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The relation between age at first birth and complete fertility

An analysis using US data

by

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Abstract: Transition to later childbearing regimes is a distinct feature of nations in the developed world. Simultaneously, the overall continuation of the declines in fertility experienced by several European nations motivated the study of the relation between postponement and complete fertility. Several widespread theories established negative associations incorporating the idea of opportunity costs associated to family formation. The US has a particular aggregate behavior that challenges these ideas and provides an alternative grounding test for such theories and their general explanatory power. Using longitudinal data, the present study estimates the causal effect of age at first birth on complete fertility and finds weak evidence supporting a postponement-quantum effect.

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Introduction

1.1 Research Problem

The consolidation of a *second demographic transition* has been a largely heterogeneous process shaped by different institutional setups, labor markets, economic crises and economic transitions, new living arrangements and the persistence of a socio-cultural inertia affecting gender roles and family formation processes. In particular, the 1990s decade witnessed a large variation in fertility rates among European nations largely driven by an unforeseen *lowest-low fertility* characterized by persistent *total fertility rates* below 1,3 children per woman. This novelty initially generated concern regarding the implications of such events in the future of these populations and fueled research that largely contributed to the consolidation of contemporary fertility's metanarrative.

Subsequently, the factors identified as fundamental in generating particular fertility outcomes with virtually null controversy included the socioeconomic and institutional environments. However, a complementary proposal articulating the transition towards later childbearing ages, a key feature of contemporary demographic regimes, and fertility outcomes was also considered as displaying relevant explanatory power. Considering that all non labor market, time-intensive activities imply high opportunity costs, the key idea behind the so called *postponement-quantum* effect lies in the proposition that delayed childbearing has a negative effect on complete fertility due to an increase in the opportunity costs associated to childbearing. These costs are typically described as foregone earnings and foregone human capital accumulation derive from labor force detachment along other factors involved in the motherhood penalty. This hypothesis contained an embedded framework useful to analyze fertility in the context of the interactions between preferences and individual characteristics, labor market and family policy through opportunity costs.

Considering the previous, a favorable economic environment along with policies improving the articulation between work and family contexts should render lower opportunity costs, less tense trade-offs and smaller distortions regarding the relation describing targeted and complete fertility. While *lowest low fertility* proved to be a, mostly, *tempo effect*, the United States context provides an alternative and potentially revealing setting in which these ideas are further challenged due to the extreme nature of the family policy arrangement, the high cost of tertiary education, a comparatively persistent and high gender wage gap, and a relatively high fertility
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Finally, there are important reasons supporting the importance of improving the understanding of the relationship between the *tempo* and *quantum* of fertility across the spectrum of practical considerations. (i) Theoretical formulations aiming to realistically describe fertility and the processes that underlie it must do so through a life-cycle perspective. (ii) Cohort fertility forecasting and period fertility adjustment as well as all sorts of demographic public policy formulation are likely to render more precise results as postponement is better understood (Kohler et al., 2001).

1.2 Aim and Scope

The present study seeks to investigate the relation between postponement, or age at which parenthood begins, and fertility considering the possibility of a *postponement-quantum* effect by integrating the role of motherhood associated opportunity costs. When exploring the particular US context, it approaches an initial conundrum arising from a context simultaneously described by apparently high opportunity costs, a transition towards later childbearing and relatively high fertility levels. Specifically, it addresses the aforementioned topics through the following principal and secondary research questions focusing on the detection of the *postponement-quantum* effect and opportunity costs: Is there evidence supporting the existence of a *postponement-quantum* effect in the context of the United States? From a purely methodological perspective these imply estimating i) the causal effect of age at first birth on complete fertility and ii) the changes in this effect as additional factors are included in the analysis. The study also aims to approach these inquiries from a causal framework as much as possible and will build on existent methodological specifications and will also explore some alternatives.

In order to achieve the previous, the document will survey the existing literature on the subject through theoretical and empirical angles. After examining the different theories aiming to describe the relation under study and a particular set of analyses trying to estimate the presumed effect, data from the National Longitudinal Survey of Youth 1979 (NLSY79) is used in order to provide an estimation based on exogenous variation in the age at which women become mothers and to reconstruct a measure of opportunity cost during the observed 1979-2012 period. This dataset was considered because longitudinal observations allow the reconstruction of several measures relevant at the moment of entry into motherhood in a contemporary setting and complete fertility is observed. As mentioned above, the US setting was chosen due to the specific entry into motherhood environment, which will be explored in further detail, and the potential it has in providing information insights in the understanding of the matter.

1.3 Outline of the Thesis

Chapter 1 introduced the general context, stated the research questions and the overall approach in which the study will take place. Chapter 2 explores the theoretical considerations explaining fertility decisions, the interaction between postponement and fertility and the nature and role of opportunity costs involved in motherhood. Additionally, it compiles the relevant previous empirical research on the subject (the more suitable will be readdressed in subsequent sections involving the proposed empirical strategy) and provides a comprehensive context of motherhood in the United States. Finally, it also clearly states what are the expectations regarding the research questions arising from the revised literature both from theoretical and empirical approaches. However, it begins by considering the basic biological constrains affecting the age-fertility interaction in order to provide a relevant deterministic framework often overlooked by the literature. Chapter 3 presents in detail the data involved in the estimations and the important transformations and decisions that shaped the working sample while considering related selection problems affecting estimations and Chapter 4 presents the specific methodological approach used in the estimations found and discussed in Chapter 5. Finally, Chapter 6 relates the findings to the research questions, the literature, and the overall context of the investigation.

2

Theory

2.1 Biological and behavioral constrains

Although it is possible for women to become pregnant from menarche to menopause, the probability of a pregnancy leading to a live birth is not constant throughout the totality of this period. In the United States this process starts on average at age 12,54. Nonetheless, some studies provide evidence supporting a decline in this measure across time (Anderson et al., 2003). Additionally, decreasing but large proportions of early cycles are anovulatory.

The other end of the interval, which is of higher importance for the present study, has been analyzed using different methodologies. A relatively recent small scale study measured ovarian reserve and concluded that the average age at which women experience menopause is 49,56 years (Wallace and Kelsey, 2010). Large scale assessment of the end of fertility or the *onset of permanent sterility* presents a measurement challenge since traditional and/or massive sources of information do not collect optimal data. One approach traditionally favoured is to examine age at last birth in populations that avoid birth control or practice *natural fertility*. Figure 2.1 displays Leridon's (Leridon, 2004) estimates for different measures of complete fertility including historic french data as no-birth-control reference population as well as modern day data. It is important to explicitly state the the share of adult women unable to have children monotonically increases with age in the considered age interval. Although the relation between the aforementioned situations and motherhood timing are not linear nor described by strictly discontinuous shifts, there seems to exist an acceleration in the number of women who enter the population displaying complete fertility, sterility or menopause. There is a similar pattern for all three measures in which larger portions of the population are rapidly incorporated into each one of the three categories and an extremely small amount of women had children beyond age 50. Without regard for the future of a given pregnancy: "The median age at onset of sterility (inability to conceive) is 44,7 years, compared to 50,5 for menopause and 41,2 for delivery of the last birth" (Leridon, 2004, p.1550). When considering the success of the pregnancy and limiting the sample to natural conception or no usage of assisted reproduction technology (ART), he finds that, by age 40, 43% of all attempted pregnancies led to no live births and, contrary to what women in their 30s or younger experience, the majority of conceptions take place after the first year of attempting pregnancy. When ART is employed, the apparent rate of success in women aged 40 is 16.5% (nearly half of the proportion of women aged 30).

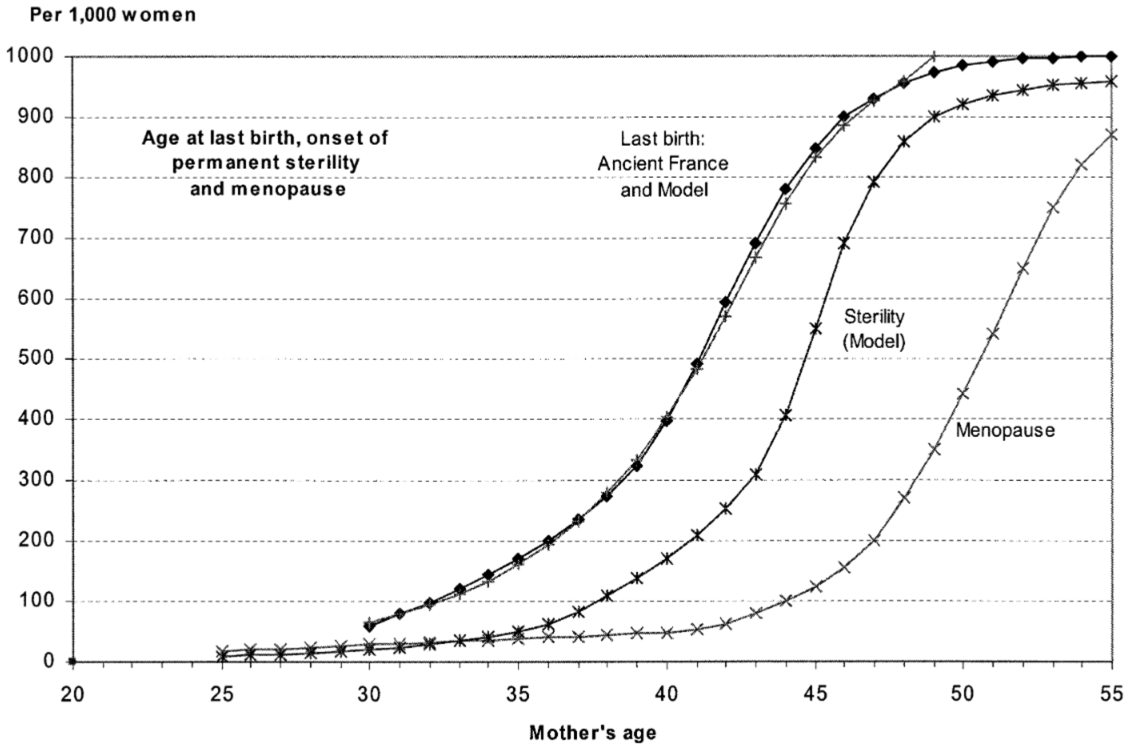

Figure 2.1: Cumulative proportions of women by age at last birth, at onset of sterility and of menopause (Leridon, 2004)

Beyond the mentioned aspects,a plethora of pregnancy related phenomenon and complications exist and become more prevalent as adult women's age increases ranging from trisomy and ectopic pregnancy to spontaneous abortion and still and preterm births; additionally, an associated increase in multiple births is related to the usage of ART which is more demanded among older couples. There are also adverse psychological consequences typically manifesting as anxiety and/or depression associated to miscarriage, involuntary sterility and failed ART processes both in males and females (Schmidt et al., 2012).

These limitations and dynamics have several implications that are likely to influence the interaction between age and fertility and therefore are probably present in the decision making process that women undergo when planning and materializing motherhood. After a certain age close to 30, the literature identifies ongoing complications which individuals would, presumably, prefer to avoid. Additionally, since pregnancies leading to live births tend to become less frequent as age increases (mostly after age 30), women who desire a relatively large family are unlikely to accomplish this if motherhood is delayed too much. Even though what *large* means in a natural fertility context and the context most women in developed countries experience amply differs in magnitude, from a purely biological perspective *et ceteris paribus*, it is conducive for women who desire a large family to enter motherhood earlier than women who desire smaller families. However, women desiring small families experience more flexibility and can reasonably reach their targeted number of children at different points of their reproductive life span. Moreover, again only considering this specific dynamic, in a hypothetical late childbearing regime, the proportion of women that do not reach their targeted amount of children is high among those who desire larger families because higher order parities are less likely to happen. In such a regime, pregnancies leading to live births are better described as a random variable.

Due to the aforementioned dynamics, it is strongly presumed that the age at first birth, or the age at which women enter motherhood, and fertility are not independent. However, such correlation might be stronger in women who target larger families. This propositions are likely to be realistic in a perfect information setting; however, several surveys and studies suggests that in America both men and women understate the role ageing potentially has on the achievement of the desired family size and overall potential associated risks (Deatsman et al., 2016). This should exacerbate the effect age has on fertility. The information presented in the current segment of the study strongly suggests that age at motherhood and fertility are variables that are likely to be linked in several ways that compromise the exogeneity requirements of a standard empirical exercise aiming to estimate the causal effect of age at first birth and overall fertility through several hypothetical mechanisms; if women want to reach a certain targeted number of children they must simultaneously decide, considering the factors mentioned above; however, because of imperfect information or/and the stochastic nature of pregnancies at advanced and relatively advanced age stages, the actual number of children a woman gives birth to might be influenced by the timing of motherhood. The later becomes relevant in explaining late childbearing regimes fertility.

Proximate determinants of fertility

Although initially developed during the 1950s as part of the work of Davis and Blake (1956), since the 1970s and particularly in the last two decades, John Bongaarts has popularized a framework for analyzing fertility through a set of variables described as having a direct effect on this particular outcome denominated *proximate determinants*. These type of determinants are closely related, biologically and behaviorally, to the ability to give birth to children and in this sense are difference from intermediate and/or distant determinants which evaluate the social and economic context surrounding individuals: "If a proximate determinant, such as contraceptive use, changes, then fertility necessarily changes also (assuming the other proximate determinants remain constant). This is not necessarily true for a background determinant of fertility such as income or education" (Bongaarts, 2015, p.536). In spite of its macro applications, this perspective establishes relations that are relevant at micro level. The set of factors has changed in time and so has the general structure of the model; this revision will focus on the most recent approach as found in *Modeling the fertility impact of the proximate determinants: Time for a tune-up* (Bongaarts, 2015).

The model explains an aggregate measure of fertility through factors that follow a multiplicative functional form and in its most detailed version makes use of age-specific variables. The first determinant (i) seeks to capture the share of a population most likely at risk of engaging in childbearing and initially did this through the relative size of married women. Nonetheless, as Stover (1998) pointed out, although fertility is still driven to an important extent by marital fertility, the overall trends in the developed world and the United States support the decreasing importance of marital fertility and suggested the need for a better measure that captures this risk with higher precision by measuring recent sexual activity. Even though most adult women in fertile ages are hypothetically capable of childbirth, in reality (ii) the use of contraception almost perfectly mediates the relation between sexual activity and pregnancy and so does (iii) abortion (which acts as a last resource mechanism to control fertility outcomes). The remaining determinant specifies a particular situation that prevent women from being at risk of having children through (iv) postpartum infecundability. The general structure of the model is synthesized in Figure 2.2.

Index	Equations	Variables
Revised aggregate model	$TFR = \sum C_m^*(a) C_c^*(a) C_i^*(a) C_a^*(a)\, f_f^*(a)$ $= C_m^* C_c^* C_i^* C_a^*\, TF^*$	TF^* = revised total fecundity rate $f_f^*(a)$ =revised fecundity rate
Sexual exposure index	$C_m^* = \sum C_m^*(a)\, w_m(a)$ $w_m(a) = \frac{f_m^*(a)}{\sum f_m^*(a)}$ $f_m^*(a) = C_c^*(a) C_i^*(a) C_a^*(a)\, f_f^*(a)$	$f_m^*(a)$= fertility rate, exposed women a=age
Contraception index	$C_c^* = \sum C_c^*(a)\; w_c(a)$ $w_c(a) = \frac{f_n^*(a)}{\sum f_n^*(a)} \approx \frac{f_f^*(a)}{\sum f_f^*(a)}$ $f_n(a) = C_i^*(a) C_a^*(a)\, f_f^*(a)$	$f_n^*(a)$= natural exposed fertility a=age
Postpartum infecundability index	$C_i^* = \sum C_i^*(a)\, w_i(a) \approx C_i$	
Abortion index	$C_a^* = \sum C_a^*(a) w_a(a) \approx \frac{TFR}{TFR + b^*\, TAR}$	

*represents revised measures

Figure 2.2: Revised aggregate proximate determinants model and equations for indexes (Bongaarts, 2015)

In spite of being clear that the model includes age specific dynamics by contemplating different age groups, the model does not create expectations on the pure age effects on fertility and age seems to be included as a precision device more than a variable in itself. Previous versions of the model included a sterility term capturing the proportion of infertile women at a given age group; however, because of "Beginning in the 1990s, however, the role of sterility variations appears to have become small enough to be ignored. This conclusion is based on the lack of variation in the proportion of childlessness reported by women aged 40–49 in recent DHS surveys. In the absence of pathological sterility, around 3 percent of women in a union are childless at the end of the childbearing years." (Bongaarts, 2015, p.543). The model then captures these sterility effects by segmenting the analysis in age groups. Nonetheless, although this might serve as a methodological device, the final model in itself states no specific relation between age and fertility other than *age groups are different* implying that age is important or significant; however it is not explicit in stating *how*.

2.2 Socioeconomic approach

Although several theoretical constructions modelling fertility have been relatively prevalent through the literature, quite a relevant segment does not include or is not concerned with how age or in general a life cycle context interacts with fertility outcomes. In particular, albeit a consumer demand framework has served as the default approach when addressing fertility as an formal problem, these proposals in their nuclear version explicitly, or tacitly, say very little about how age and fertility outcomes and/or intentions could interact mainly because it approaches the analysis from a static model virtually excluding a time dimension. This irredeemably leads to an incompatibility with a postponement analysis. Hence, the theoretical frameworks explored (and the whole problematic addressed in this study) are somewhat different from the mainstream beckerian setting and explanation (and other age-neutral formalizations) although not necessarily incompatible with these. In fact, subsequent propositions here explored build on the utility maximization approach and incorporate some dynamics which are key to this explanations.

Two main proposals are considered ahead: the *postponement-quantum* effect and the dynamic fertility models. These function as the main mechanisms by which fertility outcomes can be affected by age through socioeconomic factors. Both proposals explain how fertility and age interact through socioeconomic mechanisms.

2.2.1 Fertility and postponement

The postponement-quantum effect

The theoretical proposition that is perhaps most crucial to this study is the idea of a *postponement-quantum* effect pioneered by Hans-Peter Koehler, Francesco Billiari and José Antonio Ortega in their 2002 paper *The Emergence of Lowest-Low Fertility in Europe During the 1990s* (Kohler et al., 2002). The key idea within this concept is that "late starters in childbearing tend to have lower fertility than early starters, and a pure postponement of fertility seems to be absent." (Kohler et al., 2002, p.647). They approach the interaction between these categories on the basis of fertility being a process (i) immanently embedded on a life cycle perspective that must be modelled in a dynamic setting which is (ii) accurately controlled by individuals and (iii) irreversible once started.

In consistency with a life cycle perspective, a *postponement-quantum* effect occurs because human capital accumulation and growth in earnings display a positive association to age. In particular, higher education plays an important role in postponement since it normally involves a relatively extensive commitment to a resource intensive activity and it is, commonly, mutually exclusive with parenting. This would suggest that, on average, the decision to complete higher education is correlated with postponement. Within the *postponement-quantum* approach, Berrington et al. (2015) expand on this mechanism and state that across the education gradient more educated women are more likely to postpone the most and will therefore enter motherhood at later ages compared to those who choose not to or cannot pursue higher education: "educational differences in completed family size will result at least partly from this timing-quantum interaction" (Berrington et al., 2015, p.734). From a theoretical standpoint, education, along with work experience and other forms of training, leads to increased human capital returns which typically manifest as higher earnings because marginal productivity is positively affected.

An increase in income arising from these determinants raises the opportunity cost of allocating time to non-market activities such as leisure, starting a family and, in particular, having children since it is perceived as time intensive. Postponing or delaying motherhood therefore has a positive effect on the opportunity cost of children leading to an outcome adjustment: “These higher child costs will tend to reduce the quantum of fertility and the parity progression probabilities after the first birth”(Kohler et al., 2002, p.666).

The proposed effect incorporates the trade-off between the development of the professional life and family processes and it is hence naturally affected by variables affecting the relative cost of each activity including family policy. There are also key events that systematically raise the opportunity cost of children like the timing of tertiary education completion or periods of rapid increases in earnings (Kohler et al., 2002). Also, setting-specific characteristics like the flexibility of labor markets, the cost of childcare and even the particularities of a certain economic sector can exert an important mediation in the conflicting relation between work and family.

The fundamental intuition behind the *postponement-quantum* effect can be summarized in a closing statement from Koehler et al.: “the postponement of fertility is negatively associated with the ultimate quantum of fertility, and the magnitude of this postponement-quantum interaction depends mainly on the compatibility between formal labor force participation and children” (Kohler et al., 2002, p.667). This clearly predicts a negative relation between complete fertility and age at first birth that in the empirical framework employed in the present study should translate into a negative measure of association.

2.2.2 Dynamic fertility models: the Costs of Childbearing

As it is clearly suggested by the literature reviewed so far, the age at which women decide to have children, or the *optimal age at motherhood*, is likely to be strongly related to targeted fertility or desired family size. In particular, postponement might result in complete fertility below an original desired family size because of biological constrains and the increasingly conflicting nature between labor market and/or professional development and the family project since both activities require important allocation of time and other resources. Although some of the basic mechanisms explaining how delayed motherhood might affect fertility's *quantum* have been outlined, the present segment expands on the underlying variables and dynamics involved. The models considered understand timing as an endogenous variable determined as a function of some given preferences and parameters. Two general approaches that overlap in terms of the importance of shadow prices are considered although one significantly differs in the formulation of opportunity costs. These are not perceived as mutually exclusive but rather appear as complements.

Children's Shadow Price

The notion of a shadow price associated to having children in the sense of a series of direct and indirect costs that do not take place at the moment of birth (which is the main factor explaining *when* women decide to enter motherhood) was formalized by Walker (1995) as part of the analysis of the effect of family policy on Swedish fertility, a robust framework given the extension of such policy in the Swedish case (Walker,

1995) (in particular when compared to the US one). In his proposal, the total shadow price π at moment t is the result of three components arranged in additive functional form which Gustafsson (2003) describes as (A) Opportunity Costs (B) Net Direct Expenditures and (C) Forgone returns to forgone human capital investment (Equation 2.1).

$$\pi_t = A + B + C \tag{2.1}$$

The first term (Equation 2.2), *opportunity cost*, expresses the present value of all future earned income minus the potential parenting benefits (ϑ) at time t; income is defined as a wage rate (w) net from income tax rate (τ) times the share of time allocated to work $(1 - \phi)$. The discount factor is defined as a function of time and a real interest rate ($\delta = (1-r)^{-(t-1)}$). This term captures all unearned wages through the period where a mother remained absent from the labor market net of parenting benefits.

$$A = \sum_{j=0}^{T-t}((1 - \tau_{t+j})w_{t+j}\phi^j - \vartheta_{T+j})\delta_{t+j} \tag{2.2}$$

The second term (Equation 2.3) captures the direct pecuniary costs that are involved in having and raising children also in present value. B acts as a general measure of the monetary value of key expenses involved in having children: a direct expenditure (m) net of a child allowance or the benefits received for having children plus the expenditure on child care (C) in consistency with time allocation to childcare(ϕ).

$$B = \sum_{j=0}^{T-t}(m^j_{t+j} - a_{t+j} + (1 - \phi^j)C^j_{t+j})\delta_{t+j} \tag{2.3}$$

Finally, the last term (Equation 2.4), represents all the returns (μ) associated to the counterfactual human capital accumulation $((1 - \tau_{t+j})h_{t+j}w_{t+j}\delta_{t+j})$[1] that would have taken place if the individual had not had a particular child during the time not devoted to labor market activities. The particular calibration of the model for the Swedish case is annexed in Appendix A for exemplification purposes. Walker (1995) emphasizes that the model predicts that, depending on wage growth profiles, *ceteris paribus*, it is cheaper for women who experience important wage increases over time to have children sooner instead of later. This implies that women who display flatter earnings profiles do not experience a trade-off in the same intensity because they face a relatively smaller shadow price.

$$C = \mu_t \sum_{j=1}^{T-1}(\sum_{l=0}^{j-1}\phi^l)(1 - \tau_{t+j})h_{t+j}w_{t+j}\delta_{t+j} \tag{2.4}$$

[1] h refers to the fraction on a given period, usually interpreted as a year, of time devoted to work

Career planning

This approach synthesized by Gustafsson (2003) examines in greater detail the impact of motherhood in women's careers via shocks to the stock of human capital in a dynamic perspective. Six components are said to be "the determinants of optimal time at maternity" (Gustafsson, 2003, p.236). These depend on: the stock of human capital at the starting period of the analysis, the rate of depreciation of human capital or the rate at which labor market relevant skills decay, the rate of return to the investments made in human capital, the overall human capital accumulation or investment profile, the time separated from the labor market due to childbearing and the direct cost of children in terms of the quality expenditures[2]

So called preparental human capital is said to influence the timing of motherhood since, considering a given amount of initial human capital stock, a certain amount of time away from the labor force will trigger decay in labor market related skills so that by the end to the maternity period the level of human capital is mostly determined by the initial stock. Gustafsson (2003) suggests that there are several theoretical predictions regarding the effect of the size of this stock in the timing of births that are not convergent: Cigno (1991) states that when women enter marriage those who are better endowed will tend to achieve smaller families and will do it earlier due to parents having a positive time preference for children which generates an income effect. Nonetheless, Happel et al. (1984) state that women with higher amounts of human capital are more likely to delay because their final absolute human capital stock would remain higher compared to those who display initial smaller quantities.

The depreciation rate has a particular effect associated to the amount of lost skill because of labor force detachment; if the rate is high and most of the skills become either obsolete or have decayed in a dramatic quantity then births will be less costly if they happen as soon as possible because of the finite nature of the time horizon. If the rate of depreciation is low and only a relatively minor share of skill is compromised, postponement is more likely to happen Gustafsson (2003).

The rate of return to human capital investment is one of the key components explaining life time earnings in combination with investment profiles; it is directly responsible for the steepness of earnings' growth and in this sense determines future earnings. If there is a relatively high return rate for any given human capital investment profile and no detachments from the labor force then time spent not working in the future becomes more costly. On the contrary, smaller rates of return reduce the cost of future detachment from the labor market; nonetheless, it is always cheaper to have children earlier since the slope of earnings growth over time is positive.

The investment profile displays a similar dynamic; larger investments will increase the slope of the earnings curve for any given rate of return[3]. The amount of time away from the labor force has a negative impact on lifetime earnings through the depreciation channel and the uncollected wages that could have taken place.

Finally, the extent of child quality expenses and the time extension in which parents pay for these expenses raises the overall cost of children. In this sense,

[2]Quality in the sense described by Becker (2009) within the context of parents facing a trade-off between family size or the quantity of children and their quality or all the investments made in each children that will generate utility in the future. The later is usually interpreted as a vector containing a set of diverse traits but it usually works operationally as education.

[3]Figure A.2 depicts the effect of motherhood through labor force detachment and human capital depreciation on earnings trajectories.

parents with strong preferences for quality investments, typically highly educated couples, will aspire to relatively important investments and, because of consumption smoothing, it is more advantageous for them to postpone.

Dynamic fertility models and the *postponement-quantum* effect suggest that opportunity costs are the main explanation in the interaction between the quantum of fertility and the optimal age at motherhood although through different mechanisms. The key difference between the *postponement-quantum* effect theory and the dynamic fertility models is the assumptions over information completeness which leads to *ex-ante* and *ex-post* determinations of fertility: in the later explanations, costs, in particular opportunity costs, are part of the motherhood timing decision in consistency with the desired number of children. In the *postponement-quantum* effect world women have a preference for a certain number of children and a certain timing but once that moment approaches these future opportunity costs come into play and force a shift in the outcome. In this sense the *postponement-quantum* effect arises from imperfect information and can be potentially viewed as a realistic extension of the general dynamic fertility model.

2.3 Previous Research and Context

2.3.1 The effect of age on fertility

Fertility and age at first birth typically display a consistent negative association that constitutes an stylized fact as several studies carried on since the late seventies demonstrate (Kohler et al. (2001)). The vast majority of such studies render estimations based on aggregate figures and quite few use micro level data in order to address the specific relation under study meaning that the cited regularity is not based on estimations at individual level. Moreover, empirical exercises aiming to estimate a realistic effect of age on the *quantum* of fertility need to address some of the interactions described previously in order to produce figures with clearer causal interpretations. Although the precise mechanics explaining how these interrelations might lead to biased estimates are described in Chapter 4, in the following paragraphs a more intuitive approach to these obstacles is pursued through a concise survey of the literature. It is worth to note that most of the research investigating the effect of postponement on fertility has taken place within the European cases both at micro and macro level (the reasons for this are explored below). To the author's knowledge there are no studies prioritizing the estimation of the effect of timing on complete fertility that use micro level data from the US.

The main obstacle in the estimation of the effect under study arises from the assumption that complete fertility and age at first birth are independent and therefore it is plausible to grasp the effect of the age at which women become mothers on the total number of children they have through a standard *OLS* framework. However, as has been previously mentioned, there are strong reasons to believe that this is not the case and estimations not addressing this issue will generate biased results (see Section 4.1.1). This is why Heckman et al. (1985) and Marini and Hodsdon (1981) argue that these type of findings typically represent a combination of causal and spurious effects. Additionally, Kohler et al. (2001) identifies several sources of such endogeneity acting through unobserved heterogeneities: a) the desired number of children a couple or a women has b) the biological characteristics affecting fecundity (the degree of infertility or how difficult it is for a women to give birth) and c) the ability affecting labor market productivity. In order to account for these sources of unobserved heterogeneity they make use of data from monozygotic Danish twins (along with some assumptions) and estimate a within twins effect. They find that, for females, there is a 3% decrease in complete fertility associated to a one year delay and that the *OLS* measure underestimates this effect by 11.4%. They conclude that this implies that unobserved labor market related ability drives the relationship much more than preferences over the number of children.

The second study that estimates this effect using micro level data was carried out in 2005 by Billiari and Borgoni (Billari and Borgoni, 2005) and aims to understand whether selection effects play a role in the observed regression coefficients in different European countries with different childbearing environments. Figure 2.3 displays their final results comparing an *OLS* estimation to a Heckman correction for selection model. Although these *OLS* results are likely to underestimate the effect under study, they are very similar to the results obtained when employing the Heckman correction model which leads the authors to conclude that these sample selection effects are very minuscule. Additionally, these results are in a similar order of magnitude and direction as the ones achieved by Kohler et al. (2001). The *OLS* coefficient reported by Kohler et al. (2001) using Danish data is 2.65% and the one estimated by (Billari and Borgoni, 2005) for Sweden is 2.81%; considering the cultural, institutional and economic differences among the remaining cases in Billiari et al. estimations it appears reasonable that the coefficients for Denmark and Sweden display smaller differences as if compared to Italy, Spain and Hungary [4].

	Heckman Model			OLS		
	Estimate	Std. Er.	p-value Wald test	Estimate	Std. Er.	p-value Wald test
Italy	−0.0353	0.0023	0.000	−0.0368	0.0023	0.000
Spain	−0.0459	0.0032	0.000	−0.0457	0.0029	0.000
Hungary	−0.0305	0.0039	0.000	−0.0305	0.0036	0.000
Sweden	−0.0281	0.0023	0.000	−0.0276	0.0024	0.000

Figure 2.3: Estimated postponement effect (Billari and Borgoni, 2005)

In a more aggregate perspective, Billari et al. (2006) discusses the causes and implications of postponement among European nations. They notice that postponement of childbearing is a process that is strongly associated to an overall postponement of sociodemographic and economic events. In particular, they argue that a negative correlation tends to arise from observing postponement and fertility out-

[4] In both studies the dependent variable is the natural logarithm of fertility. In Kohler et al. (2001) they use fertility at age 38 for identical twins who have had a child by age 32 in the 1945-65 cohort and they include a covariates for cohort trends in fertility. (Billari and Borgoni, 2005) keep the 38 and use individuals born between 1945 and 1958. The study using twin data produced statistically significant results at $\alpha = 5\%$ and relies on a sample of 591 pairs of monozygotic twins; the cross-country study has similar sample sizes; 826 (Hungary),1840 (Italy) 1351 (Spain) and 1310 (Sweden).

comes (Figure 2.4); nonetheless, this relation tend to be mediated by the institutional and economic characteristics of each unit of analysis.

	Mean age at first birth		Mean age at childbearing		Total fertility rate	
	1980	2004	1980	2004	1980	2004
Bulgaria	21.9	24.4	23.9	25.7	2.05	1.29
Czech Republic	22.4	26.3	24.7	28.3	2.10	1.22
Netherlands	25.7	28.9	27.7	30.5	1.60	1.73
Russia	23.0	24.0	25.7	25.9	1.86	1.33
Spain	25.0	29.3	28.2	30.9	2.20	1.32
Sweden	25.3	28.6	27.6	30.4	1.68	1.75

Figure 2.4: Postponement and Fertility (selected European cases) (Billari et al., 2006)

Furthermore, while there is no clear cross-section aggregate evidence that supports such negative association, individual level studies tend to find it. Studies focusing on a micro perspective also reveal that there is indeed variation in the effect according to environment specific variables: " (...) postponing first births has a particularly important impact on quantum fertility in those societies where institutional arrangements such as labor market regulations, childcare system and gender relationships make it more problematic for women to combine family life and occupational careers" (Billari et al., 2006, p. 7). They recognize i) increasing opportunity costs and ii) a decreasing chance to achieve a successful birth and a higher likelihood of adverse effects related to pregnancy as the main causal mechanisms explaining the association between postponement and fertility.

The macro perspective on postponement, largely motivated by a widespread association between the age at which women became mothers and the period measure of fertility in the fashion of Figure 2.4, faces a methodological challenge that arises from the difficulty in distinguishing quantum from period effects. As mentioned previously, an important amount of the literature explaining the general causes of the *lowest-low fertility* scenario tended to heavily rely on the existence of a *postponement-quantum* effect (Billari et al., 2006).

Billari (2008) further explore the overall European fertility decrease by setting the analysis under a parity progression perspective. The data suggests that women have not ceased to have children; they tend to pause childbearing at parity one. Why is this the case? The authors propose three possible causal explanations that tend to match the overall structure of the decline in fertility observed in Europe during the nineties: i) the degree of strength of the family system in a particular nation which can also be understood as the intensity of a welfare regime in terms of the independence granted to individuals along the development of different sociodemographic life stages ii) gender regimes or how gender affects the division of labor within the household and families and labor market performance and iii) family policy and the economic costs of children; these factors and their interactions are used in order to explain the variation in fertility outcomes in spite of a generalized increase in age at childbearing (Billari, 2008).

As the past decade unfolded, the predictions formulated on the *postponement-quantum* effect proposal did not quite matched reality and demographers then relied on the idea of a postponement transition in order to explain the initial decline and subsequent increase in period fertility observed in Europe during this time frame

(Goldstein et al., 2009). Since the biological clock dimension of postponement is mostly relevant at a quite high mean age at first birth measure, it is unlikely to be a key explanation in the behavior of fertility in Europe. Instead " the major effect of later childbearing is a temporary depression of fertility during the time when ages of childbearing are changing" (Goldstein et al., 2009, p. 673). This in turn implies that the decelerated continuation of postponement is likely to give turn to slight increases in fertility and to higher Total Fertility Rates when tempo-adjusted.

Last, Balbo et al. (2013) provides a review of the research in fertility focusing on the determinants at different levels of aggregation and some of the methodological challenges faced at micro, meso and macro levels. At individual level, the factors identified by the ongoing research are fertility intentions, partnership, the role of gender in the division of labor, economic factors (income, human capital, employment) and uncertainty, cultural and behavioral factors as well as biological and demographic variables. The authors suggest that birth timing is likely to be a dynamic in which several of these factors converge. They conclude by highlighting some key aspects that the research on fertility could profit from. The ones relevant to the present type of study are the inclusion of biological characteristics among theoretical and statistical models, the need for a general understanding of fertility dynamics that articulates the US and the European findings, the role of male partners in the fertility outcomes and the interactions between factors across different levels of analysis in empirical research.

Expectations

The overall expectations are in favor of a clear negative effect between age at first birth and complete fertility explained by the role of opportunity cost and, to a certain degree, biological mechanisms. No idea supports a generalized null or positive effect.

2.3.2 Fertility and Motherhood in the United States

After experiencing an important decline in fertility during the twentieth century in consistency with demographic transitions, the US has displayed a somewhat relatively stable fertility measures centered around two children per woman during the last decades. Complete fertility measures have been coherent with this pattern since the mid nineties as seen in Figure 2.5 and reflect an overall strong revealed preference for a total number of children of two. In spite of strong evidence for pro-cyclic fertility, fertility has responded smoothly to the strong economic fluctuations of the past decade (Butz and Ward, 1979). However, the age at which US women enter motherhood has been on the rise for decades as seen in Figure 2.6. This aggregate behavior would suggests that either woman have been able to fulfill their desired family size in spite of having children later in life[5] or that a *postponement-quantum* effect has hindered family formation based on preferences for children consistent with a growing desire for larger families. The later seems quite unlikely since it would imply an important inflection point in preference trends. This tendency has prevailed in the 2005-2015 decade; the greater increases in mean age at first birth, around 1,1 years, happened during 2009 to 2014 (Mathews and Hamilton, 2016).

[5] Also, aggregate figures do not suggests the preponderance of biological mechanisms strongly negatively affecting fertility considering the age spectrum discussed in the earliest part of the

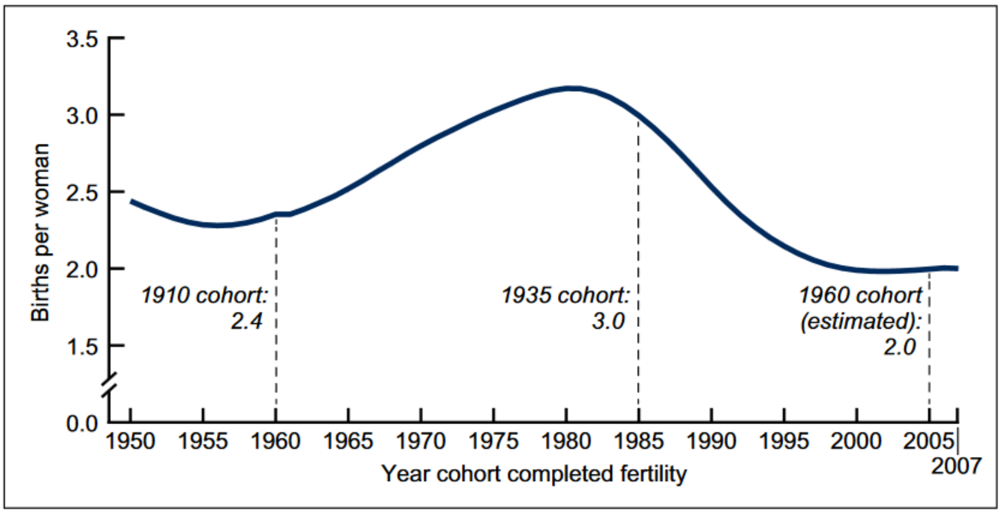

Figure 2.5: US Cohort fertility (Kirmeyer and Hamilton, 2011)

In the likely event that preferences are being fulfilled it is important to address the particularities of the maternity context and, in particular, the setting in which entering motherhood in the United States since it widely differs from the more supportive approach the majority of the developed world takes on family formation. Although it would be unfair to state that family policy in the US has not developed in comparison to the past, it is quite clear, by several standards, that the United Stated lags with regard to income support, health and early care and education in relation to children (Kamerman and Kahn, 2001) and it is the only developed nation and one of the three countries in the world that does not centrally enforce any form of paid maternity leave. Currently, the 1993 *Family and Medical Leave Act* (FMLA) provides 12 weeks of unpaid maternity leave which provides a federal standard to a previously disperse policy that was particularly unfavourable for some states (Berger et al., 2005).

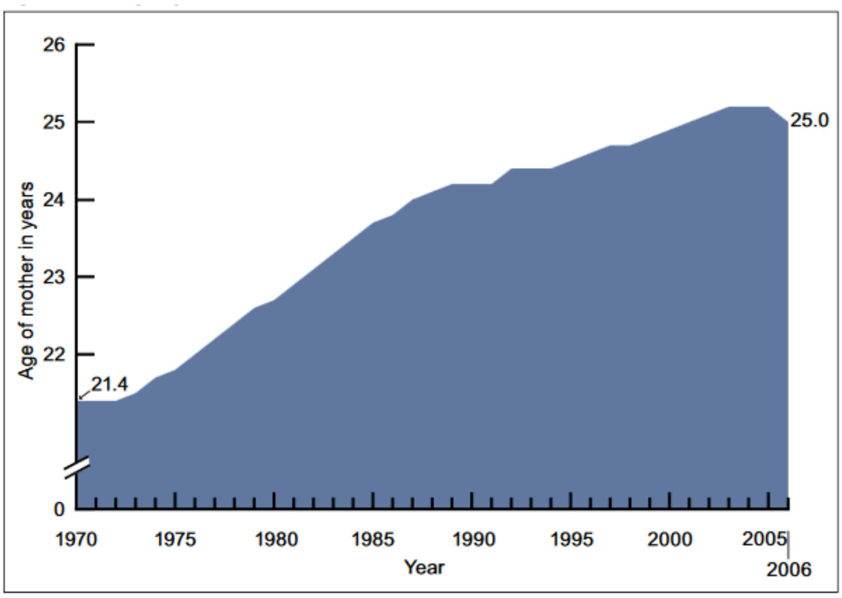

Figure 2.6: US Average age of mother at first birth (Matthews and Hamilton, 2009)

current chapter.

Even though the expansion of family policy remains somewhat controversial, with detractors supporting the idea that it will incentive discrimination, California, New Jersey and Rhode Island have developed paid leave state laws with some favourable results during the last decade and the New York state will join them in the near future (NPWF, 2016). Paid leave is, however, not entirely nonexistent but manifests mainly as a substantial benefit that firms might offer employees; there is, nonetheless, evidence suggesting that there are important barriers that dissuade women from up-taking paid leave even when available due to social norms and interactions and firm retaliation (Albiston and O'Connor, 2016). Additionally, although the Pregnancy Discrimination Act (PDA) signed in 1978 made substantial progress in reducing motherhood as a barrier to the labor market, recent trends in charges pressed by women claiming pregnancy-based discrimination displayed substantial increases and positive trends by the end of the past decade.

3

Data

The data employed for the mentioned estimations is the *National Longitudinal Survey of Youth 1979*. This data was selected because it fulfilled the specifics needs of the study and the data collection operation has demonstrated quality as the hundreds of studies carried out using this data set witness. In particular, the study needed data from the US that provided information on the reproductive behavior of women and, especially, on complete fertility. Other data sets consulted either met one or another requirement but not both.

The *NLSY79*, an initiative developed under the US Bureau of Labor Statistics, is a data collection operation that targets a cohort of 12,686 individuals that began in 1979. This cohort consisted of individuals born between 1957 and 1964 meaning that they were aged 14-22 at the moment they were surveyed for the first time and. The last wave considered displays data for individuals between ages 47 and 55 which is suitable for the study's purpose. There is also no attrition.

However, given the aims of the research, the relevant sample is limited to women who had children. Out of the 12,686 individuals followed from 1979 onward, half (6,283) are women. 4,933 had children but only 4,016 did so during the time span observed by the survey[1]. Within this group, most women had 2 children and three experienced the death of an only child and displayed no further births; these were excluded from the final sample. Eventually, the set of observations that constitutes the sample used for the estimations ahead was delimited based on an internal consistency maximization strategy; only observations that display no missing values in all variables (in the descriptive statistics table) were included. This implied that sample size was somewhat affected but comparability across estimations and figures is optimal.

Total number of children and age at first birth identification specification was straightforward and when where women had children before the observed time span the survey considered retrospective interrogation regarding timing and quantum when this was the case that more than one child was born prior to 1979. Schooling and education was quantified as years of schooling and as dummy variables representing achievement of certain stages of secondary and tertiary education since these might capture with more precision certain dynamic that years of schooling may not. Nonetheless, years of schooling was useful when determining if women had pursued more schooling after motherhood. Although income was heavily under-reported in

[1]The group of women who entered motherhood before they were interviewed by the survey display information on age at first birth but not on key covariates at that moment.

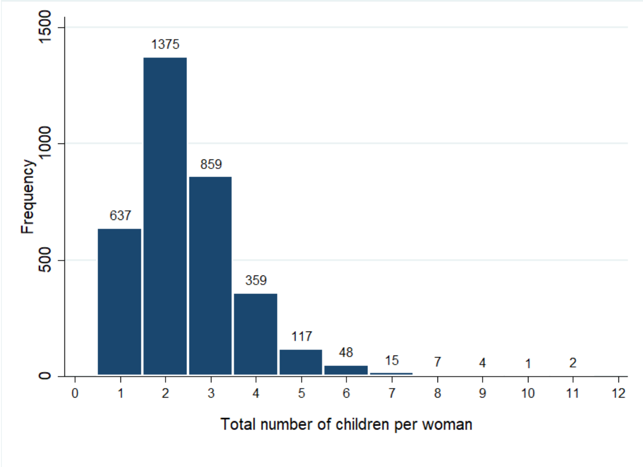

Figure 3.1: Fertility distribution

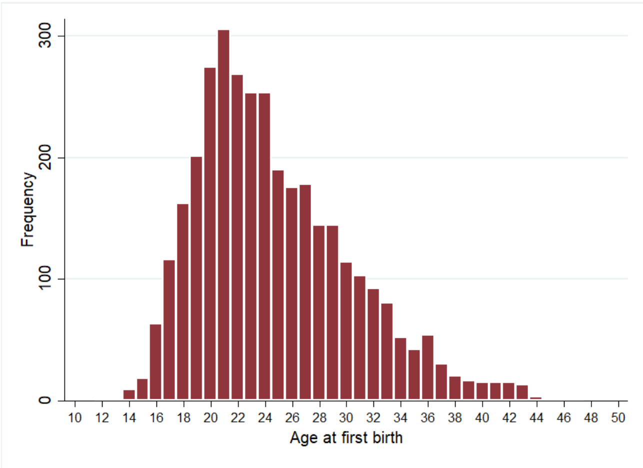

Figure 3.2: Age at first birth distribution

the survey, in particular among the pre 2000's waves making difficult to establish a direct measure of earnings in age at first birth, a highest perceived income variable was considered to assess a crucial part of the earnings profile. Hourly wage rate was initially perceived as a better measure of human capital returns and overall labor market positioning, but the extreme variation displayed suggested it was not reliable. Finally, instruments in the form of failed marriage and miscarriage/stillbirth where defined as a failed marriage and miscarriage/stillbirth prior to first birth. Failed marriage seems more likely to fulfill the identification assumption; individuals are not likely to engage in marriage expecting it to fail, otherwise, why do it? Miscarriage/stillbirth might do so to a lesser extent; having a miscarriage or stillbirth might be correlated to the overall capacity to achieve desired family size. Nonetheless, given the preference for moderate sized families and relatively early entry into motherhood, the net effect might be more in the direction of postponement. Results associated to this instrument are, nonetheless, taken with a grain of salt.

The final desired number of children quantity was obtained from the question from the first wave. Even though the measure from 1982 might seem convenient in terms of more realistic assessments the number of responses for the later wave was extremely low; this compromised the final sample size and it did not prove reliable information since some women had already entered motherhood by 1982. Ethnicity

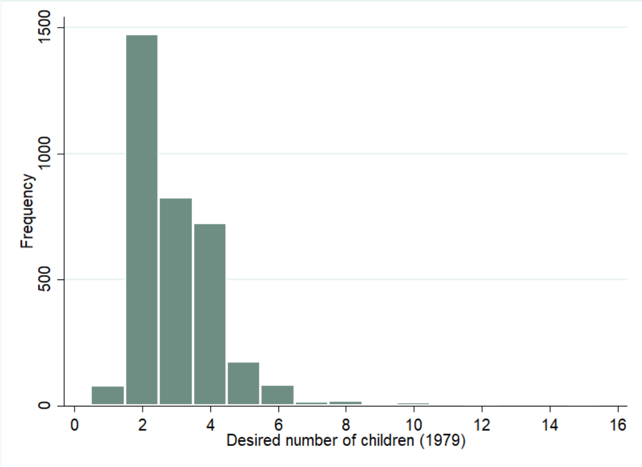

Figure 3.3: Desired number of children in 1982

was included due to the distinct fertility patterns followed by these categories in the US. Finally, the estimated cost of raising a child was included based on the estimations provided by the US department of Agriculture. Although this organization has calculated these measures since the seventies, it was no possible to find data for most of the earlier part of the series in spite of several communications. A linear projection for missing years was used to complete the series.

The figures in the current section present distributions for several variables of interests. Most women had an effective number of children around 2 and number quickly decrease as families become larger. Age at first birth reveals a preference for motherhood entry in the early twenties bit also show a distinct skewness; the share of women who enter motherhood decreased as they approach 40 and practically none enter motherhood after 45. Desired family size is more concentrated in parities 3 and 4 in comparison to actual family size; a rough analysis would suggest that targeted size is not being met. Distribution of years of education clearly show that a large part of the sample is concentrated around completed highschool education; concentration also suggests that there a shift towards more concentration in post highschool education meaning an important portion of mothers did not stop their education gain process after entering motherhood.

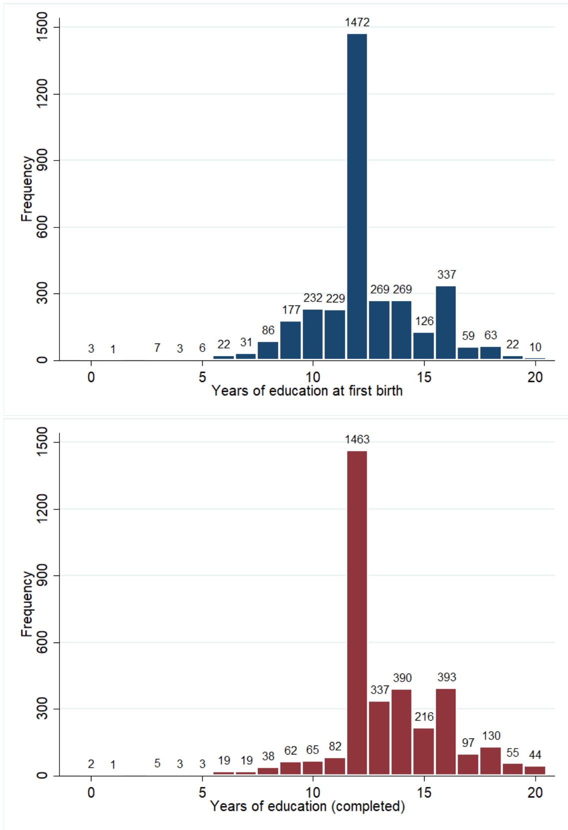

Figure 3.4: Changes in years of schooling

Figure 3.5: Direct children cost. Data from (Edwards, 1979), (Edwards, 1981) and (United States Department of Agriculture - Center for Nutrition Policy and Promotion, 1995-2012)

Table 3.1: Descriptive statistics NLSY79

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Total number of children	3,424	2.483	1.209	1	11
Failed marriage before first birth	3,424	0.0645	0.246	0	1
Miscarriage/Stillbirth before first birth	3,424	0.0526	0.223	0	1
Years of schooling at first birth or first known	3,424	12.41	2.420	0	20
Incomplete highschool	3,424	0.233	0.423	0	1
Complete highschool	3,424	0.430	0.495	0	1
Incomplete undergrad	3,424	0.194	0.395	0	1
Complete undergrad	3,424	0.0984	0.298	0	1
Complete grad	3,424	0.0450	0.207	0	1
Desired family size in 1979	3,424	2.989	1.341	0	15
Age at first birth	3,424	24.76	5.711	12	47
Age at last birth	3,424	30.62	5.848	17	51
Highest annual income (Constant USD)	3,424	38,375	40,242	0	343,830
Consumer Price Index (CPI)	3,424	107.8	28.84	40.50	218.1
Estimated cost of children (Constant USD)	3,424	109,955	65,461	20,770	291,570
Ethnicity - Black	3,424	0.298	0.458	0	1
Ethnicity - Hispanic	3,424	0.206	0.405	0	1
Ethnicity - nonblack or hispanic	3,424	0.495	0.500	0	1
Cohort	3,424	1,961	2.203	1,957	1,964
Years of schooling	3,424	13.30	2.463	0	20
Fertility differential (desired - actual)	3,424	0.506	1.711	-9	14
Multiplebirth in incomplete fertility	3,424	0.0350	0.184	0	1

4

Methods

In order to quantify the effect of age at first birth on the *quantum* of complete fertility, the study will rely on coefficient estimation product of different regression analyses. This is practical because it sets and relates the empirical analysis in terms of a common methodology in relation to similar studies. It also constitutes an advantage since the causal or descriptive nature of a study is heavily formalized within econometrics and the main hypothesis at stake constitutes not exclusively a prediction but an expression of causal mechanisms. As it has been mentioned previously, the processed by which women choose *when* to enter motherhood and *how many* children to have are very likely to be strongly related through different effects. This presumption results in a high probability of biased regression coefficients which might over or understate the importance of the effect under assessment. Additionally, conclusions based on uncritical assessments might mislead the public and constitute dubious input to policy generation. The following pages describe the general regression framework utilized.

4.1 Estimators

4.1.1 Ordinary Least Squares

Within the regression analysis framework, the Ordinary Least Squares (OLS) estimator is the default tool because, under certain assumptions, it is the Best Linear Unbiased Estimator since it resembles the true effect of a set of independent K variables ($X_{N\times K}$) on a particular outcome $Y_{N\times 1}$ and it has minimum variance among all linear unbiased estimators. This leads to the standard linear regression model (Equation 4.1) which explains the observations in Y through a $\beta_{K\times 1}$ transformation of the X matrix and a stochastic error term $\varepsilon_{N\times 1} \sim IID(\mu_\varepsilon, \sigma^2)$ in which all the unobserved factors that affect in a stochastic manner the process considered are accounted for.

$$Y = X\beta + \varepsilon \tag{4.1}$$

However, in order for an estimation of these β parameters ($\hat{\beta}$) to reasonably approach the true quantities, the model specification has to be consistent with a particular assumption about the error term. The least strong assumption that guarantees unbiasedness of the $\hat{\beta}$ coefficients is exogeneity (Equation 4.2); the independent variables must not be correlated with the error term (Verbeek, 2008). Also, the estimator is only computable when $X'X$ is invertible.

$$E(\varepsilon|X) = 0 \tag{4.2}$$

If this is not the case and the error is indeed correlated with X, then the $\hat{\beta}$ coefficients are likely to represent the influence of those unobserved factors correlated with the regressors leading to an erroneous assessment of the effect of X on Y; in this sense, $\hat{\beta}_{OLS}$ is *biased*. The definition for the estimator in terms of the observables derived from the minimization of the Residual Sum of Squares ($\varepsilon'\varepsilon$) (Equation 4.3), can be transformed to demonstrate how, under exogeneity, the OLS estimator is unbiased (Equation 4.7-Equation 4.8)

$$\hat{\beta} = (X'X)^{-1}X'Y \tag{4.3}$$
$$\hat{\beta} = (X'X)^{-1}X'(X\beta + \varepsilon) \tag{4.4}$$
$$\hat{\beta} = (X'X)^{-1}(X'X)\beta + \varepsilon \tag{4.5}$$
$$\hat{\beta} = \beta + \varepsilon \tag{4.6}$$
$$E(\hat{\beta}|X) = E(\beta) + E(\varepsilon|X) \tag{4.7}$$
$$E(\hat{\beta}|X) = \beta + 0 \tag{4.8}$$

Nonetheless, the exogeneity assumption can become controversial under many general situations. If X and ε are not independent then the expected value of the error term is different from 0 (Equation 4.9). The calculated coefficients will represent something different from the real coefficient based on the degree of dependence between the covariates and the unobserved factors (Equation 4.10.

$$Cov(X|\varepsilon) \neq 0 \rightarrow E(\varepsilon|X_d) \neq 0 \tag{4.9}$$
$$E(\hat{\beta}|X) = \beta + E(\varepsilon|X) \tag{4.10}$$

4.1.2 Generalized Instrumental Variables Estimator

When OLS estimations become unrealistic because of presumptive biasedness arising from endogeneity, the instrumental variables approach constitutes a potential solution to the problem. Conditional on data availability, a set of variables that fulfills some requirements can be used to calculate an instrumental variables estimator which is unbiased, consistent and efficient. A variable constitutes a viable instrument if (i) it is strongly correlated to the endogenous regressor (so called first stage) and (ii) only has an effect on the outcome through its interaction with a mechanism based on the defective variable (exclusion restriction) (Angrist and Pischke, 2008). While the effect of an instrument Z_r on X_k can be tested through regression analysis, the exclusionary restriction is an identification assumption. Since the empirical strategy will make use of several instruments used simultaneously to approach the suspected endogeneity problem, the generalized version of the instrumental variables estimator is considered.

A given $Z_{N\times R}$ matrix containing R instruments such that $R \geq K$, meaning at least one instrument per defective variable, will serve as the building block of a projection strategy that, if conditions are met, will render unbiased, consistent and efficient estimators of (β). The key idea behind the instrumental variables estimator is to 'break' the endogenous part of the variation in X through a projection matrix P_z. If the original X matrix of regressors is transformed by the P_z projection then the resulting estimator from the minimization of the RSS is unbiased and consistent under a basic invertibility assumption of the $X'Z$ matrix and $E(\varepsilon|Z) = 0$. The estimator is derived through the Method of Moments and its formula is presented in Equation 4.11

$$\hat{\beta_{IV}} = (X'ZW_N Z'X)^{-1} X'ZW_N Z'Y \tag{4.11}$$

When the number of instruments R is equal to the number of endogenous regressors, Equation 4.11 collapses into the usual $(Z'X)^{-1}Z'Y$ estimator because $X'Z$ is squared invertible by assumption (Verbeek, 2008). When the number of instruments is larger than the amount of defective independent variables, the efficiency of the estimator becomes dependent on the selection a W_N matrix. The optimum W_N matrix, which minimizes the asymptotic variance, W_N^* is $((1/N)Z'Z)^{-1})$ resulting in Equation 4.12 where the projection matrix P_z takes the form $Z(Z'Z)^{-1}Z'$.

$$\hat{\beta_{IV}} = (X'Z(Z'Z)^{-1}Z'X)^{-1} X'Z(Z'Z)^{-1}Z'Y \tag{4.12}$$

Because of the exclusionary restriction this estimator is unbiased meaning that, unlike β_{OLS}, the expected value of the $GIVE$ estimator is β:

$$\begin{aligned}
\hat{\beta}_{GIVE} &= (X'P_zX)^{-1}X'P_zY \\
\hat{\beta}_{GIVE} &= (X'P_zX)^{-1}X'P_z(X\beta + \varepsilon) \\
\hat{\beta}_{GIVE} &= (X'P_zX)^{-1}(X'P_zX)\beta + (X'P_zX)^{-1}X'P_z\varepsilon \\
\hat{\beta}_{GIVE} &= \beta + (X'P_zX)^{-1}X'P_z\varepsilon \\
E(\hat{\beta}_{GIVE}|X,Z) &= E(\beta|X,Z) + E(((X'P_zX)^{-1}X'P_z\varepsilon)|X,Z) \\
E(\hat{\beta}_{GIVE}|X,Z) &= \beta + (X'P_zX)^{-1}X'P_z * E(\varepsilon|X,Z) \\
E(\hat{\beta}_{GIVE}|X,Z) &= \beta + (X'P_zX)^{-1}X'P_z * 0 \\
E(\hat{\beta}_{GIVE}|X,Z) &= \beta
\end{aligned}$$

4.2 Model

Three basic models are estimated. The first model in its most general version develops an OLS estimation of the effect of age at first birth (A) and a set of controls (X).

$$F_i = \alpha + \beta A_i + X\gamma + \varepsilon_i \tag{4.13}$$

First stages for all instruments are estimated by explaining age at first birth (A) in terms of an instrument $I_r \ \forall \ r \in \{1, ..., R\}$ (Equation 4.14).

$$A_i = \zeta + \eta I_{r,i} + \varepsilon_i \tag{4.14}$$

The final model constitutes the instrumental variables version of the first model which incorporates the projected version of age at motherhood $\hat{A}$ and different combinations of covariates (Equation 4.15).

$$F_i = \alpha + \beta \hat{A}_i + X\gamma + \varepsilon_i \tag{4.15}$$

The main coefficient of interest is β since it will capture the effect of the variable of interest on fertility. In relation to the initial research question relating to the evidence of a *postponement quantum* effect, the models considered are a univariate and multivariate versions of Equation 4.13 which will result in the suspected biased coefficient; these will be compared to the instrumented versions of the exact same models and are based on Equation 4.15 in order to assess whether, once attempting to address the endogeneity problem, a causal in nature effect remains or does not.

5

Empirical Analysis

5.1 Results

Estimations of the stated models are presented in the pages ahead. Bivariate coefficients for all four models render a negative and highly significant effect of age at first birth on complete fertility. In relation to the research question there is a consistent negative association supported by statistical significance.

Table 5.1: Postponement-Quantum effect

VARIABLES	(1) OLS	(2) 2SLS - I^1	(3) 2SLS - I^2	(4) 2SLlS - I^3
Age at first birth	-0.0895***	-0.0840***	-0.105***	-0.0966***
	(0.00328)	(0.0142)	(0.0122)	(0.00979)
Constant	4.699***	4.563***	5.091***	4.873***
	(0.0833)	(0.351)	(0.302)	(0.243)
Observations	3,424	3,424	3,424	3,424
R-squared	0.179	0.178	0.173	0.178

I^1: Miscarriage/Stillbirth I^2: Failed Marriage I^3: All
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

First stages for the pair of instruments introduced reveal a clear strong and significant effect on the age of entry into motherhood. Although the failed marriage instrument has a stronger effect and, given the presumption of a more clean instrumentation, the 2SLS estimations rendered by this instrument a likely to be more reliable.

Complete multivariate models where estimated and presented in the last table. In the presence of covariates, the age at first birth coefficient for the three models still implies a negative effect. However, in all cases the statistical significance present in the bivariate version of each model is lost, standard errors increase substantially and magnitudes fluctuate widely in comparison to the initial values reported.

Table 5.2: First Stages

VARIABLES	(1) Age at first birth	(2) Age at first birth
Miscarriage/Stillbirth before first birth	5.929***	
	(0.426)	
Failed marriage before first birth		6.279***
		(0.382)
Constant	24.44***	24.35***
	(0.0976)	(0.0972)
Observations	3,424	3,424
R-squared	0.054	0.073

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.2 Discussion

In term of the presumed relation between age at first birth or age of entry into motherhood and complete fertility, considering the specific characteristics of the sample favoring internal consistency, the estimations are consistent with a negative effect in accordance to what the theory and research suggest. In strict consistency with the aim of the employed methodology, the lack of statistical significance is inconsistent with a clear causal mechanism. There are wide margins regarding the uncertainty surrounding these results based on the loss of precision and statistical significance once considering the multivariate models estimated.

While these results are somewhat ambivalent in supporting a causal mechanism affecting complete fertility, the are hardly representative of the wider fertility phenomenon experienced in the US. Nonetheless, multivariate estimation reveal the prevailing importance of schooling in fertility dynamics which given the nature of the tertiary education provision arrangement in the US might capture all the variance associated to any sort of postponement. Also, the proportion of women with higher education is relatively small and large gains along earnings profiles in critical ages where family formation and labor market are not then likely to characterize a large fraction of the observations.

Table 5.3: Postponement-Quantum effect (Multivariate)

	(1)	(2)	(3)
VARIABLES	2SLS - I^1	2SLS - I^2	2SLS - I^3
Age at first birth	-0.00966	-0.240	-0.157
	(0.255)	(0.199)	(0.161)
Complete highschool	-0.285***	-0.218***	-0.242***
	(0.0918)	(0.0799)	(0.0715)
Incomplete undergrad	-0.127	-0.0595	-0.0839
	(0.108)	(0.0980)	(0.0906)
Complete undergrad	0.267**	0.316***	0.299***
	(0.120)	(0.117)	(0.113)
Complete grad	0.402**	0.485***	0.456***
	(0.169)	(0.161)	(0.153)
Desired family size in 1979	0.0665***	0.0685***	0.0678***
	(0.0141)	(0.0143)	(0.0140)
Highest annual income (Constant USD)	-1.82e-06***	-1.68e-06***	-1.73e-06***
	(5.13e-07)	(5.14e-07)	(5.01e-07)
Estimated cost of children (Constant USD)	-7.12e-06	1.32e-05	5.89e-06
	(2.25e-05)	(1.76e-05)	(1.42e-05)
Ethnicity - Black	0.0444	0.0297	0.0350
	(0.0476)	(0.0473)	(0.0460)
Ethnicity - Hispanic	0.170***	0.203***	0.191***
	(0.0615)	(0.0580)	(0.0548)
Cohort	0.0437	-0.159	-0.0859
	(0.224)	(0.175)	(0.141)
Years of schooling	-0.0335***	-0.0333***	-0.0334***
	(0.0121)	(0.0123)	(0.0121)
Constant	-81.79	318.4	174.5
	(443.3)	(346.3)	(279.8)
Observations	3,424	3,424	3,424
R-squared	0.209	0.178	0.206

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6

Conclusion

The study stated a research problem within the environment of the second demographic transition; is the transition towards a late childbearing regime affecting the intentions of family formation in a negative way. Although research in this topic has focused on the European case motivated by unforeseen fertility declines during the last decade of the previous century, shifts towards greater childbearing ages are also a reality in the US. However, fertility has remained somewhat stable.

The main objective was to assess the effect of age at first birth on complete fertility using quantitative data and quasi-experimental method. Several theoretical considerations were stated in order to contextualize the effect and all pointed in the direction of an overall negative association.

So far, the results produced would suggest that the postponement mechanism is not likely to explain declines in fertility when assessed through a causal framework and in consideration of additional mechanisms. In the perspective of the postponement-quantum effect this suggests that opportunity costs are not rivaling family formation processes to the point where noticeable responses are observed.

Future research might consider more representative sample in order to account for driving mechanisms that selection processes associated to missing data might be shadowing. Advances in complete fertility projection might ease the difficulties associated to this research rendering some insights in relation to empirical evidence that support mediating mechanisms in the postponement-quantum hypothesis.

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Appendix A

(Appendix A title)

$$\pi_t = \sum_{j=0}^{T-t} ((1-\tau_{t+j}) w_{t+j} \phi^j - \theta_{t+j}) \delta_{t+j} + \sum_{j=0}^{T-t} (m^j_{t+j} - \alpha_{t+j} + (1-\phi^j) c^j_{t+j}) \delta_{t+j} + \mu_1 \sum_{j=1}^{T-t} \left(\sum_{l=0}^{j-1} \phi^l \right) (1-\tau_{t+j}) h_{t+j} w_{t+j} \delta_{t+j}$$

Component	Description	Value/Source
τ_t	Average tax rate in year t	National and local tax rates from Tasiran and Gustafsson (1990)
w_t	Annual earnings	Age-specific earnings for female shop-assistants from Tasiran and Gustafsson (1990)
ϕ^j	Fraction of year required for parental child care	$\phi^0 = 1$, $\phi^j = 0.5$, $1 \leq j \leq 6$
θ_t	Parental insurance benefits in year t	Olson (1987) and Walker (1991)
m_t^s	Direct expenditure on child-related goods for child age s	Obtained from consumer expenditure survey of 1969 (see Appendix A)
α_t	Child allowances in year t	Statistik Årsbok 1991
c_t^s	Expenditure on child care	A weighted average of private child care costs and public child care costs. Fees for public child care from Gustafsson and Stafford (1992); private fees assumed four times the fee for public care. The weight factor equals the probability of obtaining a public child care slot
μ_1	Return on human capital	From Walker (1994) and Hibbs (1990): 4.1% before 1966; 2.7% 1966–1975; 1.3% 1976–1989
r	Real interest rate	3%
δ_t	Discount factor	$(1+r)^{-(t-1)}$
h_t	Fraction of year t spent working	1
T	Terminal period	Age 65

Figure A.1: Children shadow price Walker (1995)

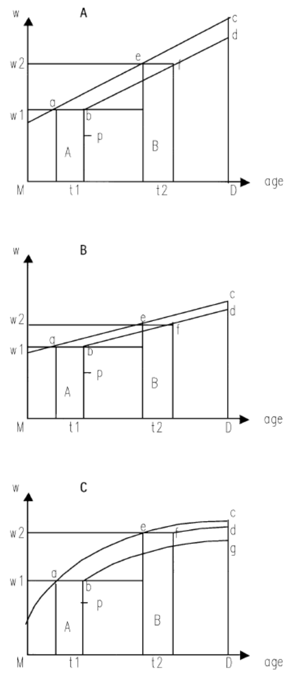

Figure A.2: Timing of first birth and lifetime earnings of the mother (Gustafsson, 2003)