Educational Pairings and Fertility Decline in Brazil: An Analysis Through Cohort Fertility

Abstract

BACKGROUND

The fertility transition in Brazil was the result of multiple socioeconomic transformations that initiated from 1930s on-wards. The education expansion played an important role in this process by promoting changes in social norms and in assortative mating profiles.

OBJECTIVE

We aim to address the interaction of male and female education on completed fertility levels. Additionally, we want to estimate the effects of educational pairings compositional changes in the context of fertility transition in Brazil.

METHODS

We estimate cohort fertility rates (CFR) for different educational pairings, considering female cohorts born between 1925 and 1969. Further, we decompose differences in CFR between young and older cohorts into rate and structure (educational pairing composition changes) effects.

RESULTS

The couple's CFR in Brazil fell from levels higher than 6 children per women for cohorts born in 1925-1929 to less than 3 for females born in 1965-1969. Educational pairing composition changes responded for approximately one third of these changes in cohort fertility. We have observed marked fertility gradients between male educational categories controlling for female schooling, especially between couples in which males did not complete primary education and in which males finished primary school.

CONCLUSIONS

Results suggest that changes in educational pairing composition through males' or females' rising educational responded for an important share of the cohort fertility decline in couples. Additionally, we argue that to a certain extent, a slower male educational expansion might have restrained the pace of fertility transition of the country.

CONTRIBUTION

The cohort analysis and male schooling influences on family size represent good tools to understand Brazilian fertility transition, and it also provides new perspectives of analyses for other Latin American countries that have experienced a similar reproductive decline process.

1. Introduction

Brazil observed a significant reduction of its total fertility rates since 1960s (Merrick and Berquó 1983) and by 2010-2015 the country was already under below-replacement fertility levels (Berquó and Cavenaghi 2014; Castanheira and Kohler 2015; Lima et al. 2018; Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018). The country's fertility transition was marked by heterogeneous starting, timing and pace across its regions and socioeconomic strata (Potter et al. 2010).

The pioneers of the fertility decline were social groups with higher socioeconomic status, especially those living in urban and industrialized areas of South and Southeast of the country; they were forerunners in the practice of birth control, which took place before the beginning of the generalized decline of fertility in the 1960s (Gonçalves et al. 2019; Guzmán and Rodríguez 1993; Merrick and Berquó 1983). In opposition to the steady and gradual fertility transition seen in developed nations, the acceptance of modern contraceptive methods rapidly spread from higher social status groups to lower socioeconomic strata of Northern and Northeastern parts of Brazil (Berquó and Cavenaghi 2014; Carvalho and Wong 1992; Perpétuo and Wajnman 1998). To illustrate, in these two regions, social groups of lower schooling levels and lower household income started to experience a fertility decline by the 1980s, but at a much-accelerated pace than similar groups from other regions, where the fertility decline

commenced twenty years earlier (Potter et al. 2010; Potter, Schmertmann, and Cavenaghi 2002).

Several factors explain the converging fertility regimes among social groups and, thus, the fast pace of fertility transition in Brazil. We can mention industrialization and urbanization, changes in labor market and productive structures, reduction of infant mortality rates, higher access to formal schooling followed by a higher rates of female participation in the labor market, changes in gender relations, expansion of consumer society and communication systems among other factors related to socioeconomic and technological development (Alves 1994; Castanheira and Kohler 2017; Faria 1989; Lam, Sedlacek, and Duryea 1992; Martine 1996; Merrick and Berquó 1983; Oliveira 1989; Paiva 1987; Potter, Schmertmann, and Cavenaghi 2002; Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018). Notwithstanding, the difference in paces and periods that each region experienced the fertility transition can be attributed to an uneven spread of these processes through the country, resulting in non-negligible demographic inequalities (Carvalho and Brito 2005; Patarra and Oliveira 1988; Wong and Carvalho 2006; Wood and Carvalho 1988).

Despite the relevance of all these variables, we may argue that the expansion of population's access to education was one of the main drivers of the fertility transition in Brazil (Carvalho and Wong 1992; Lam, Sedlacek, and Duryea 1992; Merrick and Berquó 1983), especially

in more recent periods. Education exerts direct and indirect influences on demographic processes by shaping the life course of individuals through human capital formation (Lutz 2010). For instance, recent trends in rising female educational attainment favored more female participation in the labor market and fostered the postponement of childbearing (Neels et al. 2017). Recent rising educational attainment movements throughout the globe also promoted changes in the composition of conjugal markets and assortative mating profiles of countries (Esteve and McCaa 2007; Mare 1991; Ribeiro and Silva 2009). At last, education plays an important role regarding individual's social and gender norms, encouraging new ideals of family size and cooperation between partners in the household realm (Adserà 2018; Esping-Andersen 2009; Jejeebhoy 1995; McDonald 2000).

Recently, demography scholars have been exploring cohort and male fertility as tools to study fertility trends in the context of postponement of childbearing (Neels et al. 2017; Rosero-Bixby, Castro-Martin, and Martin-Garcia 2009; Sobotka 2004), rising of female schooling (Esping-Andersen 2009; Neels et al. 2017; Van Bavel, Schwartz, and Esteve 2018) and its effects on changing gender norms, family commitment and reproductive behavior (Adserà 2018; Esping-Andersen 2009; Goldscheider, Bernhardt, and Lappegård 2015; McDonald 2000). Yet, neither of these approaches have been broadly explored for the Brazilian fertility context.

In this work, we estimate cohort fertility levels in Brazil using census data, because the country does not dispose of longitudinal data to track down life course demographic processes. With the information of respondent's age and the inquiry reference date of multiple Brazilian national censuses (1970, 1980, 1991, 2000 and 2010), we reconstruct birth cohorts and reproductive indicators (mean children ever born) and make associations with schooling expansion processes that took place in the country throughout the second half of the XX century. Afterwards, by linking female's reproductive data with the schooling level of their partners, we assess the associations between male education and cohort fertility during the country's fertility transition. In addition, our analysis also reports regional cohort fertility trends.

This work fosters important discussions and make valuable contributions for Brazilian fertility transition studies, because few studies evaluate cohort fertility trends throughout the process of educational expansion in the country. Additionally, this work also incorporates the discussion of partners' education contribution to completed fertility levels of couples (Nitsche et al. 2018; Thomson 1997; Van Bavel 2017). In this sense, this analysis shed light on processes of fertility transition that have been promoting changes in gender norms and in family structure for several generations. Merging the perspectives of cohort changes and partners' education to fertility

analysis might provide new insights and spark new research questions in Brazilian fertility transition studies.

2. Background

2.1 Fertility decline and school expansion in Brazil

The fertility transition in Brazil have been well documented by several studies. This process was marked by contrasting fertility regimes among distinguished socioeconomic groups, as for example, highly educated social groups already adopted birth control practices prior to the onset of a generalized decline of the country's fertility levels (Merrick and Berquó 1983). A second noteworthy characteristic is that, compared to more developed regions, the fertility rates from different social strata converged into replacement fertility levels in a short period of time (Berquó and Cavenaghi 2014) and, more recently, the overall TFR reached below population replacement levels (Castanheira and Kohler 2015).

The diffusion of new contraceptive methods - in particular, female sterilization and the contraceptive pill - contributed for the rapid transition and the fertility convergence processes (Martine 1996; Merrick and Berquó 1983; Perpétuo and Wajnman 1998; Perpétuo and Wong 2009). There were, however, differences in contraceptive access and knowledge between social groups that illustrate the social

inequalities within the access to family planning (Carvalho and Brito 2005). Groups of lower socioeconomic status had access to more harmful contraceptive methods (sterilization and clandestine abortion), whereas wealthier families could consume other safer options, and opted for female sterilization only when their family size goals was achieved (Faria 1997; Martine 1996; Perpétuo and Wajnman 1998; Perpétuo and Wong 2009). Nowadays, despite similar fertility levels, these social groups differ in fertility timing, for example, females with lower schooling levels display younger mean ages at first child and fertility postponement is more common among women with completed higher education (Lima et al. 2018; Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018).

In common, these studies show how education has become one and, if not, the most important key element to determine fertility outcomes in Brazil. Schooling acts as a strong determinant of reproductive behavior of women through several mechanisms (Jejeebhoy 1995). Moreover, formal education affects females' exposure to childbearing by shaping both labor market participation and conjugal decisions (Castro-Martin and Juarez 1995; Neels et al. 2017). Additionally, education also helps to provide the accomplishment of reproductive intentions, by promoting the access to information on modern contraceptive methods and other relevant scientific knowledge (Cleland and Wilson 1987; Jejeebhoy 1995).

By the time of fertility transition started in Brazil, its educational system expansion was already ongoing, fomented by a shift in the economic and production model adopted by the country (Romanelli 1986). The rupture between dominant political classes promoted a gradual transformation in the country's economy and social environment (Merrick and Graham 1981; Paiva 1987). In time, Brazil's productive model shifted from an economy based on exports of agricultural goods to an economic model partially based on urban centers growing service sector and import substitution industries which fomented the urbanization of the country and, in particular, of the Southeastern state of São Paulo (Merrick and Graham 1981; Singer 1973).

The main transformations in the educational policy from 1930 to 1960 were targeted to expand the educational system to provide productive and consumption capacity for an urban-industrial economic model (Romanelli 1986). This movement began with the foundation of Ministry of Education and Health in 1931, followed by the creation of the National Institute of Pedagogy (which now is the National Institute for Educational Studies and Research "Anísio Teixeira"), the National Institute of Geography and Statistics (responsible for country's statistics and national censuses), and national services of industrial and commercial education (Marcílio 2014). In 1961, the first Law of Directives and Bases of National Education, reviewed in 1971, set up

the obligation of basic education to the whole population, and established the bases of the current educational system of the country, composed by primary and secondary compulsory schooling (Marcílio 2014). From 1970 to 2000, Brazil experienced relevant increases in enrollment rates across all educational levels (Komatsu et al. 2017), and in the 1990s the country finally achieved universal primary schooling enrollment (Castro 1998).

The Brazilian formal schooling expansion occurred, however, at a slower pace than in other South American countries and was not evenly distributed across educational levels (Komatsu et al. 2017). For example, primary education has received lower investments for its expansion than secondary or tertiary education (Kang 2006; Komatsu et al. 2017; Romanelli 1986). This was partly explained by the adopted education administration structure between government entities. The administration of primary educational systems was under states and municipal accountability, while the financial resources were centralized at federal government level (Kang 2011), which was also responsible for the regulation of the tertiary education system. Therefore, urbanized industrial municipalities (in the South and Southeast) had more resources to invest in primary education than underfunded areas (from North and Northeast), which later reflected in structural inequalities that are still visible in the country to this day (Barros and

Mendonça 1995; Komatsu et al. 2017; Merrick and Graham 1981; Wood and Carvalho 1988).

The educational composition of the Brazilian population also changed over the course of the XX century, in particular, women were significantly affected by the country's educational expansion (Fígoli 2006). At first, females benefited from schooling gains through a gender-stratified educational system, in which they received instruction to operate in specific labor sectors such as health, hospitality and education (Besse 1999). This process affected the female labor market structure and status, creating persisting wage inequalities between men and women, but it also fostered women the opportunity to leave their household and to participate more in the public spheres of the society (public spaces such as commerce and labor market) (Azevedo and Ferreira 2006; Maluf and Mott 1998).

In sum, female schooling resulted in the reversion of male educational advantages (Beltrão and Alves 2009), and it has promoted important transformations in gender relations and social norms of the country through the course of the XX century (Itaboraí 2015). As a result, we saw an increasing participation of women in the labor market (Scorzafave and Menezes-Filho 2001) and a larger female attendance in secondary and tertiary education (Godinho et al. 2006). In the course of the country's fertility transition women achieved higher educational gains than men (Beltrão and Alves 2009; Ribeiro and Silva

2009), leading to a decrease in educational hypergamy - conjugal profiles in which male partners have higher educational attainment level than their female partners (Ribeiro and Silva 2009).

2.2 Assortative mating trends in Brazil

The population's assortative mating patterns depends to a great extent on the heterogeneity of social characteristics of its individuals (Blau and Schwartz 1997). Conjugal unions represent an opportunity of social interaction between distinct social groups, but this interaction depends on the conjugal market's composition and the size of each group (Kalmijn 1998). In this context, educational composition of conjugal markets plays an important role and are usually analyzed by demographers due to some important advantages over other socioeconomic indicators such as income. Besides its importance in shaping an individual's life course, preferences and professional realizations, education attainment is usually stable over time for adults. Individual income, on the other hand, is volatile and sensitive to macroeconomic fluctuations (Esteve, Garcia-Román, and Permanyer 2012; Kalmijn 1998; Mare 1991; Warren 1966).

In addition, schools are the environment that shapes social networks among individuals and in which union formation generally takes place (Eckland 1968; Warren 1966). Therefore, the massification of formal education is one of the drivers of the biased (and sometimes

unconscious) allocation of couples in conjugal formation. In general, unions take place between people of similar educational levels, due to closer social contact of school classmates and the shared human capital formation (Kalmijn 1998). College-educated couples are a good example of high homogamy (unions of individuals with similar characteristics) rates around the world, since these individuals have spent most of their youth in the educational system with similar peers (Mare 1991), favoring a posterior conjugal union.

The educational composition changes in Brazilian society were not only responsible for fertility decline (Lam, Sedlacek, and Duryea 1992), but it had also major effects on the country's assortative mating trends (Ribeiro and Silva 2009). Both educational hypogamy (couples in which females have higher education level than their partners) and educational hypergamy (couples in which females have lower education level than their partners) increased expressively from 1970 to 2010. Although, educational hypogamy increased at a higher pace due to female accelerated educational gains in the same period considered (Esteve, Garcia-Román, and Permanyer 2012; Esteve and McCaa 2007; Ribeiro and Silva 2009). The prevalence of educational homogamy (couples with the same educational level), on the other hand, has decreased over the time (Esteve and McCaa 2007; Ribeiro and Silva 2009).

In Brazil, homogamous mating profiles have historically shown a major prevalence between lower educated social groups and its reduction can be attributed to the expansion of the country's educational system (Ribeiro and Silva 2009). On the other hand, highly educated couples also show high educational homogamy rates (Esteve and McCaa 2007; Ribeiro and Silva 2009), and that fact shed light on the existing societal barriers in detriment of the social interactions between groups of different educational backgrounds (Torche 2010). For this reason, assessing educational levels of both partners and its relationship with couples reproduction, within a context of changing gender norms and diversifying assortative mating profiles, could provide new insights for fertility studies (Nitsche et al. 2018).

2.3 Reproductive decision making and family conflicts

Despite its relevant role in population reproduction, male and female interactions in fertility decision making have been scarcely analyzed in demography (Nitsche et al. 2018). Generally, in reproductive studies, males are left out of fertility analysis (Goldscheider and Kaufman 1996; Oliveira, Bilac, and Muszkat 1994; Van Bavel 2017). It happens due to the lack of information on male's reproductive intentions and behavior in most data sources (Schoumaker 2019). However, one can argue that males interfere in family size, because of their important role on resource allocation inside the household and in family planning

decisions (Thomson 1997). In addition, evaluating and studying male's role in couples reproduction gained importance in a period of changes in gender relations, cultural norms, family relations and assortative mating patterns.

The Western trend of female schooling expansion, followed by an increased demand for female labor force, was well as the reduction of the social costs of reproduction, led to the first phase of the Gender Revolution (Goldscheider, Bernhardt, and Lappegård 2015). This phase is marked by the increased participation of women in public life and institutional spheres (England 2010; Esping-Andersen 2009; Goldin 2006). The second phase of this still ongoing revolution would be guided by an increase in men's participation in the private sphere, e.g., in household chores and childbearing decisions (Esping-Andersen 2009). An optimistic view of this second phase expects a new balance of gender relations in the near future, with lower constraints to female reproduction and greater commitment of male partners to childbearing and domestic activities (Goldscheider, Bernhardt, and Lappegård 2015; Myrskylä, Kohler, and Billari 2011). Yet, neither the increments in female participation in public spaces nor the higher achieved female schooling levels achieved have led to improvements in division of labor by gender within families (England 2010).

Female participation in the Brazilian labor market resulted in a double burden, especially for the most vulnerable social classes that are

unable to acquire domestic and child rearing services in the private market (Guedes 2015; Itaboraí 2016). Moreover, these social constraints have induced women to undertake different strategies to conciliate their labor activities with social motherhood responsibilities (household chores and childbearing). For example, they often choose to work part-time jobs (England 2010; Guedes 2015) or they either leave formal labor or opt for jobs in the informal market (Teixeira 2014). In contrast to this group of females, women from higher socioeconomic strata dedicate lesser time to household chores, because they have easier access to home care services in the private sector, or due to the fact that highly educated male partners tend to be generally more active and cooperative in domestic activities (Itaboraí 2016).

Taking all that into consideration, in the next sections, we will analyze past Brazilian cohort fertility trends, using couples' educational pairings as a tool to capture the association of male educational levels on the completed fertility of couples.

3. Data and Methods

3.1 Data

We use data collected via IPUMS-International from Brazilian National Censuses of 1970, 1980, 1991, 2000 and 2010, conducted by the

Brazilian Institute of Geography and Statistics (IBGE, from Portuguese *Instituto Brasileiro de Geografia e Estatística*). The IPUMS data is harmonized in time and space, which allows for the comparison of different demographic scenarios and areas without the need for compatibilization (Esteve and Sobek 2003; Minnesota Population Center 2019).

For the construction of educational pairings and for computing the mean number of children ever born or cohort fertility of each pairing we used the following variables (Minnesota Population Center 2019):

- Household serial number (SERIAL);

- Person weight (PERWT) - to compute accurate statistics for the population;

- Relationship to household head (RELATE) - to identify women and its respective partners;

- Marital status (MARST) - to identify couples married or in union;

- Age (AGE);

- Children ever born (CHBORN); and,

- Educational attainment, international recode - available in four levels at IPUMS (besides unknown or not in universe codes): 1) Less than Primary Education (LP), 2) Complete Primary Education (P), 3) Complete Secondary Education (S) and 4) Complete Tertiary Education (T).

We chose to evaluate either formal or consensual unions, because cohabitation has, historically, spread across different social groups in Brazil and it corresponds to a relevant share of observed fertility levels (Esteve, Garcia-Román, and Permanyer 2012; Laplante et al. 2015; Vieira 2016). Despite the formal matrimonial and the consensual unions display different age-specific fertility profiles (Vieira and Alves 2016), as well as different fertility levels (Vieira 2016), they do not exhibit significant differentials in terms of assortative mating patterns (Esteve and McCaa 2007).

By taking the difference between census reference period and the age of women, we were able to estimate cohort fertility rates (CFR) for Brazil and selected regions. We limited the female age range to 40 to 69 years old, and the male ones to 40 to 99. We considered that, by the age of 40 years old, women would already have completed or would be close to complete their reproductive lifespan. This makes it possible to reconstruct fertility from cohorts born between 1901 and 1970.

We restrict our analysis to the cohorts born in the period between 1925-1969, because of data quality issues related to older women memory misstatements on the correct number of children ever born (Brass et al. 1968), and due to data contiguity issues among educational groups of these older cohorts (Monteiro da Silva 2019). Regarding men, we have chosen a broader age range to increase the

number of couples' observations, allowing men to be older than their female partners, and that is usually common among Brazilian couples (Vieira and Alves 2016).

Finally, we also analyzed cohort fertility, taking into account the regional socioeconomic disparities of the country, grouping the CRFs into 3 regions: 1) Midwest, 2) South-Southeast and 3) North-Northeast. These groups were chosen based on similar socioeconomic characteristics, shared characteristics of cohort fertility, as well as the assortative mating verified in previous analysis (Monteiro da Silva 2019). This regional aggregation facilitates managing issues of small sample sizes in regions of lower population density and lower population counts of some educational groups. Notwithstanding, the general Brazilian fertility decline also followed this regional grouping (Gonçalves et al. 2019).

We provide more details on the sample size and data treatments in the appendix A.

3.2 Cohort fertility trends of educational pairings

Assuming the mentioned conditions and the educational categories, we estimated cohort fertility rates for each educational pairing profile by

$$CFR^t_{F,M} = \frac{CHBORN^t_{F,M}}{W^t_{F,M}},$$

Where,

- $CFR^t_{F,M}$: Cohort Fertility Rates for cohorts of women born in time **t** with an educational attainment level **F** married/in-union with a partner that reached an educational attainment level **M**;

- $CHBORN^t_{F,M}$: Children Ever Born to cohorts of women born in time **t** with an educational attainment level **F** married/in-union with a partner that reached an educational attainment level **M**;

- $W^t_{F,M}$: Total number of women from the cohort born in time **t** with an educational attainment level **F** married/in-union with a partner that reached an educational attainment level **M**.

We compute CFRs in two ways for different methodological evaluations. First, we estimate CFRs for each educational pairing of women born cohorts, ranging from the years 1925-1969, grouped in five-year age groups and educational levels LP, P and S+ (secondary or tertiary education completed). The last two educational levels were grouped together to avoid small sample size problems and noisy CFRs estimates, due to few people with tertiary educational attainment levels from older cohorts, and to account for limitations of census educational data that shall be discussed in the section 3.4 (Nepomuceno and Turra 2020).

The CFR trends were then evaluated in terms of both males' and females' educational attainment levels, as a means to visualize how each partner's level of schooling influences the development of regional fertility in Brazil.

3.3 Decomposition of CFRs by educational pairing

As second analysis, we have computed CFR for three female cohorts corresponding to a 15-year time interval. We have divided these cohorts according to phases of schooling expansion, for men and women, and their correspondent fertility transition phase as described below:

- Cohorts born between the years 1925-39: older female cohorts, forerunners of the processes of fertility decline in the country which experienced the intensification of female schooling (Azevedo and Ferreira 2006);

- Cohorts born between the years 1940-54: women born in a period of educational system expansion and who still presented lower schooling levels than men (Beltrão and Alves 2009). These women, however, were responsible for a large share of the fertility decline, which took place in the period of 1960-80, driven by the diffusion of modern contraceptive methods (Carvalho and Wong 1992; Goldin and Katz 2002; Merrick and Berquó 1983);

- Cohorts born between the years 1955-1969: younger female cohorts that have achieved higher schooling levels than men, and have experienced higher labor market participation rates than previous female cohorts (Beltrão and Alves 2009; Lam, Sedlacek, and Duryea 1992; Scorzafave and Menezes-Filho 2001).

After computing prevalence rates of educational pairings and CFRs for each educational pairing for the three female birth cohorts mentioned above, we decomposed the differences of CFR observed between younger and older cohorts. We apply the Kitagawa's demographic decomposition method (Das Gupta 1993; Kitagawa 1955), implemented by Yoo (2014), to assess both influence of educational pairings composition changes (**composition/structure effects**) and cohort changes (**rate effects**) on observed cohort fertility decline ($ CFR $).

The overall CFR for a given period T is computed by

$$CFR^T = \sum_i^{ep} CFR_{ep}^T P_{ep}^T.$$

Further, the differences in CFR from time T1 to time T2 are given by

$$\Delta CFR_{12} = CFR^{T1} - CFR^{T2} = \sum_i^{ep} CFR_{ep}^{T1} P_{ep}^{T1} - \sum_i^{ep} CFR_{ep}^{T2} P_{ep}^{T2},$$

Where,

- T is the female cohort birth period that assume 3 cohort intervals: T = {1925-39, 1940-54, 1955-69};

- ep is the educational pairing profile, which assumes 9 possible combinations of female and male educational levels (F,M): ep = {(LP,LP), (LP,P), (LP,S+), (P,LP), (P,P), (P,S+), (S+,LP), (S+,P), (S+,S+)};

- P^T_{ep} is the proportion of education paired couples for female cohort T with an ep profile.

The cohort fertility differences are estimated pairwise, i.e. between female cohorts born in 1925-39 and 1940-54, between 1940-54 and 1955-69 cohorts, and between 1925-39 and 1955-69 cohorts. These cohort fertility differentials can be decomposed in compositional effects of conjugal markets, which are related to changes in educational pairings distribution, and rate effects, related to changes in CFR specific for each educational pairing (see Das Gupta (1993:37) for more details on decomposition of rates as functions of two vector-factors). Therefore:

$$\Delta CFR_{1,2} = \Delta CFR^{\text{effect}}_{1,2} + \Delta P^{\text{effect}}_{1,2}$$

We evaluate compositional differences in terms of changing conjugal educational profiles among female cohorts and other unobserved effects that affect CFRs among each educational profile of couples.

3.4 Limitations of analysis

The national census data impose some limitations onto our methodological approach. Firstly, they do not provide information about the duration of past unions and their influence on reproductive levels of women. As such, we assume that women conceived all the declared children (or most of them) within the conjugal unions reported at the time of the census inquiries. An increase in the number of divorces (or re-marriages) over time in Brazil is likely to influence our estimates (Camarano 2014:146). On the other hand, the union dissolution rates in the country have been considerably stable at the low values of 0.5 and 1%, from the 1980s until the beginning of the 2000s (IBGE 2014), which, in turn, could cause little harm to our analyses.

Secondly, only cohabiting couples from the same household are considered in the estimates, because the Brazilian censuses do not allow the construction of family ties from different households. Therefore, usually for economic reasons, couples may live apart, a feature commonly observed in the Brazilian Northeast (Maluf and Mott 1998), and we may miss some reproductive information of women whose partners were not living in the same household at the time of the census inquiries. As a matter of fact, this migration effect in lower-developed areas is higher for cohorts born in periods of intense migration flows, from the North/Northeast towards the Southeastern

regions of the country, as a result of the industrialization process (Singer 1973). We tried to reduce this migration effect by grouping the geographical areas into big regions. Notwithstanding, the period of intense migration flow from the rural Northern to the urban Southern areas of the country all but ended by 1960 (Baeninger 2012), affecting mostly the older cohorts born in the period of 1925-39. Nevertheless, these last cohorts are, as expected, still presenting the highest levels of fertility in the North-Northeast regions compared to the rest of the country, meaning that migration might affect the fertility education pairing estimates, but this effect is not substantial.

Finally, recent findings have brought attention to important inconsistencies of demographic measures using educational variables of Brazilian censuses. Nepomuceno and Turra (2020) analyzed survival advantages among educational groups using Brazilian census data and their results provide evidence of educational level or years of schooling misreporting. When the variable years of schooling was grouped into broader categories, such as 0-3, 4-8, 9-11 and 12+, this problem was attenuated, but implausible results for survival advantages are still remained. In our analysis, we used the broader harmonized educational categories provided by IPUMS (Minnesota Population Center 2019). The complete primary education (P) category, for instance, accounts for at least 6 years of schooling. Furthermore, we merged the two highest educational categories (complete secondary

and complete tertiary) due to the small sample of people with tertiary schooling (especially in older cohorts), which also attenuates misreporting effects of these two groups (Nepomuceno and Turra 2020).

4. Results

4.1 Assortative mating trends in Brazil

Earlier findings have already accounted for changes in assortative mating trends in Brazil (Esteve and McCaa 2007; Ribeiro and Silva 2009). In this section, we briefly present the trends in educational pairings composition by female birth cohorts. Figure 1, shows that both hypergamic (male with higher educational attainment level than female partner) and hypogamic couples (female with higher educational attainment level than male partner) have increased among cohorts. Hypogamic couples have been increasing in a faster pace due to females' higher educational gains relative to males' over the last decades (Beltrão and Alves 2009). On the other hand, prevalence rates of homogamic couples (partners with the same educational attainment level) among cohorts have been experiencing a steady decline, which is driven by the reduction of proportion of couples in which both partners did not complete primary school (see Table 1). Nevertheless, the homogamic couples are still the most prevalent in the country with prevalence rates of approximately 65% among females born in 1965-

1969 period. These trends have been observed in all regions of the country at distinguished levels, but with similar paces.

Figure 1. Prevalence rates of heterogamic educational pairings composition for female birth cohorts grouped in five-year intervals for Brazil and regions. Source: Brazilian national censuses 1970, 1980, 1991, 2000, 2010.

Figure 2. Prevalence rates of homogamic educational pairings composition for female birth cohorts grouped in five-year intervals for Brazil and regions. Source: Brazilian national censuses 1970, 1980, 1991, 2000, 2010.
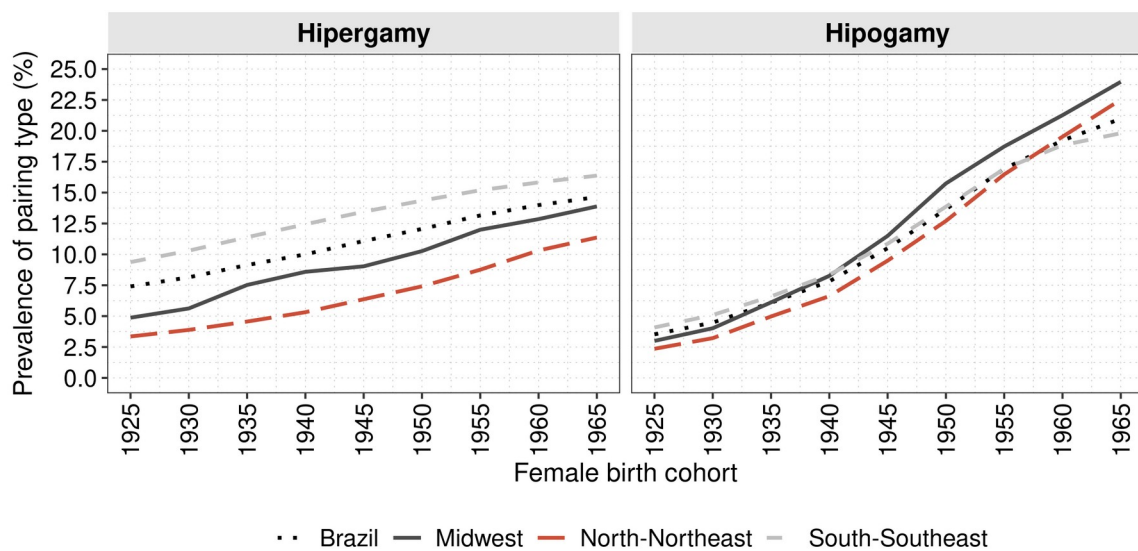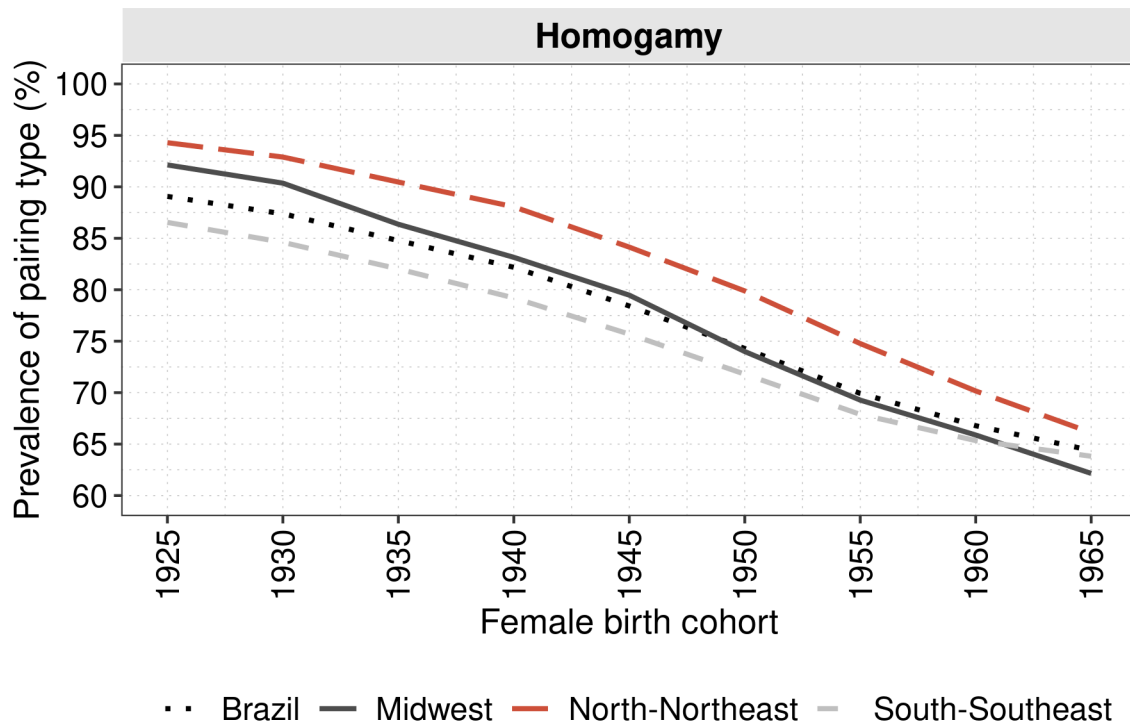

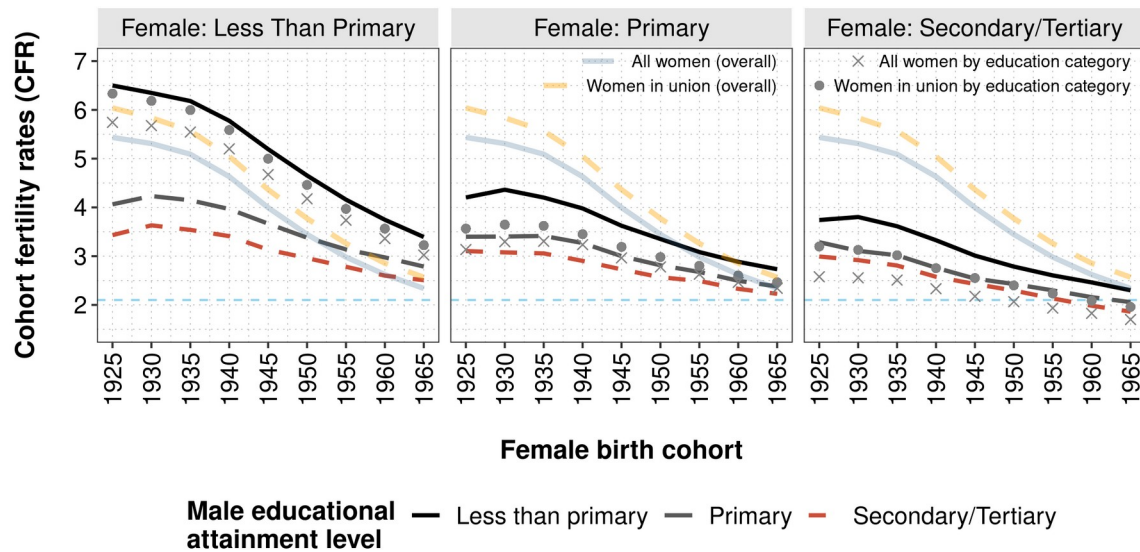## 4.2 Educational pairings cohort fertility trends in Brazil

We now turn our attention to analyze cohort fertility trends of educational pairings, following the CFRs of five-year grouped female cohorts for Brazil (Figure 3). Each panel of Figure 3 presents the variation between male educational categories for each fixed female educational attainment level. CFR estimates are also shown for all

females and for all females in union by educational attainment level. Graphical results for the three regions of the country are presented in the appendix B.

We observed significant reductions in CFR for women from all educational groups. The decline was steeper among females without complete primary education - from around 5.5 and 6 for 1925-1929 female cohorts to around 3 for 1965-1969 cohorts.

For the country, we observed marked fertility differentials for both male and female partners. For older female born cohorts, couples with at least one partner without complete primary school presented higher fertility levels than other pairings. We speculate that male partners' low educational levels could have limited the pace of the fertility transition in Brazil. On the other hand, higher female educational attainment seems less affected by males' educational category, since education increases bargaining power and autonomy of women in family decision making (Jejeebhoy 1995). Therefore, high schooled women have reproductive profiles less attached to their husband's educational characteristics and more related to females own socioeconomic status and perceived opportunity costs of reproduction (Becker 1993).

Figure 3. Educational pairings cohort fertility trends for female birth cohorts grouped in five-year intervals for Brazil. Source: Brazilian national censuses 1970, 1980, 1991, 2000, 2010.

Next, we will decompose the differences in CFR between older and younger cohorts to compute the share of structure effects of educational pairings composition and the share of rate effects. Hence,

4.3 Decomposition of cohort fertility rates

Table 1 present the prevalence rates of each educational pairing and the estimated CFR for female cohorts born in 1925-39, 1940-54 and 1955-69 for Brazil. Results for the three selected regions are presented in the appendix B.

Table 1. Educational pairings prevalence rates and cohort fertility rates for female cohorts born in 1925-39, 1940-54 and 1955-69 - Brazil. Source: Brazilian National Censuses, 1970, 1980, 1991, 2000, 2010.
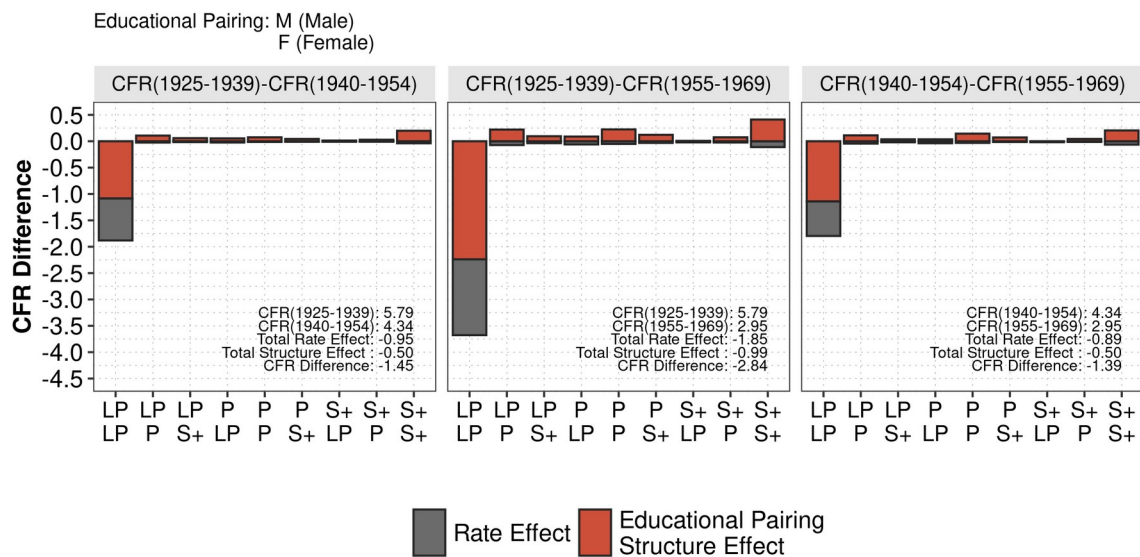
Education		Prevalence (%)			CFR		
Female	Male	1925-1939	1940-1954	1955-1969	1925-1939	1940-1954	1955-1969
LP	LP	80.70	61.94	36.89	6.33	5.21	3.89
LP	P	2.37	5.11	8.54	4.25	3.57	2.93
LP	S+	1.43	3.19	4.52	3.69	2.98	2.47
P	LP	3.99	5.39	6.50	4.15	3.63	2.99
P	P	1.96	4.29	9.55	3.41	2.97	2.52
P	S+	1.02	2.58	5.63	3.11	2.53	2.17
S+	LP	2.29	2.70	2.53	3.54	3.15	2.66
S+	P	2.03	3.03	4.77	3.08	2.70	2.36
S+	S+	4.22	11.77	21.07	2.88	2.40	2.00

As already seen, we verify that educational homogamy reduced its share in all regions of the country. The reasons are linked to decreases in prevalence rates of LP_{male}-LP_{female} educational pairings. For women born in 1925-39, approximately 81% were from the lowest schooling level and married with males from this same educational level. This number declined to 37% for females from 1955-69 birth cohorts, as an effect of compositional changes in population's education (Fígoli 2006). On the other hand, educational homogamy has increased among couples with complete secondary education, from less than 5% in

1925-1939 cohorts to 21% in 1955-1969 birth cohorts. Therefore, educational pairings in the country dispersed among higher education categories as the educational expansion was taking place.

Figure 4 presents the results of the decomposition between CFR observed for older and younger cohorts. overall CFR for these three cohorts for each region and also the results of the decomposition exercises. Brazilian couple's estimated CFR dropped from 5.79 for 1925-1939 female cohorts to 2.95 for women born in 1955-1969. The highest decrease was observed in North-Northeast regions, which we observe an expressive reduction in CFR across female birth cohorts, from 7.45 to 3.83. Yet, they started their fertility transition process from higher levels and later than other areas, hence, they still presented the highest CFR for younger cohorts - 3.83 children/women estimated for 1955-1969 cohorts compared to 2.87 for Midwest and 2.56 for South-Southeast regions (see Figures C1, C2 and C3 in appendix C for regional decomposition results).

Figure 4. Decomposition of CFR in Rate and and Educational Pairing Structure effects for female birth cohorts born in 1925-39, 1940-54, 1955-69 - Brazil. Source: Brazilian National Censuses, 1970, 1980, 1991, 2000, 2010.

In general, for Brazil and its regions, most of the reduction of conjugal CFR was driven by the rate effect (between 66 and 70% of CFR differences). The remaining share of CFR decline between older and younger cohorts is attributed to the educational pairing composition change. In this sense, the cohort fertility decline in Brazil was associated with structural changes in conjugal markets pushed by educational expansion efforts of the country that increased levels of schooling for men and women.

This structural effects of educational pairing changes are to great extent explained by the reduction of homogamous couples without

complete primary education. Between 1955-1969 and 1925-1939 cohorts, the change in prevalence rates of LP-LP couples accounted for 2 out of the 2.44 observed difference in CFR. Also, the rate effect for LP-LP couples was approximately 1.5, which indicates significant declines of CFR within the lower educated couples.

5. Discussion and conclusions

In this paper, we have shown the association between educational expansion and cohort fertility decline in Brazil and its regions for women in union. In order to assess male's schooling association with fertility levels, we computed cohort fertility rates (CFR) for different educational pairing combinations between three educational attainment categories: less than primary school completed, complete primary school and complete secondary school. By using data from Brazilian 1970, 1980, 1991, 2000 and 2010 censuses we estimated the CFR for cohorts born from 1925 to 1969.

The educational expansion in the country led to significant changes in conjugal markets, reflecting in decreasing homogamy prevalence rates (Ribeiro and Silva 2009). On the other hand, females have been experiencing higher schooling gains than males throughout the XX century, and thus, prevalence rates of hypogamic couples have risen at a faster pace than hypergamic couples'.

The changing composition of couples' educational pairings and the fertility profile of each of these pairings have not been explored in demographic studies until recently (Nitsche et al. 2018). Then, our methodological procedure allows for assessing the interaction between male and female schooling influences on completed fertility of couples, which take into account not only associations of female education and reproductive decision making, but also the male partners' role in couples' fertility levels.

As previous findings have shown, interacting partners' educational levels result in different fertility profiles (Nitsche et al. 2018). For instance, our findings show that Brazilian CFR display differences between male and female educational categories. Couples composed by partners without complete primary education have exhibited the highest cohort fertility levels, especially for older female cohorts. These CFR values exhibited a marked gradient between males' educational categories, after controlling for female schooling, with couples with males from higher educational levels showing lower fertility levels. Results for the country's regions reflect the overall trends observed for the country but at different pace and levels (see appendix B) and have been discussed in detail elsewhere (Monteiro da Silva 2019).

We also observed a sharp decline in CFR within educational categories between cohorts. We argue that this convergence of cohort fertility towards replacement regime is a result of multiple factors. First, the

reduction of illiteracy (Fígoli 2006) itself plays a key role in reproductive control adoption (Castro-Martin and Juarez 1995; Perpétuo and Wajnman 1998; Perpétuo and Wong 2009), however, it does not necessarily result in individuals finishing primary school. Second, unintended effects of institutional reforms of the Brazilian state, between 1970-1990 decades, fostered changes in social and cultural norms of the Brazilian society, which in turn increased female autonomy in family planning (Faria 1989, 1997; Martine 1996). This transformations in Brazilian society were related to the development of communications system infrastructure, which connected distant regions of the country and contributed for the diffusion of small nuclear family concept portrayed in the soap operas (Faria and Potter 1999; La Ferrara, Chong, and Duryea 2012), and to the medicalization of female population, which led to higher adoption of contraceptive methods, even by the most vulnerable social groups (Faria 1997; Martine 1996; Perpétuo and Wajnman 1998; Perpétuo and Wong 2009).

Finally, we decomposed the differences in CFR between younger and older female birth cohorts into rate and structure (educational pairings compositional changes) effects. We estimated that approximately 35% of the difference in CFR observed between 1955-1969 and 1925-1939 female birth cohorts were attributed to changes in educational pairing composition. Most shares of rate and structure effects were attributed to changes observed for couples without complete primary education,

e.g., rising educational attainment for either males or females were associated with lower fertility levels. Therefore, we hypothesize that the slower pace of males educational gains in relation to females' might have restricted higher reductions in couples' CFR.

It is important to mention that the lack of information of union histories lead to the main limitation of our analysis: all children reported by women are linked to current unions' partners. Also, CFR are likely to be underestimated due to differential mortality among educational categories (Silva, Freire, and Pereira 2016). Yet, this work brings major contributions to Brazilian fertility analysis and rises relevant insights and hypothesis on males' education role in the fertility transition process through evaluating the cohort fertility of educational pairings.

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Appendix A

Table A1 presents the sample size of each five-year birth cohort (1925-1969) for each census year. Previous findings have shown that by overlapping cohorts from subsequent census provide reliable information of CFR by educational strata, even though the estimates for most recent census are underestimated by differential mortality between social groups (Monteiro da Silva 2019). Therefore, we merged birth cohorts from different censuses to enhance statistical capacity and sample size.

Table A1. Number of sampled couples in each five-year female birth cohort and census year. Source: Brazilian National Censuses, 1970, 1980, 1991, 2000, 2010.

Cohort	Census Year	Brazil	Midwest	North-Northeast	South-Southeast
1925-1929	1970	75786	3308	22335	50143
1925-1929	1980	64691	2905	18989	42797
1925-1929	1991	48324	2389	14835	31100
1930-1934	1970	22472	1096	8039	13337
1930-1934	1980	81772	4329	23687	53756
1930-1934	1991	66500	3834	19518	43148

Cohort	Census Year	Brazil	Midwest	North-Northeast	South-Southeast
1930-1934	2000	40398	2260	12391	25747
1935-1939	1980	91252	5072	26351	59829
1935-1939	1991	88923	5421	27210	56292
1935-1939	2000	73107	4432	22847	45828
1940-1944	1980	22259	1332	7513	13414
1940-1944	1991	111885	7647	34961	69277
1940-1944	2000	100666	6717	32359	61590
1940-1944	2010	51799	3568	16418	31813
1945-1949	1991	137596	9458	42217	85921
1945-1949	2000	132781	8904	40367	83510
1945-1949	2010	91920	6380	28325	57215
1950-1954	1991	59020	4217	18210	36593
1950-1954	2000	172835	12174	51975	108686
1950-1954	2010	128652	9509	38886	80257
1955-1959	2000	195635	14286	57010	124339
1955-1959	2010	161941	12544	47396	102001
1960-1964	2000	40195	3080	12112	25003

Cohort	Census Year	Brazil	Midwest	North-Northeast	South-Southeast
1960-1964	2010	193302	15979	58052	119271
1965-1969	2010	200007	17303	62418	120286

We did not make use of imputation for missing variables, since it was not a major issue in the evaluated censuses, as can be seen in Tables A2 and A3. Missing values for the educational attainment (EDATTAIN) variable represented less than 0.25 % of the sample in all census years for all regions. In regard to children ever born (CHBORN), the missing values share was higher for the North-Northeast region in the 1991 census, responding for 7.09% of the couples in the sample. For other census years, however, this value was not higher than 2%. It is important to acknowledge that for the 2000 and 2010 national censuses, all the variables presented 0% of missing variables because they were treated by the Brazilian national statistics office. Therefore, since the missing values did not account for a significant share in the composition of the five national censuses, we just excluded the observations with missing values from our analysis.

Table A2. Proportion (%) of missing values for education variable (EDATTAIN) - Brazil and regions. Source: Brazilian National Censuses, 1970, 1980, 1991, 2000, 2010.

Census Year	Brazil	Midwest	North-Northeast	South-Southeast
1970	0.07	0.14	0.06	0.08
1980	0.13	0.11	0.21	0.09
1991	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00

Table A3. Proportion (%) of missing values for children ever born variable (CHBORN) - Brazil and regions. Source: Brazilian National Censuses, 1970, 1980, 1991, 2000, 2010.

Census Year	Brazil	Midwest	North-Northeast	South-Southeast
1970	0.69	0.87	0.87	0.59
1980	1.07	1.18	1.62	0.80
1991	5.60	4.48	7.12	4.98
2000	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00

Improbable and unreliable statements on the number of children ever born were also addressed prior to the estimation of CFR. Hence, we assumed that women can bear only one living child every 18 months,

starting from age 12 (Moultrie et al. 2013). Following this rule of thumb, at the age of 15 years old, it is expected that women have no more than two children; at 20 years of age, they may have given birth to a maximum of five children, and so on. Thus, when the stated number of children ever born exceeded this threshold expected parity, for a given woman's age, we set its value to the maximum expected number of offspring, according to the expected mother's age, following this rule of thumb. After the application of this approach, a small share of women had their parity counts modified (Table A3). In this sense, these improbable parities does not seem to impact negatively our estimates, since they only account for 0.52% of the couples at the most, in North-Northeast for women inquired in the 1970 census.

Table A4. Proportion (%) of improbable children ever born values imputed by rule of thumb - Brazil and regions. Source: Brazilian National Censuses, 1970, 1980, 1991, 2000, 2010.
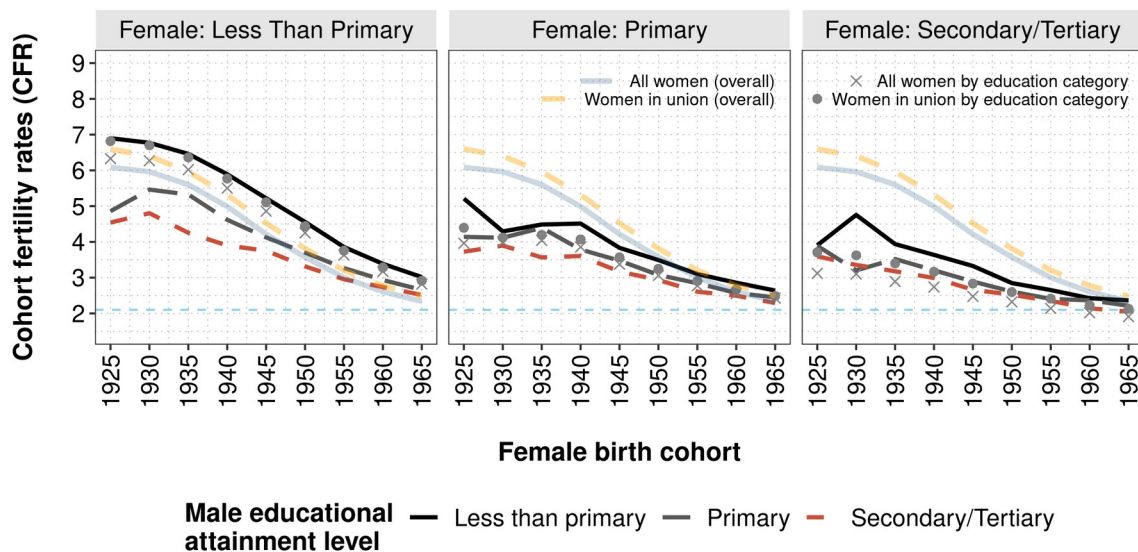
Census Year	Brazil	Midwest	North-Northeast	South-Southeast
1970	0.22	0.18	0.52	0.08
1980	0.04	0.00	0.12	0.01
1991	0.02	0.01	0.06	0.00
2000	0.01	0.00	0.01	0.00
2010	0.01	0.01	0.01	0.00

Appendix B

In this appendix B section we present the graphical results and a brief discussion of CFR trends for the three Brazilian regions - Midwest, North-Northeast and South-Southeast.

The Midwest region (Figure B1) presented a CFR transition similar to the one observed for the whole country. In this region, male schooling displayed significant fertility differentials for older female cohorts. Younger cohorts exhibit similar CFR values for all educational categories of the partner and convergence towards population replacement levels.

Figure B1. Educational pairings cohort fertility trends for female birth cohorts grouped in five-year intervals for Midwest region, Brazil. Source: Brazilian national censuses 1970, 1980, 1991, 2000, 2010.

In the North and Northeast regions, cohorts started their CFR reductions from rates near to 8 children per woman for groups in the lower educational strata. In these regions, we observed important differentials between male's educational categories, in especial between those with and without complete primary education.

Figure B2. Educational pairings cohort fertility trends for female birth cohorts grouped in five-year intervals for North-Northeast regions, Brazil. Source: Brazilian national censuses 1970, 1980, 1991, 2000, 2010.
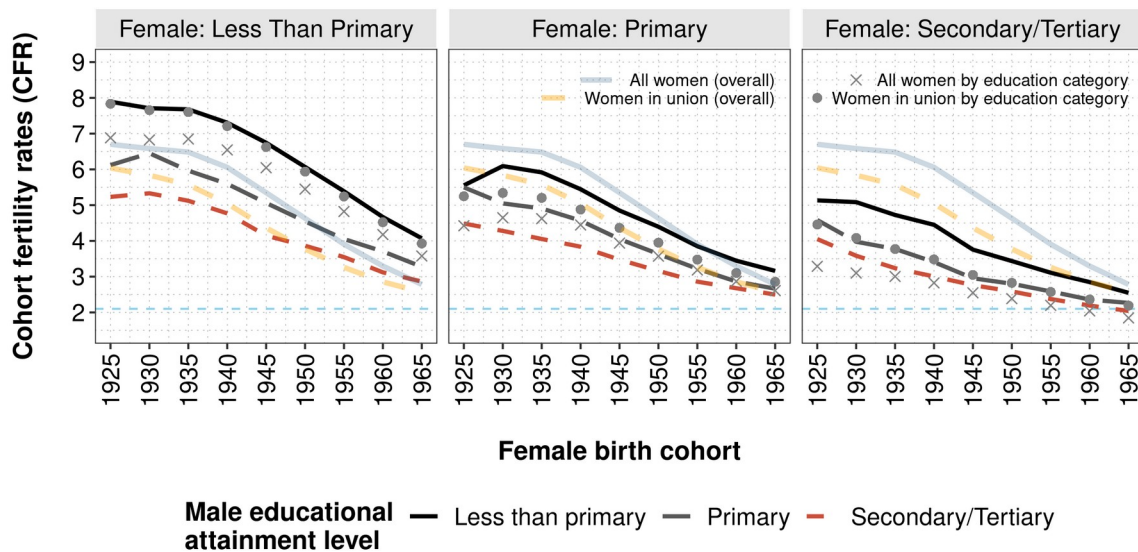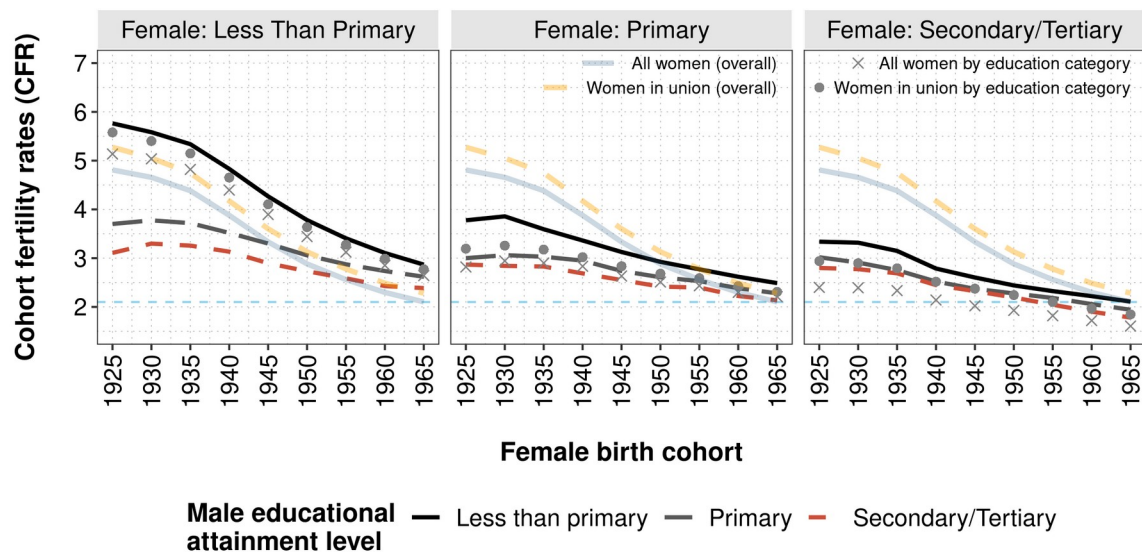
Figure B3. Educational pairings cohort fertility trends for female birth cohorts grouped in five-year intervals for South-Southeast regions, Brazil. Source: Brazilian national censuses 1970, 1980, 1991, 2000, 2010.

South and Southeast regions started their cohort fertility transition from lower CFR levels relative to other areas of the country. i.e. the rates show less than 6 children per woman for those with incomplete primary education. In contrast to lesser developed regions of the country, these areas exhibit lower CFR differentials between male educational categories. These areas have also shown the most marked CFR convergent trend towards replacement levels. For instance, for younger cohorts, born in 1965-1969, all couples with females without complete primary schooling reported bearing on average less than 3 children.

Table B1. Educational pairings prevalence rates and cohort fertility rates for female cohorts born in 1925-39, 1940-54 and 1955-69 - Midwest region, Brazil. Source: Brazilian National Censuses, 1970, 1980, 1991, 2000, 2010.

Education		Prevalence (%)			CFR		
Female	Male	1925-1939	1940-1954	1955-1969	1925-1939	1940-1954	1955-1969
LP	LP	83.47	62.51	35.12	6.68	5.23	3.55
LP	P	2.36	5.68	9.30	4.55	3.80	2.89
LP	S+	1.36	3.70	5.44	4.16	3.17	2.49
P	LP	2.88	4.65	6.05	5.27	4.07	2.98
P	P	1.68	3.96	9.34	4.26	3.34	2.62
P	S+	0.93	2.82	6.26	3.50	2.79	2.32
S+	LP	1.59	2.12	2.19	4.48	3.63	2.75
S+	P	1.76	2.60	4.55	3.70	3.18	2.47
S+	S+	3.97	11.96	21.74	3.29	2.65	2.18

Table B2. Educational pairings prevalence rates and cohort fertility rates for female cohorts born in 1925-39, 1940-54 and 1955-69 - North-Northeast regions, Brazil. Source: Brazilian National Censuses, 1970, 1980, 1991, 2000, 2010.

Education		Prevalence (%)			CFR		
Female	Male	1925-1939	1940-1954	1955-1969	1925-1939	1940-1954	1955-1969
LP	LP	89.16	73.81	48.94	7.75	6.71	4.88
LP	P	1.81	4.48	8.70	5.90	4.76	3.51
LP	S+	1.19	3.29	5.40	4.90	3.76	2.85
P	LP	2.01	3.39	5.01	6.15	4.99	3.70
P	P	1.03	2.44	6.59	5.09	3.96	2.91
P	S+	0.65	2.02	4.97	3.98	2.96	2.40
S+	LP	1.02	1.45	1.79	5.22	4.20	3.21
S+	P	0.96	1.58	3.15	4.22	3.42	2.68
S+	S+	2.17	7.54	15.45	3.48	2.72	2.21

Table B3. Educational pairings prevalence rates and cohort fertility rates for female cohorts born in 1925-39, 1940-54 and 1955-69 - South-Southeast regions, Brazil. Source: Brazilian National Censuses, 1970, 1980, 1991, 2000, 2010.

Education		Prevalence (%)			CFR		
Female	Male	1925-1939	1940-1954	1955-1969	1925-1939	1940-1954	1955-1969
LP	LP	76.62	56.36	31.57	5.55	4.30	3.22
LP	P	2.63	5.35	8.37	3.72	3.08	2.65
LP	S+	1.54	3.09	4.00	3.24	2.58	2.23
P	LP	4.98	6.40	7.23	3.73	3.26	2.77
P	P	2.40	5.18	10.93	3.03	2.72	2.40
P	S+	1.19	2.81	5.86	2.87	2.35	2.07
S+	LP	2.92	3.35	2.91	3.23	2.91	2.49
S+	P	2.54	3.74	5.55	2.84	2.53	2.27
S+	S+	5.17	13.72	23.58	2.74	2.29	1.92

Appendix C

Figure C1. Decomposition of CFR in Rate and and Educational Pairing Structure effects for female birth cohorts born in 1925-39, 1940-54, 1955-69 - Midwest region, Brazil. Source: Brazilian National Censuses, 1970, 1980, 1991, 2000, 2010.
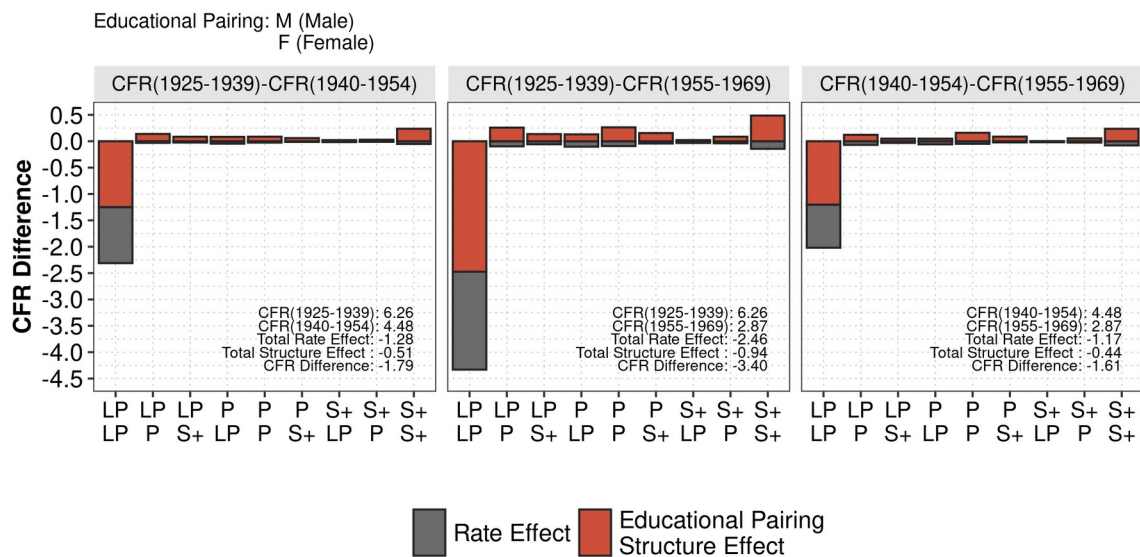
Figure C2. Decomposition of CFR in Rate and and Educational Pairing Structure effects for female birth cohorts born in 1925-39, 1940-54, 1955-69 - North-Northeast regions, Brazil. Source: Brazilian National Censuses, 1970, 1980, 1991, 2000, 2010.
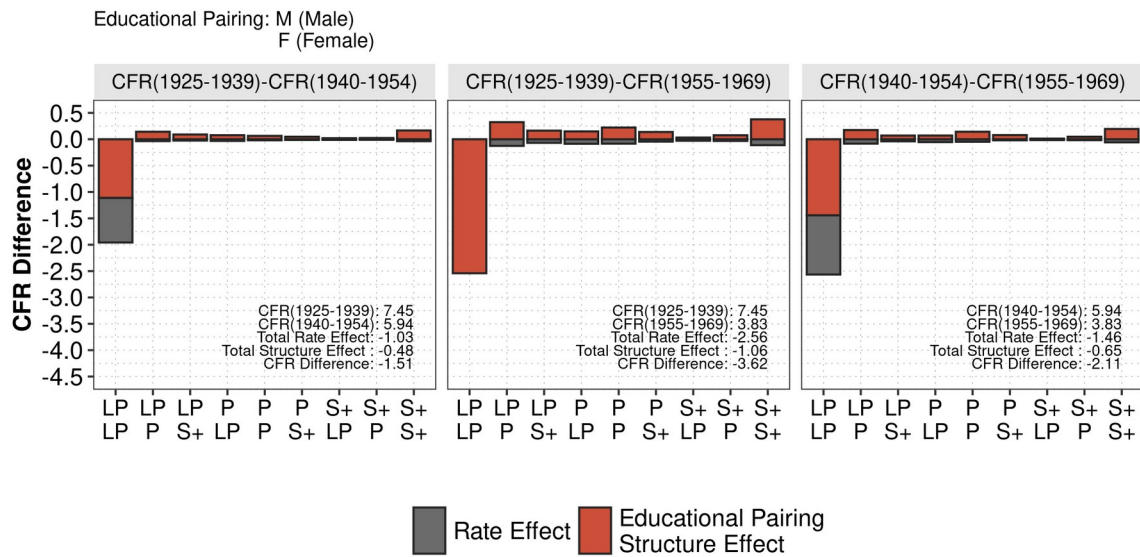
Figure C3. Decomposition of CFR in Rate and and Educational Pairing Structure effects for female birth cohorts born in 1925-39, 1940-54, 1955-69 - South-Southeast regions, Brazil. Source: Brazilian National Censuses, 1970, 1980, 1991, 2000, 2010.