0.071) | | | | | | | | | (0.130) | (0.062) | (0.117) | (0.061) |
| Urban | | | -0.46*** | | | | | | | | -0.60*** | -0.42*** | -0.63*** | -0.35*** |
| | | | (0.085) | | | | | | | | (0.049) | (0.063) | (0.056) | (0.070) |
| Owner | | | | -0.17*** | | | | | | | -0.13** | -0.13*** | -0.16** | -0.04 |
| | | | | (0.052) | | | | | | | (0.048) | (0.044) | (0.050) | (0.052) |
| High income | | | | | -0.43*** | | | | | | -0.31*** | -0.33*** | -0.38*** | -0.16*** |
| | | | | | (0.078) | | | | | | (0.070) | (0.058) | (0.084) | (0.041) |
| Active | | | | | | -0.47*** | | | | | -0.58*** | -0.46*** | -0.61*** | -0.40*** |
| | | | | | | (0.047) | | | | | (0.079) | (0.047) | (0.075) | (0.053) |
| Age at first marriage | | | | | | | -0.11*** | | | | -0.12*** | | -0.12*** | |
| | | | | | | | (0.009) | | | | (0.010) | | (0.011) | |
| Foreign born | | | | | | | | 0.48*** | | | 0.50** | | 0.63*** | |
| | | | | | | | | (0.162) | | | (0.157) | | (0.173) | |
| Foreign parent | | | | | | | | | -0.13*** | | 0.08 | | 0.13* | |
| | | | | | | | | | (0.042) | | (0.053) | | (0.059) | |
| Education | | | | | | | | | | -0.16*** | -0.09*** | | | -0.13*** |
| | | | | | | | | | | (0.013) | (0.020) | | | (0.011) |
| Constant | 5.77*** | 6.18*** | 5.78*** | 5.84*** | 5.95*** | 5.78*** | 6.28*** | 5.97*** | 6.06*** | 4.02*** | 7.42*** | 6.42*** | 7.50*** | 4.41*** |
| | (0.080) | (0.113) | (0.097) | (0.104) | (0.102) | (0.082) | (0.261) | (0.081) | (0.098) | (0.092) | (0.260) | (0.155) | (0.259) | (0.147) |
| Observations | 634,682 | 634,682 | 609,608 | 613,911 | 634,682 | 634,682 | 297,496 | 298,605 | 298,605 | 566,511 | 113,367 | 609,608 | 113,367 | 541,437 |
| R-squared | 0.161 | 0.165 | 0.179 | 0.172 | 0.169 | 0.168 | 0.104 | 0.150 | 0.148 | 0.107 | 0.174 | 0.196 | 0.169 | 0.131 |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Standard errors clustered by state and cohort in parenthesis
*** p<0.01; ** p<0.05; * p<0.1

Table 19: Dependent variable: children ever born. Standard errors clustered by state and cohort.

| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extended vertical | -0.27*** | -0.29*** | -0.28*** | -0.27*** | -0.27*** | -0.26*** | -0.27*** | -0.36*** | -0.38*** | -0.21*** | -0.22*** | -0.28*** | -0.23*** | -0.23*** |
| | (0.060) | (0.054) | (0.065) | (0.066) | (0.056) | (0.060) | (0.057) | (0.055) | (0.062) | (0.053) | (0.048) | (0.053) | (0.052) | (0.043) |
| Extended horizontal | 0.72*** | 0.62*** | 0.69*** | 0.68*** | 0.67*** | 0.71*** | 0.73*** | 0.70*** | 0.69*** | 0.63*** | 0.42*** | 0.55*** | 0.46*** | 0.52*** |
| | (0.075) | (0.061) | (0.078) | (0.077) | (0.070) | (0.075) | (0.105) | (0.095) | (0.097) | (0.069) | (0.088) | (0.062) | (0.089) | (0.060) |
| White | | -0.65*** | | | | | | | | | -0.68*** | -0.61*** | -0.79*** | -0.50*** |
| | | (0.109) | | | | | | | | | (0.154) | (0.101) | (0.144) | (0.098) |
| Urban | | | -0.40*** | | | | | | | | -0.56*** | -0.38*** | -0.59*** | -0.32*** |
| | | | (0.081) | | | | | | | | (0.042) | (0.057) | (0.048) | (0.066) |
| Owner | | | | -0.26*** | | | | | | | -0.18*** | -0.20*** | -0.22*** | -0.13** |
| | | | | (0.050) | | | | | | | (0.046) | (0.039) | (0.047) | (0.048) |
| High income | | | | | -0.45*** | | | | | | -0.33*** | -0.32*** | -0.41*** | -0.18*** |
| | | | | | (0.079) | | | | | | (0.073) | (0.057) | (0.081) | (0.041) |
| Active | | | | | | -0.34*** | | | | | -0.48*** | -0.35*** | -0.52*** | -0.30*** |
| | | | | | | (0.028) | | | | | (0.068) | (0.029) | (0.063) | (0.035) |
| Age at first marriage | | | | | | | -0.09*** | | | | -0.09*** | | -0.10*** | |
| | | | | | | | (0.009) | | | | (0.012) | | (0.012) | |
| Foreign born | | | | | | | | 0.46*** | | | 0.41** | | 0.56** | |
| | | | | | | | | (0.156) | | | (0.156) | | (0.167) | |
| Foreign parent | | | | | | | | | -0.17*** | | 0.01 | | 0.07 | |
| | | | | | | | | | (0.039) | | (0.060) | | (0.064) | |
| Education | | | | | | | | | | -0.15*** | -0.10*** | | | -0.11*** |
| | | | | | | | | | | (0.014) | (0.016) | | | (0.011) |
| Constant | 6.39*** | 6.94*** | 6.38*** | 6.52*** | 6.56*** | 6.39*** | 6.18*** | 6.61*** | 6.68*** | 4.59*** | 7.65*** | 7.18*** | 7.79*** | 5.13*** |
| | (0.075) | (0.146) | (0.090) | (0.096) | (0.098) | (0.077) | (0.250) | (0.081) | (0.095) | (0.094) | (0.211) | (0.180) | (0.203) | (0.182) |
| Observations | 561,911 | 561,911 | 541,230 | 545,094 | 561,911 | 561,911 | 263,757 | 261,183 | 261,183 | 499,831 | 94,406 | 541,230 | 94,406 | 479,150 |
| R-squared | 0.196 | 0.203 | 0.217 | 0.212 | 0.206 | 0.201 | 0.078 | 0.172 | 0.170 | 0.123 | 0.160 | 0.236 | 0.151 | 0.149 |
| Cohort FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Standard errors clustered by state and cohort in parenthesis
*** $p<0.01$; ** $p<0.05$; * $p<0.1$

Table 20: Dependent variable: children ever born, women with at least 1 child. Standard errors clustered by state and cohort.

## A.5 Proof of Proposition 3

Point 2.1: the Post-Malthusian regime.

The $\partial n_a^*/\partial h_t^y < 0$ result follows directly from computing the derivative of Equation (9). The $\partial n_c^*/\partial h_t^y < 0$ is result less immediate. From Equation (14), we have:

$$\frac{\partial n_c^*}{\partial h_t^y} = \frac{\partial \frac{\gamma(h_t^o + h_t^y)}{h_t^y \phi}}{\partial h_t^y}\theta + \frac{\partial \theta}{\partial h_t^y}\frac{\gamma(h_t^o + h_t^y)}{h_t^y \phi}. \tag{55}$$

Computing the derivative and simplifying the expression, it turns out that the sign of the derivative can be expressed as a function of $\kappa^y$. In particular, the derivative is negative if

$$\gamma\left(h_t^o(1-\zeta) - \left(\frac{h_t^o}{h_t^o + h_t^y}\right)^{\frac{1}{1-\zeta}}(h_t^o(1-\zeta) + h_t^y)\right)(1-\lambda) - h_t^o\gamma\zeta\left(\frac{h_t^y}{\kappa^y(h_t^o + h_t^y)}\right)^{\frac{1}{1-\zeta}}\lambda > 0 \tag{56}$$

Now, this condition holds as equality if $\kappa^y = \Phi_{h^y}$. The result in the Proposition then follows from the fact that the second term of the expression is decreasing in $\kappa^y$.

Point 2.2: the Modern regime.

The $\partial n_a^*/\partial h_t^y < 0$ result follows directly from computing the derivative on Equation (9). The $\partial n_c^*/\partial h_t^y < 0$ is again less immediate. From Equation (14), we have:

$$\frac{\partial n_c^*}{\partial h_t^y} = \frac{\partial \frac{(1-\beta)\gamma w_t(h_t^o + h_t^y)}{h_t^y w_t \phi - 1}}{\partial h_t^y}\theta + \frac{\partial \theta}{\partial h_t^y}\frac{(1-\beta)\gamma w_t(h_t^o + h_t^y)}{h_t^y w_t \phi - 1}. \tag{57}$$

Computing the derivative and simplifying the expression leads to the result.

## A.6 The impact of fertility on coresidence: theory and data

In the model, we have assumed that the young invest in the human capital of their children out of warm-glow altruism. This implies that they do not internalise how this will affect their own bargaining position in the subsequent period, when they will be old. This assumption was made for the sake of analytical tractability. Furthermore, we have also assumed that coresidence only implies one (couple of) young and one (couple of) old. Such an assumption finds ample justification in the empirical evidence. As a consequence of these assumptions, it turns out that in the model fertility does not affect the choice of coresidence at the household level. Proposition 1 is in effect independent from $n$. Hence, the theory we have developed establishes a causal link going from family structure to fertility at the household level. In the aggregate, however, one cannot make the same causal claim as easily. In particular, since the coresidence choice depends on cultural factors (preferences) and economic factors (relative income), one may think that having more children increases the probability that at least one of them will have the right characteristics for coresidence to be the chosen outcome.

At a closer scrutiny, this argument is not very compelling for what concerns the economic factors. The relative income, indeed, depends on education and on technical progress. Under the assumption that parents cares equally for their children, the education choice is fully taken into account by our model, and produces no effect on coresidence. By the same token, there is no obvious effects of technical progress on sibling's heterogeneity in terms of relative income.

On the other hand, the argument might hold good for what concerns the cultural factors. In fact, while sibling shares the same cultural traits, they might differ in terms of preferences. In particular, within the range specific to their cultural trait, some might like coresidence more than others. Pushing the argument to its extremes, if for each child the probability of liking coresidence is an independent random event, having more children will mechanically increase the probability that at least one of them has a taste for coresidence that exceeds the one from Proposition 1. In our simulations, we have ruled out this possibility through the assumption that siblings share the same preferences when it comes to coresidence. This greatly simplifies the computational exercise, but holds the implication that, by construction, fertility does not have any direct impact on coresidence even in the aggregate. We are now going to dig deeper into the argument, in order to assess what the actual bearing on our analysis is. To do so, let's assume that siblings have preferences that are a random draw from the distribution used for our simulation. We are interested to understand to what extent the probability of success – *i.e.* the probability of having at least one value of $\kappa^y$ such that $\kappa^y > \Phi^c$ for a given $\iota$ – depends on the number of draws from the distribution – fertility $n$, in our case. This situation, akin to a Bernoulli experiment, corresponds to the probability of having $k = 1$ success in a binomial distribution, or

$$P = \binom{n}{k} p^n (1-p)^{n-k}. \tag{58}$$

In our example, $k = 1$, for we are interested in a binary outcome (coresidence or non-coresidence). The probability of success $p$ can be retrieved as $1 - F_{\kappa^y}(\Phi^c)$, where $F$ is the cumulative distribution function for $\ln \kappa^y \sim N(\mu, \sigma^2)$, and the moments of the distribution correspond to those calibrated in Section 5. Since $\Phi^c$ depends also on $\iota$, we compute $P$ for $\iota \in [0.8, 5]$, the extreme values in our simulations. It turns out that $P$ ranges from 0.99 to 1, for $n \in [1, 10]$. Its sensibility to $n$ increase with $\iota$. When $\iota = 5$, meaning that the young has a human capital that is 500% higher than the old, $P = 1$ for $n \in [4, 10]$ and $P = 0.99$ otherwise. So, for the range of values taken by the relative income in our simulation, and indeed for any reasonable range of values, the mechanical impact of fertility in intergenerational coresidence due to the aggregation of heterogenous agents is likely to be minor at best, most realistically negligible.

## A.7 Preference for coresidence: the old

In the paper, we have assumed that $\kappa^o = 1$, while the parameter $\kappa^y$ is assumed to be heterogeneous within each cohort. In this Appendix, we use the quantitative model presented in Section 5 to study the impact of using an alternative assumption on the taste of coresidence of the young and the old. In particular, we now assume that $\kappa^o = \kappa^y = \kappa$, i.e., parents and children have the same taste of coresidence, which is distributed with a log-normal distribution. Apart from this assumption, the model and the calibration strategy are unchanged with respect to Section 5. Figure 31 presents the result for the endogenous growth version of the model, i.e. $\epsilon = 1$. Figure 32 shows the results when $\epsilon$ is set to get the same average annual growth rate we get in Figure 20, i.e. a value of about 2.3%. This requires $\epsilon = 0.84$ (and not $\epsilon = 0.7$ as in Figure 20)

## A.8 The inverted Caldwell hypothesis

### A.8.1 Model with exogenous coresidence

The simplest way to model the inverted Caldwell hypothesis under the assumption of exogenous coresidence is to introduce a cost/benefit from coresidence with the old in an otherwise standard model of endogenous fertility.

The economy is populated by three overlapping generations of individuals; the young, denoted by a superscript $y$; the old, denoted by a superscript $o$; and the children. Both the old and the children do not take any decision in this model. The old may live with the young in vertical

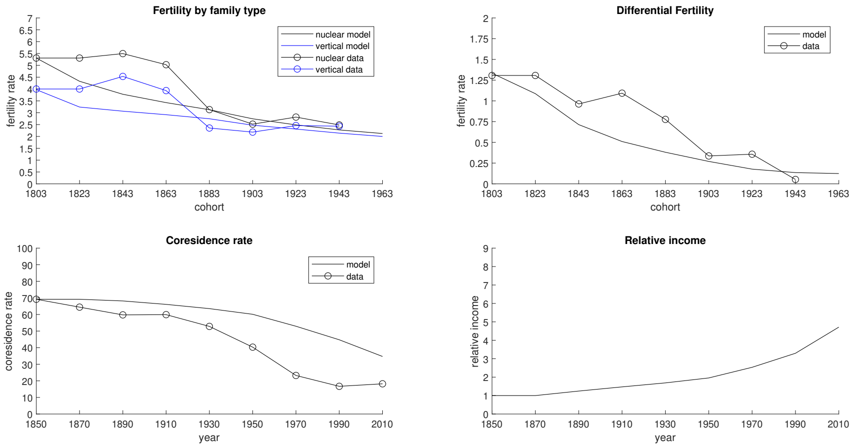


Figure 31: Simulation results ($\kappa^y = \kappa^o$). Endogenous growth model: $\epsilon = 1$.

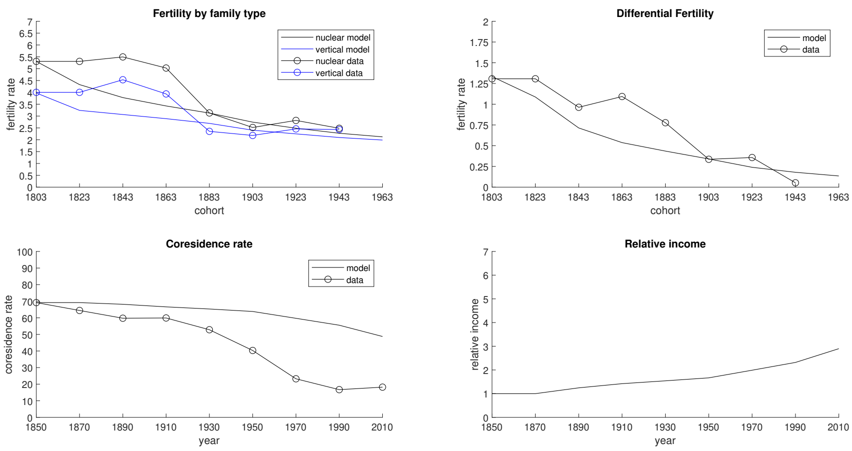


Figure 32: Simulation results ($\kappa^y = \kappa^o$). Exogenous growth model: $\epsilon = 0.84$.

families, but this is taken as given. The children accumulate human capital as chosen by the young.

There are two possible living arrangements, coresidence – the extended vertical family, denoted by a subscript $c$ – or living alone – the nuclear family, denoted by a subscript $a$.

We assume preferences are independent of the family structure. The young care for consumption $c$, the number of children $n$, and their human capital $h$:

$$U(c_t, n_t, h_{t+1}) = (1-\gamma)\ln c_t + \gamma \ln(n_t h_{t+1}). \tag{59}$$

Young parents pay a time cost $\phi \in (0,1)$ for raising each child, and a good cost $e$ for educating him. Education builds up the child's human capital according to the following production function:

$$h_{t+1} = (1+e_t)^{\beta}. \tag{60}$$

There is time cost-benefit $\chi \in (-1,1)$ of having coresiding elderly, $o$.

The budget constraint differs along the family dimension. With no coresidence (nuclear family),

$$w_t(1-\phi n_t)h_t = c_t + e_t n_t. \tag{61}$$

With coresidence (extended vertical family),

$$w_t(1-\phi n_t - \chi o_t)h_t = c_t + e_t n_t. \tag{62}$$

Hence, the optimal fertility and education choices for nuclear families are:

$$e_{a,t} = \begin{cases} 0 & \text{if } w_t \leq \frac{1}{\beta\phi h_t} \\ \frac{\beta\phi h_t w_t - 1}{1-\beta} & \text{if } w_t > \frac{1}{\beta\phi h_t} \end{cases}, \tag{63}$$

$$n_{a,t} = \begin{cases} \frac{\gamma}{\phi} & \text{if } w_t \leq \frac{1}{\beta\phi h_t} \\ \frac{\gamma(1-\beta)h_t w_t}{\phi h_t w_t - 1} & \text{if } w_t > \frac{1}{\beta\phi h_t} \end{cases}. \tag{64}$$

By the same token, the optimal education and fertility choices for extended vertical families are:

$$e_{c,t} = \begin{cases} 0 & \text{if } w_t \leq \frac{1}{\beta\phi h_t} \\ \frac{\beta\phi h_t w_t - 1}{1-\beta} & \text{if } w_t > \frac{1}{\beta\phi h_t} \end{cases}, \tag{65}$$

$$n_{c,t} = \begin{cases} \frac{\gamma(1-\chi o_t)}{\phi} & \text{if } w_t \leq \frac{1}{\beta\phi h_t} \\ \frac{\gamma(1-\beta)h_t w_t(1-\chi o_t)}{\phi h_t w_t - 1} & \text{if } w_t > \frac{1}{\beta\phi h_t} \end{cases}. \tag{66}$$

We assume $h_t w_t > \frac{1}{\phi}$.

So, the model features both the Post-Malthusian and the Modern regimes as defined in the main text.

Using Equations 64 and 66, one gets

$$n_{c,t} = (1 - \chi o_t) n_{a,t}. \tag{67}$$

Hence, in the model, $n_a > n_c$ if $\chi o_t < 1$. This implies that if the old are a liability (*i.e.*, if $\chi \in (0,1)$), the model conforms to Fact I: fertility differs by family type, with intergenerational coresidence systematically associated with lower fertility than nuclear families.

Furthermore, it is straightforward to verify that in this model fertility is always non increasing both in the wage per unit of efficiency and in the human capital of the young, or:

$$\frac{\partial n_a}{\partial w_t} \leq 0, \quad \text{always;} \tag{68}$$

$$\frac{\partial n_a}{\partial h_t} \leq 0, \quad \text{always;} \tag{69}$$

$$\frac{\partial n_c}{\partial w_t} \leq 0, \quad \text{if } \chi o_t < 1; \tag{70}$$

$$\frac{\partial n_c}{\partial h_t} \leq 0, \quad \text{if } \chi o_t < 1. \tag{71}$$

Thus the model conforms to Fact II as well.

The conformity of the model to Fact I and II is illustrated in Figure 33.

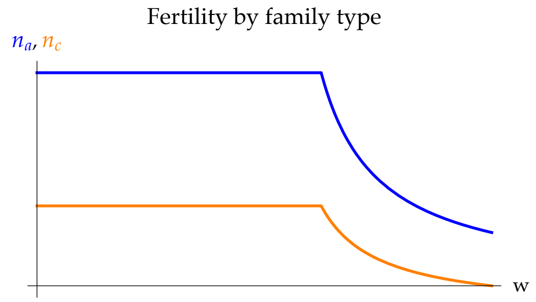


Figure 33: The income-fertility relationship by family type and the cross-family differential fertility under the inverted Caldwell hypothesis (exogenous coresidence, elderly are a liability).

While the static nature of the model does not allow to tackle Fact III and IV head on, one can say something under the assumption that wages increase over time. In this case, since both $n_a$ and $n_c$ are non-increasing in $w$, they will both decline when the latter increase sufficiently. Furthermore, it follows from Equation 67 that the ratio $n_c/n_a$ is constant. Since both are decreasing in $w$ in the modern regime, it must be true that their difference shrinks. In more formal terms, defining $\Delta_{n,t} \equiv n_{a,t} - n_{c,t}$, one has

$$\Delta_{n,t} = \begin{cases} \frac{\gamma\chi o_t}{\phi} & \text{if } w_t \leq \frac{1}{\beta\phi h_t} \\ \frac{\gamma\chi(1-\beta)h_t w_t o_t}{\phi h_t w_t - 1} & \text{if } w_t > \frac{1}{\beta\phi h_t} \end{cases}. \tag{72}$$

Hence,

$$\frac{\partial \Delta_{n,t}}{\partial w_t} \leq 0 \;\text{ for }\; w_t > 0,$$

$$\lim_{w_t \to \infty} \Delta_{n,t} = \frac{\gamma\chi(1-\beta)o_t}{\phi}.$$

The shrinking $\Delta_n$ (with no reversal in the differential fertility) is showed in Figure 34.

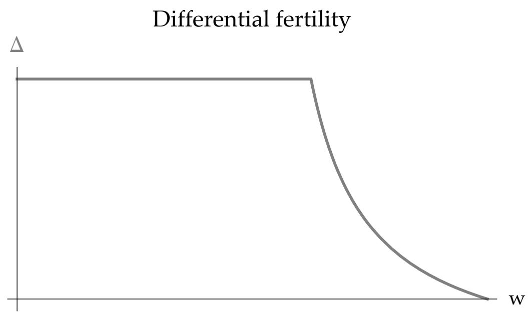


Figure 34: Differential fertility and income.

Notice that this simple model can arrange a reversal in differential fertility through variations in $\chi$. In fact, when $\chi \in (0,1)$, the coresiding elderly are a liability, a time cost. This is the case considered so far. But when $\chi \in (-1,0)$, the coresiding elderly are an asset, a time gain. This corresponds to the widespread view that having coresiding grandparents, or at least grandparents living nearby, frees some parental time from childcare. In this case, we observe a complete reversal of the fertility differential, with nuclear families now having less children than vertical families. This case is depicted in Figure 35.

### A.8.2 Model with endogenous coresidence

The model is the same as the one in Section 3, with two modifications. First, as in the previous Section, we assume that there is time cost-benefit

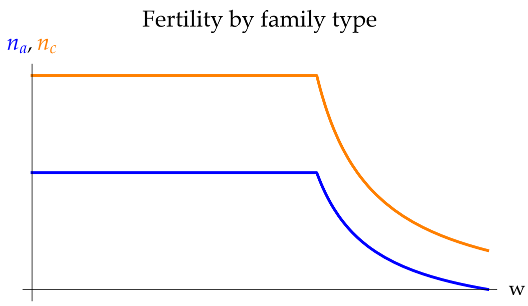


Figure 35: The income-fertility relationship by family type and the cross-family differential fertility under the inverted Caldwell hypothesis (exogenous coresidence, elderly are an asset).

$\chi \in (-1, 1)$ of having coresiding elderly. Second, we assume that the elderly work only a fraction $\tau$ of their last period of life, while receiving a pension $b$ in the remaining fraction $1 - \tau$ of their life. We further assume that it is only during this latter period that the elderly may be a liability or an asset to the young. Like in Section 3, and in accordance with the empirical evidence, we assume that coresidence only happens between one young and one old agent (couple).[20] With these assumptions, the budget constraint of the elderly when living alone, Equation (6), becomes

$$\tau w_t h_t^o + (1 - \tau) b_t = c_t^o + p_t^x x_t^o. \tag{73}$$

By the same token, the budget constraint of the household under coresidence, Equation (11), becomes

$$w_t \{h_t^o \tau + h_t^y [1 - \phi n_t - \chi(1 - \tau)]\} + b_t (1 - \tau) = c_t^o + c_t^y + e_t n_t + p_t^x x_t. \tag{74}$$

To simplify the analytics of the model, we impose that the pension benefit is a fixed replacement rate of the labour income of the elderly, or $b_t = \xi w_t h_t^o$.

Using the same procedure as in Section 3, the optimal choices for education and fertility reads:

$$e_{a,t}^* = e_{c,t}^* = \begin{cases} 0 & \text{if } w_t h_t^y \leq \frac{1}{\beta\phi} \\ \frac{\beta h_t^y w_t \phi - 1}{1 - \beta} & \text{if } w_t h_t^y > \frac{1}{\beta\phi} \end{cases}; \tag{75}$$

$$n_{a,t}^* = \begin{cases} \frac{\gamma}{\phi} & \text{if } w_t h_t^y \leq \frac{1}{\beta\phi} \\ \frac{\gamma(1-\beta) h_t^y w_t}{\phi h_t^y w_t - 1} & \text{if } w_t h_t^y > \frac{1}{\beta\phi} \end{cases}; \tag{76}$$

[20] Hence, $o = 1$ always.

$$n^*_{c,t} = n^*_{a,t}\theta \frac{h^y_t[1-(1-\tau)\chi] + h^o_t[\xi(1-\tau)+\tau]}{h^y_t}. \tag{77}$$

By equating the indirect utility functions in case of coresidence and non-coresidence for both the young and the old, one gets:

$$\theta_{min} = \left( \frac{1}{\kappa^y} \frac{\frac{h^y_t}{h^o_t}}{\xi(1-\tau)+\tau] + \frac{h^y_t}{h^o_t}(1-(1-\tau)\chi)} \right)^{\frac{1}{1-\zeta}}; \tag{78}$$

$$\theta_{max} = 1 - \left( \frac{\xi(1-\tau)+\tau}{\xi(1-\tau)+\tau+\frac{h^y_t}{h^o_t}(1-(1-\tau)\chi)} \right)^{\frac{1}{1-\zeta}}. \tag{79}$$

As before, coresidence turns out to be Pareto improving if $\Delta_\theta \equiv \theta_{max} - \theta_{min} > 0$.

Notice that for $\tau = 1$, we retrieve Equations (19) and (20). As the old always work and never affect the time endowment of the young, the model reduces in effect to that of Section 3.

For $\tau \in (0,1)$, instead, both the coresidence choice and the cross-family differential fertility are affected by $\chi$, $\tau$ and $\xi$. Proceeding as in Section 3, we can characterise the coresidence and differential fertility frontiers.

**Proposition 4** *Given the coresidence frontier*

$$\Phi_c \equiv \frac{\frac{h^y_t}{h^o_t}\left(1-\left(\frac{\xi(1-\tau)+\tau}{\xi(1-\tau)+\frac{h^y_t}{h^o_t}(1-(1-\tau)\chi)+\tau}\right)^{\frac{1}{1-\zeta}}\right)^{\zeta-1}}{\xi(1-\tau)+\frac{h^y_t}{h^o_t}(1-(1-\tau)\chi)+\tau}, \tag{80}$$

*if $\kappa^y > \Phi_c$, then $\Delta_\theta > 0$: coresidence is Pareto efficient.*

*Proof*
Upon request. ■

**Proposition 5** *Given the differential fertility frontier*

$$\Phi_n \equiv \frac{\frac{h^y_t}{h^o_t}\lambda^{1-\zeta}\left(\left(\frac{\xi(1-\tau)+\tau}{\xi(1-\tau)+\frac{h^y_t}{h^o_t}(1-(1-\tau)\chi)+\tau}\right)^{\frac{1}{1-\zeta}} + \frac{\frac{h^y_t}{h^o_t}}{\xi(1-\tau)+\frac{h^y_t}{h^o_t}(1-(1-\tau)\chi)+\tau} - 1 - \lambda\left(\left(\frac{\xi(1-\tau)+\tau}{\xi(1-\tau)+\frac{h^y_t}{h^o_t}(1-(1-\tau)\chi)+\tau}\right)^{\frac{1}{1-\zeta}} - 1\right)\right)^{\zeta}}{(1-\lambda)(\xi(1-\tau)+\tau)\left(\left(\frac{\xi(1-\tau)+\tau}{\xi(1-\tau)+\frac{h^y_t}{h^o_t}(1-(1-\tau)\chi)+\tau}\right)^{\frac{\zeta}{1-\zeta}} - 1\right) + \frac{h^y_t}{h^o_t}((1-\lambda)(1-\tau)\chi+\lambda)}. \tag{81}$$

*If $\kappa^y > \Phi_n$, then $n_a > n_c$: nuclear families have more children than extended vertical families.*

*Proof*
Upon request. ■

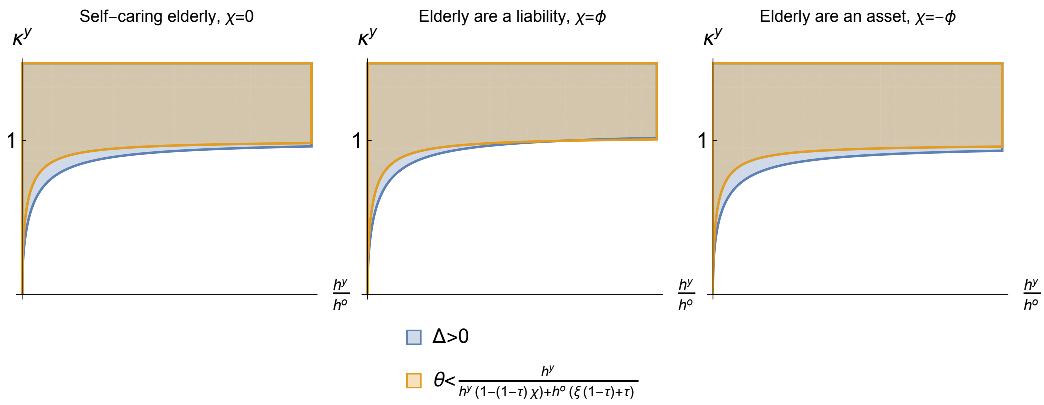


Figure 36: The inverted Caldwell hypothesis as a special case of the relative income hypothesis. When the two areas overlaps, coresidence is Pareto improving and $n_a > n_c$.

The logic of the model is the now familiar logic of the relative income hypothesis. For a given relative human capital of the young, a higher taste for coresidence makes coresidence more likely. *Vice versa*, given the taste for coresidence, higher relative human capital makes coresidence less likely. As to the differential fertility, in this model, $n_a > n_c$ if $\theta < \frac{h^y}{h^y(1-(1-\tau)\chi)+h^o(\xi(1-\tau)+\tau)}$. As before, there is an income effect at work. If the young reap less (more) resources from coresidence than they would have reaped by leaving alone, then they will have less (more) children under coresidence. The prevalence and strength of this income effect depends on the relative human capital of the young, and the parameters $\lambda$, $\kappa^y$ and $\zeta$. What the inclusion of the retirement age, pensions, and the inverted Caldwell hypothesis do is basically to affect the relative income of the young, by making it dependent also on the parameters $\tau$, $\xi$ and $\chi$. To witness it, in Figure 36 we represent Proposition 4 and 5 in the $(k^y, h^y/h^o)$ plane. We fix $\lambda$ and $\zeta$ equal to the calibrated values in Section 5, and we assume $\tau = 1/2$ and $\xi = 70\%$ for the purpose of illustration. We then plot the two frontiers for different values of $\chi$, so as to assess how biting is the inverted Caldwell hypothesis. We first fix $\chi = 0$, meaning that the elderly are neither an asset nor a liability. This allows a comparison between a model with retirement age and pensions, and our benchmark model of Section 3. Then, we explore the case $\chi = \phi$ meaning that the elderly cost to the young an amount of time equivalent to that necessary to raise one child. We see this as a reasonable upper bound. Finally, we explore the case $\chi = -\phi$, meaning that the elderly allow the young to save an amount of time equivalent to that necessary to raise one child. In all three cases, the picture is remarkably similar to that from the benchmark model (Figure 16). This suggests that neither the inverted Caldwell hypothesis, nor the explicit consideration of pensions and retirement are necessary to explain the cross-family differential fertility.[21]

[21]This does not exclude the possibility that either mechanism helps to bring a quantitative model closer to the data. We leave the evaluation of this possibility to further research.

INSTITUT DE RECHERCHE
ÉCONOMIQUES ET SOCIALES

Place Montesquieu 3

1348 Louvain-la-Neuve

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