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Expected Number of Siblings by Education during the Demographic Transition in Brazil

Belo Horizonte, MG
UFMG/Cedeplar
2016

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Thesis presented to the course of Master in Demography of the Centro de Desenvolvimento e Planejamento Regional da Faculdade de Ciências Econômicas da Universidade Federal de Minas Gerais, as a partial requirement to obtain the Title of Master in Demography.

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Centro de Desenvolvimento e Planejamento Regional
Faculdade de Ciências Econômicas - UFMG
2016

F363e
2016

Fernandez Menjivar, Rogelio Eduardo.
Expected number of siblings by education during the demographic transition in Brazil [manuscrito] / Rogelio Eduardo Fernandez Menjivar. – 2016.
82 f.

Orientador: Cássio Maldonado Turra.
Coorientador: Simone Wajnman.

Dissertação (Mestrado) - Universidade Federal de Minas Gerais, Centro de Desenvolvimento e Planejamento Regional.
Inclui bibliografia (f. 63-65).

1. Transição demográfica - Brasil - Teses. 2. Levantamentos de vida familiar - Teses. 3. Estatística educacional - Teses. I. Turra, Cássio Maldonado. II. Wajnman, Simone. III. Universidade Federal de Minas Gerais. Centro de Desenvolvimento e Planejamento Regional. IV. Título.

CDD: 304.62

Elaborada pela Biblioteca da FACE/UFMG – JN032/2016

I dedicate this to my father for always challenging me to be better.

ACKNOWLEDGEMENTS

I want to thank my teachers at CEDEPLAR for the knowledge they have shared and imparted over the years, my colleagues and friends for the companionship.

I want to thank the "Conselho Nacional de Desenvolvimento Cientifico e Tecnologico" (CNPq) for the financial support offered during my period as a student at CEDEPLAR.

I wish to acknowledge the statistical office that provided the underlying data making this research possible: Institute of Geography and Statistics, Brazil.

I want to thank Cassio and Simone for the guidance, both academic and beyond. Particularly for bringing my attention to this important subject, from which, I have learned much.

I want to thank by father, because when I thought I had nothing more to give, he helped me find more.

I want to thank by mother, because when I thought I had nothing to care for, she showed there is plenty.

I want to thank my sister, because when I thought I was truly alone, she was always there.

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RESUMO

O processo de transição demográfica pode variar entre os diversos grupos que compõem uma população, por exemplo por grupo educacional. Dado que a composição familiar é produto do comportamento reprodutivo e a sobrevivência, corresponde que se o caminho percorrido ao longo da transição difere entre grupos educacionais, a composição familiar também varie seguindo estes critérios.

O propósito deste trabalho é investigar a relação entra a transição demográfica no Brasil e a composição familiar. Pontualmente, procura-se elucidar a relação entre a educação e o numero esperado de irmãos que uma pessoa teria em determinada idade. A investigação tem um foco empírico. Usam-se dados dos Censos Demográficos do Brasil entre 1970 e 2010 pra gerar estimativas das funções de fecundidade e mortalidade usando técnicas indiretas de estimação. Posteriormente essas estimativas são incorporadas num modelo analítico pra produzir estimativas da disponibilidade de irmãos.

Isto é um passo fundamental pra poder estudar as transferências intergeracionais em forma de herança no Brasil. Este trabalho não abrange o tema de herança; espera-se desenvolver essa linha de pesquisa numa próxima fase. A ligação entre a transição demográfica e as transferências intergeracionais é complexa e dinâmica. Este trabalho é de caráter técnico já que ele esta concentrado em gerar estimativas de fecundidade, mortalidade e disponibilidade de irmãos usando técnicas indiretas e modelos analíticos de estimação. Tais estimativas são fundamentais pra poder fazer estudos mais sofisticados sobre a transição demográfica e o processo de concentração ou dispersão de capital num população.

Palavras-chave: Transição Demográfica, Educação, Disponibilidade de Irmãos, Transferências Intergeracionais

ABSTRACT

The process through which the demographic transition occurs can vary between educational groups within the same population. Seeing as family structures are a product of fertility and mortality trends, it follows that if the path of demographic transition has differed by educational level, then the resulting family structures will also vary.

The purpose of this work is to investigate the relation between the demographic transition in Brazil and family structures, more precisely, the relation between education and the expected number of siblings that a person of a given age may have. The investigation focuses on empirical research using the Brazilian Demographic Census data between 1970 and 2010 to generate fertility and mortality estimates employing indirect estimation techniques. Subsequently said estimates are incorporated in an analytic method to produce estimates for sibling kin.

This is a fundamental preliminary stage to research intergenerational transfers in the form of inheritance in Brazil, between 1970 and 2010. Research on inheritance is not included in this thesis; it is to be developed at a later stage. The relation between the demographic transition and intergenerational transfers is complex and dynamic. The focus of this work is primarily technical seeing as the bulk of it is destined to generating estimates for fertility, mortality and sibling kin relations using indirect methods of estimation and analytic methods of estimation. These estimates are fundamental in order to carry out a more sophisticated study of how the demographic transition affects the process of capital concentration or dispersion in a population.

Keywords: Demographic Transition, Education, Sibling Kin Relations, Intergenerational Transfers

RESUMEN

El proceso de transición demográfica puede variar entre diversos grupos de una misma población, por ejemplo, por grupo educacional. Dado que la estructura familiar es un producto del comportamiento reproductivo y la sobrevivencia, corresponde que si el camino recorrido a lo largo de la transición demográfica difiere entre grupos educacionales, la estructura familiar también varíe según este criterio.

El propósito de este trabajo es investigar la relación entre la transición demográfica en Brasil y la composición familiar. Precisamente, lo que se busca es elucidar la relación entre la educación y el numero esperado de hermanos que una persona de determinada edad tendría. La investigación tiene un foco empírico. Se usan los datos de los Censos Demográficos de Brasil entre 1970 y 2010 para generar estimativas de las funciones de fecundidad y mortalidad mediante técnicas indirectas. Subsecuentemente tales estimativas son incorporadas en un modelo analítico para producir estimativas de relaciones de hermandad.

Esto es un paso fundamental para poder investigar transferencias intergeneracionales en forma de herencia en Brasil entre 1970 y 2010. Este trabajo no abarca el tema de herencias; se espera desarrollar esa línea de investigación en una próxima fase. El vinculo entre la transición demográfica y las transferencias intergeneracionales es compleja y dinámica. Este trabajo es de carácter técnico debido a que esta volcado en generar estimativas de fecundidad, mortalidad y disponibilidad de hermanos mediante el uso de técnicas indirectas y modelos analíticos de estimación. Estas estimativas son fundamentales para poder emprender estudios mas sofisticados sobre la transición demográfica y el proceso de concentración o dispersión de capital en una población.

Palabras Clave: Transición Demográfica, Educación, Disponibilidad de Hermanos, Transferencias Intergeneracionales

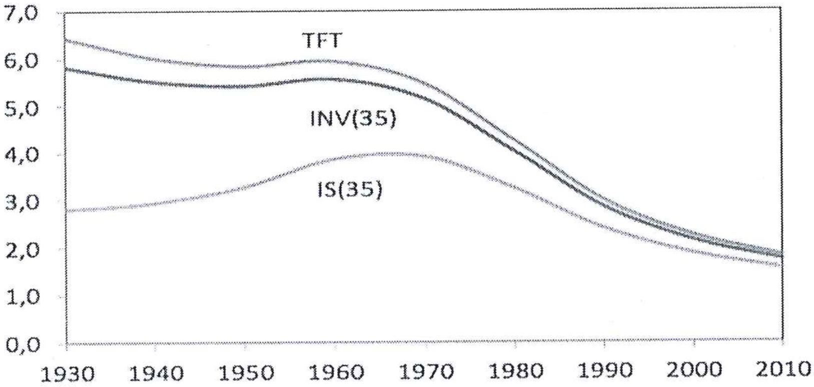
1 INTRODUCTION

The demographic transition denotes the process through which a population shifts from a regime of high fertility and mortality to one of low fertility and low mortality. This process re-shapes the way populations, and their composing individuals, reproduce, live and die. Even though there is a wide consensus in the demographic community as to the general phases experienced along the period of transition, it is also true that each population presents its own particular nuances and differentiating features. Therefore, it is important to examine how each population experiences the demographic transition and in turn, how this process dialogues with specific social, cultural and economic contexts. During the last two decades, demographic research has shed light on the relevant role demographic dynamics play with respect to social and economic processes, like economic growth, inequality, poverty reduction and the development of public policies.

Many studies have analyzed national populations when studying the demographic transition. However, national populations are composed of sub-populations, each following distinctive paths in the transition process, which can be different from the paths observed at the national level. This means that along the demographic transition, family structure, dependency ratios, and other relevant characteristics would diverge among population groups, resulting in different social and economic consequences for each subgroup. This is particularly true for a country like Brazil, which is characterized by important socioeconomic differences.

Earlier research has shown that the Brazilian demographic transition began approximately in the 1940s with infant mortality decline. The fertility transition started two decades later, in the 1960s. At the onset of the fertility transition, the TFR was slightly above six children per woman. In 2010, the TFR has dropped below replacement level. Because of both fertility and mortality declines, the size and structure of families have also changed substantially. Recently, some studies have looked more closely at these other family variables for the Brazilian population as whole, over the demographic transition (Wajnman 2012; Guerra, 2014; Guerra, Wajnman, Turra, 2016). For example, Figure 1 illustrates the impact of the rapid demographic transition on the number of siblings estimated by Guerra (2014). Changes of this magnitude in such a short period offer a rich context to study the relation between socioeconomic and demographic dynamics.

Figure 1: Trends in TFR, mean number of siblings born alive at age 35 (INV35), and surviving siblings at age 35 (IS35) of ego, in scenarios of stability; Brazil 1930-2010



(Guerra, 2014)

The interplay between the demographic components shaping kin relationships is clear in Figure 1. Following the mortality decline in the 1940s, there is an increasing number of siblings for the average individual at age 35 until the 1970s, once the fertility transition starts to reflect into a lower number of births. These patterns may vary for different population subgroups in Brazil, given the differences in the timing and in the quantum of the demographic changes by socioeconomic status. The existence of these divergent paths by social groups is recognized in the demographic literature. Yet their demographic and social implications have not been fully explored.

1.1 Objectives

To shed some light on this gap in the Brazilian literature regarding the impact of these divergent trends, the purpose of this thesis is to examine the demographic transition by educational groups, and its consequences for the expected number of siblings. The specific objectives are:

1. Examine how mortality and fertility transitions have evolved according to education groups between 1970 and 2010 in Brazil.

2. Measure and analyze how the different socio-economic subgroup paths along the demographic transition have translated into varying number of siblings by education groups.

3. Discuss possible pathways linking changes in the number of siblings and socioeconomic development, particularly the distribution of capital through inter-vivo intergenerational transfers and bequests.

Regarding each specific objective, the hypotheses are the following:

1. There have been distinctive paths along the demographic transition in Brazil according to education groups, although I expect a convergence in levels and patterns over time;

2. The diverse patterns of the demographic transition have led to different family structures by education groups; although variance in the number of surviving siblings would be expected to decline over time.

3. The various patterns of demographic transition by education and the convergence after five decades resulted in less inequality in the distribution of capital.

2 METHODS AND MATERIALS

2.1 Materials

The basic data come from the Brazilian Censuses from 1970 to 2010, drawn from the IPUMS International databases. Tabulations were produced from these data sources, on children ever born and children surviving by mother's age, as well as children born during the year immediately preceding the census. These materials were complemented with bibliographic sources exploring the consistency between the 2000 and 2010 census questions and its effects on fertility schedules. Also, I used life tables for Brazil produced by the United Nations in the 2015 Revision of the World Population Prospects.

2.2 Methodology

2.2.1 General Considerations on the Methodology

The central objective of this study is to estimate the number of siblings in 1970, 1980, 1991, 2000 and 2010, by education group. Due to the nature of the data available, the number of siblings will be estimated employing an analytic method initially proposed by Goodman, Keyfitz and Pullum (Goodman, Keyfitz, & Pullum, 1974)—herein referred to as GKP. However, the application of the method proposed by GKP requires fertility and mortality functions. Consequently, the first methodological task of this study is the estimation of the fertility and mortality functions by education groups, in each one of the reference years (1970, 1980, 1990, 2000 and 2010).

Given the nature of data available in Brazil, I employ indirect methods to estimate fertility and mortality functions. I use the Brass P/F ratio method to estimate indirectly the fertility functions for each educational subgroup between 1970 and 2010. In a similar manner the mortality functions were defined based on child mortality indirect estimates from data on children ever born and surviving children. Subsequently, the results obtained through this method were then employed as an anchor to develop life tables, by using the one-parameter "logit" system. To overcome the mortality age structure limitations—implicit in the one-parameter system— the standard schedules for the model life tables were selected to best reflect the mortality patterns of the Brazilian population at each point in time.

Since the information comes from the responses to census interviews, the methodology consists of indirect estimation methods, which allow obtaining conventional mortality and fertility estimates, measuring the level and age distribution of these variables at a time which is around the censuses dates of reference. The mortality estimates cover a time span of more than ten years preceding the census, which generates time series from different census with some overlapping periods that facilitate the assessment of their reliability and consistency over time.

2.2.2 Fertility Estimates

A indicated above, the study of fertility is based on information collected in the Brazilian censuses of 1970, 1980, 1991, 2000 and 2010. The basic information consist on the responses provided by women, classified by five-year age groups, on the number of children ever born by the date of the census, and on the number of children born alive during the 12 months preceding the census date. To estimate the fertility functions by level of education, individual tabulations were produced for each population group by education level categories.

Information on children ever born and children born in the last 12 months preceding the census provides the basic data needed to apply William Brass's P/F estimation technique (Brass, 1985). The tabulations required to apply the P/F method are *i*) number of women by education level category, classified by five-year age groups; ***ii***) total number of children born alive to those women in each five-year age group***; iii***) children born alive to those women in each five-year age group during the last 12 months preceding the census.

The rational of the method is based on William Brass' empirical studies and observations, which revealed that women could report on surveys and censuses accurately about the total number of children they had born. The quality of these reports starts to be affected by memory failures after a certain age (generally over 40 years old), when women may omit some of the children ever born—particularly those whom might have died very early, close to birth. These reports give, for each of the interviewed cohorts, an indication of their cohort fertility—the parity of women in that age group. The limitation of these fertility indexes is that they do not provide information on age specific fertility rates, and they cover a time span that can be long, depending on the age of the women.

By adding a question on how many children these women have had in the last 12 months, the age distribution of fertility can be obtained for the same population group. Yet, reports on the number of children born during the last 12 months are frequently affected by errors on the time location of the reported births. Sometimes women include births occurred in the previous calendar year, which would add births occurred before the last 12 months preceding the census. Nevertheless, evidence suggests that even when the time reference period is misreported, this divergence follows a similar pattern across all age groups. Hence, the level of fertility for the last 12 months may be over or under estimated, but the age distribution of the recent births gives a good estimate of the true age distribution of fertility for the reporting women.

Based on the observations described above, Brass concluded that relying on the most robust aspects of the two types of reports: children ever born with regards to fertility level, and births in the last 12 months for the age distribution of fertility, a procedure that combines both would provide reliable estimates for the level of fertility, as well as, for the fertility age distribution corresponding to dates close to the census (i.e. the previous year).

Such procedure uses the time period fertility rates of the last 12 months to define the fertility age distribution; then, it compares the level of fertility given by births in the last 12 months with the level of fertility implicit in the total children ever born reported. This is done by using the fertility rates of the last 12 months to generate comparative measures of cumulated fertility up to the mid point of each five-year age group. These are labeled by the term F_i where the sub-index "*i*" stands for the age group, being ***i=1*** for age group 15-19, ***i=2*** for 20-24, and successively up to ***i=7*** for age group 45-49. The F_i is a kind of "synthetic cohort fertility", reflecting the recent level of fertility (reported for the last 12 months). The F_i would be comparable to the actual cumulative fertility for women in that age group represented by P_i, if there were no fertility changes in previous years. In extension, if the reports on children ever born and children born in the last 12 months are accurate, F_i and P_i would be equal, provided that fertility had not changed during the previous years.

Recent fertility (F_i) is compared to past fertility (P_i) by means of the P_i / F_i ratios. The series of P_i / F_i ratios are then explored; the variation of the ratios by age groups would reveal if there were declining fertility trends, and would also give indication on possible reporting errors. From the analysis of the P_i / F_i ratios the data quality can be evaluated and an adequate adjustment factor can be selected in order to correct the level of recent fertility. With this correction factor the fertility level is adjusted, and the age specific fertility rates (ASFR) and the total fertility rate (TFR)[1] are calculated. In our study we are estimating demographic variables by population subgroup; hence, I generate specific fertility functions by applying the P/F ratio method to each education group. We define the education groups as 0-3, 4-8, 9-11 and 12+ years of schooling.

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[1] Details of this method are explained at: http://demographicestimation.iussp.org/content/overview-fertility-estimation-methods-based-pf-ratio (accessed 21 March 2016, at 10:00 hs).

2.2.3 Mortality Estimates

In order to apply the GKP framework, we need to derive life tables for each point in time, and for each of the education groups. This is done in two stages: first, by determining the level of mortality for each of the education level categories; then, defining the life table for the respective categories.

To establish the mortality levels, I apply the William Brass (Brass, 1964) indexes of child mortality from information on aggregate numbers of children ever born and children surviving, reported by women classified by five-year age groups and education, collected in surveys or censuses. This type of information is frequently called the "summary birth history" (SBH).

From the time this methodology was first developed and widely disseminated, some fifty years ago (Brass & Coale, 1968), the technique has been extensively applied—either in its original form or in different variations of the method—to estimate early childhood mortality levels and trends in countries with limited or defective data.

The necessary questions to apply this method were included in the Brazilian censuses. This allows us to estimate the level and trends of early childhood mortality for Brazil, in 1970, 1980, 1990, 2000 and 2010, by education level of the reporting women.

The proportion of children born alive, which have died by the time their mothers were interviewed in the census, represents and indicator of the mortality affecting the children of the reporting women. However, this measure is not a conventional life table indicator. It gives an indication on the level of child mortality, but it does not provide information on the length of time children were exposed to the risk of dying, nor on the age pattern of mortality during early childhood. Ingeniously, the methodology derives conventional life table measures by modeling the age pattern of child mortality as well as the age distribution of fertility, converting the proportions of children dead into probabilities of dying from birth up to an exact age n (${}_nq_0$). This conversion is done through adequate multipliers k_i, that translate the proportion of children dead (Q_i)[2], classified by age group of the mothers, into conventional life table probabilities ${}_nq_0$: ${}_nq_0 = k_iQ_i$. The k_i can be obtained through different procedures, depending on the variation of the technique that would be utilized. The procedure used in this paper is described in the recently edited IUSSP-UNFPA manual "***Tools for Demographic Estimation***" (Moultrie, et al., 2013). It obtains the k_i factors through the equation $k_i = a_i + b_i\ [P_1/P_2] + c_i\ [P_2/P_3]$, where the values of a_i, b_i and c_i were determined through appropriate modeling, and P_1, P_2 and P_3 are the average number of children born (parity) to women in age groups 15-19 (P_1), 20-25 (P_2) and 25-29 (P_3) respectively, which were calculated from the census data.

In a context of declining mortality, after determining the value of ${}_nq_0$, it is necessary to establish the ***time location*** for these estimates. The time location is obtained through the equation $t_i = e_i + f_i\ [P_1/P_2] + g_i\ [P_2/P_3]$, where the values of e_i, f_i and g_i are modeled coefficients and P_1, P_2 and P_3 are the average parity of the reporting women in those age groups).

The calculation process requires tabulations on the ***i***) number of women in each education level category, grouped by five-year age groups; ***ii***) number of children ever born alive to women by education level and age group; ***iii***) number of children who died to women in each one of the age and education groups

On the basis of these tabulations, the proportions of children who had died, Q_i, can be calculated, as well as the average parity of women in age groups 15-19, 20-24 and 25-29 (P_1, P_2 and P_3). With these inputs, the ${}_nq_0$ and the time location (t_i) for those probabilities can be calculated, completing the first stage of the calculation process—that is, determining the level of mortality at given points in time.

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[2] Index "*i*" indicates the mother´s age group, with *i*=1, 2, ..., 7 respectively for the mother´s age groups 15-19, 20-24, ..., 45-49.

These indirect estimates of mortality are subject to certain assumptions; the most relevant of which are: ***a***) changes in early childhood mortality in the recent past have been gradual and unidirectional (no ups and downs in mortality levels have occurred); ***b***) there is no association between the age of the mother and the mortality risks of children; ***c***) there is no correlation between the survival of mothers and the mortality risks of children, and ***d***) the age pattern of fertility and the age pattern of child mortality are adequately described by the models used to determine the coefficients a_i, b_i, c_i, e_i, f_i and g_i of the method.

2.2.4 Estimation of the Number of Siblings

The GKP framework consists of a series of mathematical formulas, which can be employed to estimate the availability of any type of kin, given the mortality and fertility functions of a population. Yet, the formulas proposed by Goodman, Keyfitz and Pullum contain an inherent limitation, since they are structured around a single sex model, and thus, only accounts for the female sex. This limitation is associated to the difficulty of estimating the male fertility function.

In order to circumvent this limitation, Guerra (2014) proposed an adaptation of Goodman, Keyfitz and Pullum original formulas. Basically, this consists of estimating separately female and male kin relations, parting from the assumption that they have the same mother. Note, this implies that step siblings or siblings with the same father, but different mother will not me included in the estimates. Nevertheless, this contribution represents a significant improvement. Further refinement is theoretically possible; yet the methodological implications are more complex and the data requirements are much more demanding.

The mathematical formulas proposed by Guerra (2014) estimate the number of brothers and sisters born alive and surviving separately. Also the estimates for these kin relations are done separately for older and younger siblings. These formulas are as follows:

For the number of older siblings born alive when Ego is aged **a**, at time ***t***:

$$\sum_{x=\alpha+1}^{x=\beta}\left[\sum_{y=\alpha}^{y=x-1} {}_1F_y^M(t-a-x+y)\right] {}_1W_x\ (t-a) \qquad (1)$$

$$\sum_{x=\alpha+1}^{x=\beta}\left[\sum_{y=\alpha}^{y=x-1} {}_1F_y^F(t-a-x+y)\right] {}_1W_x\ (t-a), \qquad (2)$$

in which, α and β represent the beginning and end of childbearing ages. ${}_1F_y^M$ and ${}_1F_y^F$ are the age specific reproductive rates, of males and females respectively, at time *t-a-x+y*. ${}_1W_x$ is the age distribution of the women that had children born alive at the time of Ego's birth, *t-a*.

For the number of surviving older siblings:

$$\sum_{x=\alpha+1}^{x=\beta}\left[\sum_{y=\alpha}^{y=x-1} {}_1F_y^M(t-a-x+y)\ {}_1L_{a+x-y}^M(t)\right] {}_1W_x\ (t-a) \qquad (3)$$

$$\sum_{x=\alpha+1}^{x=\beta}\left[\sum_{y=\alpha}^{y=x-1} {}_1F_y^M(t-a-x+y)\ {}_1L_{a+x-y}^F(t)\right] {}_1W_x\ (t-a), \qquad (4)$$

in which, α and β represent the beginning and end of childbearing ages. ${}_1F_y^M$ and ${}_1F_y^F$ are the age specific reproductive rates, of males and females respectively, at time *t-a-x+y*. ${}_1W_x$ is the age distribution of the women that had children born alive at the time of Ego's birth, *t-a*. ${}_1L^M{}_{a+x-y}$ and ${}_1L^F{}_{a+x-y}$ are the proportion of male and female survivors, respectively, observed at time *t*; pertaining to the birth cohort of Ego's siblings at time *t-a-x+y*.

For the number of younger siblings born alive:

$$\sum_{x=\alpha}^{x=\beta-1}\left[\sum_{y=x+1}^{y=x+a} \frac{{}_1L_y^F(t-a-x+y)}{{}_1L_x^F(t-a)}\ {}_1F_y^M(t-a-x+y)\right] {}_1W_x\ (t-a) \qquad (5)$$

$$\sum_{x=\alpha}^{x=\beta-1}\left[\sum_{y=x+1}^{y=x+a}\frac{{}_1L_y^F(t-a-x+y)}{{}_1L_x^F(t-a)}\ {}_1F_y^F(t-a-x+y)\right]\ {}_1W_x\ \ (t-a), \tag{6}$$

in which, α and β represent the beginning and end of childbearing ages. ${}_1F_y^M$ and ${}_1F_y^F$ are the age specific reproductive rates, of males and females respectively, at time *t-a-x+y*. ${}_1W_x$ is the age distribution of the women that had children born alive at the time of Ego's birth, *t-a*. ${}_1L^F_y\,/{}_1L^F_x$ is the chance of Ego's mother surviving from the moment of Ego's birth to the birth of Ego's younger sibling; given that Ego's mother is aged *x* at the beginning of this interval and aged *y* at the end and that this exposure occurs between time *t-a* and *t-a-x+y*.

For the number of surviving younger siblings:

$$\sum_{x=\alpha}^{x=\beta-1}\left[\sum_{y=x+1}^{y=x+a}\frac{{}_1L_y^F(t-a-x+y)}{{}_1L_x^F(t-a)}\ {}_1F_y^M(t-a-x+y)\ {}_1L_{a+x-y}^M(t)\right]\ {}_1W_x\ \ (t-a) \tag{7}$$

$$\sum_{x=\alpha}^{x=\beta-1}\left[\sum_{y=x+1}^{y=x+a}\frac{{}_1L_y^F(t-a-x+y)}{{}_1L_x^F(t-a)}\ {}_1F_y^F(t-a-x+y)\ {}_1L_{a+x-y}^F(t)\right]\ {}_1W_x\ \ (t-a), \tag{8}$$

in which, represent the beginning and end of childbearing ages. ${}_1F_y^M$ and ${}_1F_y^F$ are the age specific reproductive rates, of males and females respectively, at time *t-a-x+y*. ${}_1W_x$ is the age distribution of the women that had children born alive at the time of Ego's birth, *t-a*. ${}_1L^F_y\,/{}_1L^F_x$ is the chance of Ego's mother surviving from the moment of Ego's birth to the birth of Ego's younger sibling; given that Ego's mother is aged *x* at the beginning of this interval and aged *y* at the end and that this exposure occurs between time *t-a* and *t-a-x+y*. ${}_1L^M{}_{a+x-y}$ and ${}_1L^M{}_{a+x-y}$ are the proportion of male and female survivors, respectively, observed at time *t* corresponding to the birth cohort of their siblings at time *t-a-x+y*.

2.2.4.1 Estimates of the number of sibling kin by education level groups

In this thesis, fertility and mortality functions were determined by five-year age groups—instead of single years of age—for each education level group and reference year. Since our estimates are cross-sectional—for specific calendar year—then kin estimates would refer to cross-sectional synthetic cohorts for each time reference period, instead of longitudinal cohorts.

Hence, the preceding formulas—as stated by Guerra—would need to be adjusted; in those formulas we would need to specify the corresponding time reference period and the education level group to which the fertility and mortality functions correspond. Yet, in order to simplify the notation—assuming this would be obvious in the calculation process—in the equations presented below we write these formulas without specifying the year and the education groups, in the following manner:

$$Older\ Siblings\ Born\ Alive = \sum_{x=\alpha-1}^{x=\beta} \left\{ 5 \sum_{y=\alpha}^{y=x-1} {}_{5}^{bs}f_{y} \right\} w_x \qquad (9)$$

Where: α and β represent the beginning and end of childbearing ages; ***a*** stands for ***Ego's*** age; ***x*** is the age of the mother at the birth of Ego; ***y*** is the age of the mother at the birth of Ego's siblings; ${}_{5}^{bs}f_{y}$ are the age-specific fertility rates (both sexes children) in the five-year age interval (***y,y+4***) when Ego's older siblings are born—in line with the estimated fertility rates. Relation (10) allows the estimation of the number of these older siblings who survive to Ego's age ***a***:

$$Older\ Sibl.\ Surv.\ to\ Ego's\ age\ "a" = \sum_{x=\alpha-1}^{x=\beta} \left\{ \sum_{y=\alpha}^{y=x-1} {}_{5}^{bs}L_{a+x-y}\ {}_{5}^{bs}f_{y}\ {}_{5}^{bs}f_{y} \right\} w_x \qquad (10)$$

Where: all the concepts are as in relation (9), except for the probability that older siblings who were born when their mothers were ***y*** years old (${}_{5}^{bs}f_{y}$), are still surviving when Ego reaches age **a**, which is represented by ${}_{5}L_{a+x-y}$ that is, the probability that a child survives from birth to age group (*a+x-y, a+x-y+4*).

$$Younger\ Siblings\ Born\ Alive = \sum_{x=\alpha}^{x=\beta-1} \left\{ \sum_{y=x+1}^{y=x+a} \frac{{}_{5}^{f}L_{y}}{{}^{f}l_{x}}\ {}_{5}^{bs}f_{y} \right\} w_{x} \qquad (11)$$

Where: all concepts are similar to the previous relations, except that in relation (11) the lower limit of the inner summation is the year following the birth of "Ego", that is when the mother's age is ***y=x+1***; the upper limit is ***y=x+a*** that is when Ego has reached age **a**; on the other hand, the younger brother would be born only if the mother survives from the birth of "Ego" —age x— to the moment the younger brother is born —at age y—, so this probability, $\frac{{}^{f}L_{y}}{{}^{f}l_{x}}$, is incorporated into the relation (11).

$$Younger\ Siblings\ surviving = \sum_{x=\alpha}^{x=\beta-1} \left\{ \sum_{y=x+1}^{y=x+a} \frac{{}_{5}^{f}L_{y}}{{}^{f}l_{x}}\ {}_{5}^{bs}f_{y}\ {}_{5}^{bs}L_{a+x-y} \right\} w_{x} \quad (12)$$

Where: all concepts are as in relation (11), except for the condition that the younger siblings have to survive until the moment Ego reaches age **a**, which is incorporated through the probability that the younger siblings would survive for *a+x-y* years from their birth—when the mother was in age group (*y,y+4*)— to the moment when Ego reaches age **a**, ${}^{bs}L_{a+x-y}$.

The number of siblings (younger and older) that Ego has had by the time he is ***a*** years old, as well as the surviving siblings, can be estimated from the preceding relations. If ***n*** is the number of surviving brothers and sisters that Ego has by age **a**, under the assumption that the whole inheritance is distributed at the time Ego is ***a,*** and it is divided only among the siblings, then the ratio ***1/n*** would represent the share of total inheritance that Ego would be receiving at age **a**.

3.3 Assumptions and Limitations

The assumptions and the limitations with regards to the methodologies to estimate kinship relationships can be classified in three categories. Two of these categories relate to the fertility and mortality functions, which constitute the inputs to the analytical demographic equations used here to estimate kinship relationships. In this sense, obviously the assumptions on which the indirect estimation methods are based would also prevail for the results of kingship estimates, which were derived from those data inputs. In the calculation of kinship estimates it is assumed that both the fertility functions and the mortality functions properly describe the cross-sectional summary indicators, used to develop the stable population approach implicit in the estimation of kinship at a given point in time.

In addition, since the original mathematical relations proposed by GKP hold true in theoretical populations for continuous age and time variables (Goodman, Keyfitz, & Pullum, 1974), as these are expressed in a discrete format—aggregated at five-year age groups—additional assumptions are incorporated as they pertain the distribution of the vital functions within the five-year age groups. This is relevant for the age distribution of the mortality and fertility functions, but in particular it appear to be very relevant for the maternity function—expressed by w_x —in the respective formulas. The age distribution of the maternity function describes the probability of a woman becoming a mother at the moment she gives birth to "Ego". This would most closely be described by a continuous variable, and can be described with reasonable approximation by discrete variables in single-year age intervals. Yet, the approximation weakens as the discrete age interval expands: within the five years interval the function can have a relevant variation, particularly in the age segments where most changes occur from one single year of age to the next; this is at the beginning of the reproductive period (fast increases) and after the age segment when women have had most of their children, and from there on the probability of a woman becoming mother decreases rapidly afterwards. Inadequate definition of the w_x function may cause some variations in the number of Ego's siblings, estimated at Egos' age ***a***.

3 RESULTS

3.1 Fertility

According to the Brazilian Institute of Geography and Statistics (IBGE) the Total Fertility Rate (TFR) of Brazil has dropped from 5,8 to 1,86 children per woman, between 1970 and 2010. This constitutes a rapid and accentuated drop in fertility by any standards. It is opportune to point out that the reproductive life cycle of a woman spans roughly 35 years (between ages 15 to 50 years, approximately). The calendar time period referred to in this study spans 40 years, little over the average female reproductive life cycle. Thus the demographic transition in Brazil has brought about fertility declines from very high levels (about 6 children) to under replacement levels in the time that it takes one generation of women to enter and exit their fertile life.

As previously mentioned, for this study, fertility functions were estimated using the Brass P/F Ratio Method to define Age Specific Fertility Rates (ASFR) for the total population and educational sub-groups (0-3 years of education, 4-8 years of education, 9-11 years of education and 12 or more years of education) of the Brazilian population in the years 1970, 1980, 1991, 2000 and 2010. In order to generate a mechanism to verify the internal consistency and accuracy of the data, the P/F Ratio Method was used to estimate the fertility of each education sub-group as well as the total population independently. That is, evaluation of the age structure and determining the adjustment factor to correct the fertility level were done individually for each sub-group and for the total population. Subsequently, the ASFR's obtained for the educational groups were applied to the women classified by five-year age groups within each education group category, to obtain the expected number of births -in line with the estimated level and fertility age distribution. The numbers of births obtained in this way were then accumulated, to obtain the expected number of births by five-year age groups in the total population.

Then, total fertility rates were calculated using these accumulated births obtained within each education group. In analytical terms, the number of births in age group x,x+4 in the total population, obtained by aggregating the estimated number of births in each education group in those ages would be:

$$ {}_5^tB_x = \sum_{j=1}^{j=4} {}_5^tN_x^j \; {}_5^jf_x \qquad (13) $$

Where ${}_5^tN_x^j$ is the number of women aged x,x+4 in education group j, and ${}_5^jf_x$ is the specific fertility rate for women aged x,x+4 in the education group j (being *j=1* for education group 0-3, *j=2* for education group 4-8, *j=3* for education group 9-11, and *j=4* for education group 12+).

Then, the total (aggregated) age-specific fertility rates (ASFR) for the total population would be: ${}_5^tf_x = {}^tB_x / {}_5^tN_x^t$; where ${}^tB_x$ is the total (aggregated) births in age group x,x+4, and ${}_5^tN_x^t$ is the total number of women in age group x,x+4. Hence, $TFR^{agg} = 5\sum {}_5^tf_x$ would be the total fertility rate obtained by aggregating the number of births estimated for each education sub-group by five-year age group of the women.

Thus, ASFR and the TFR were calculated by using two independent procedures. First, fertility estimates obtained independently for each educational sub-group; from these, reconstituted estimates of the total population's fertility rates (ASFR as well as TFR) were generated. These reconstituted estimates were then compared with the results obtained by applying the P/F Ratio Method to the total population independently, without disaggregating by educational group.

The logic behind this procedure was to ensure that the disaggregated results, attained by educational group, were internally consistent with the trends observed at the aggregate level. Since fertility estimates for the four education groups and that of the total were calculated independently, the consistency of these results constitute an indication that both the estimated levels as well as the age pattern of fertility and the differentials obtained by education groups are consistent among themselves and with the total fertility of the population as a whole. Furthermore, both the reconstituted total population estimates and the P/F Ratio estimates for the total population were compared with the figures acknowledged by the IBGE to ensure that our estimates were accurate for each respective year.

3.1.1 Evaluation of Internal Consistency and Accuracy

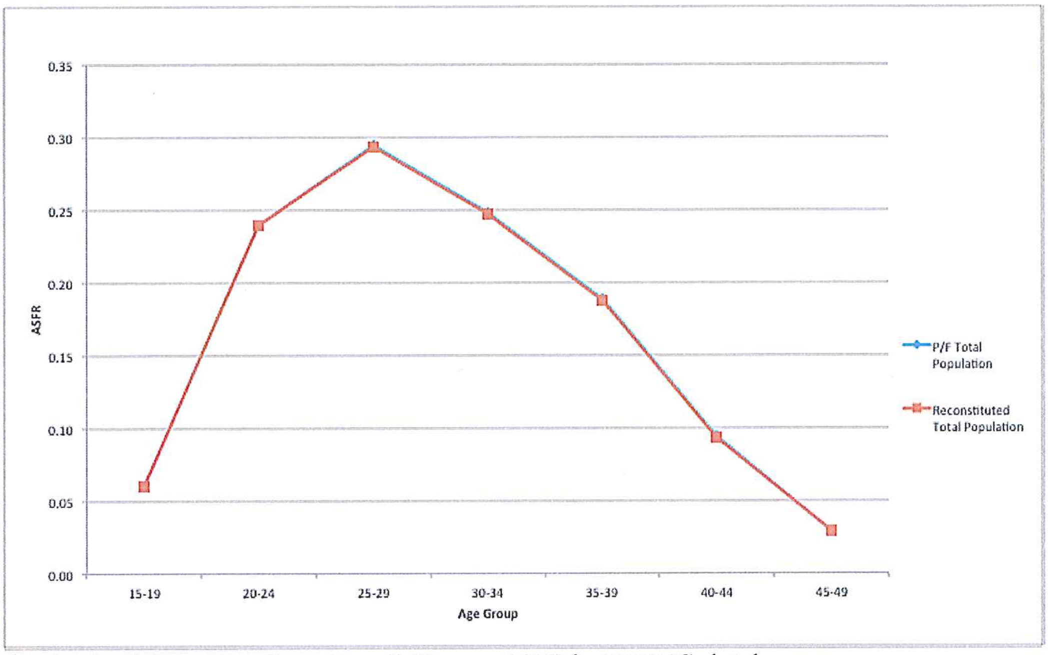
This section will consist in reviewing the estimated ASFR's generated when: (1) employing the Brass P/F Ratio Method without disaggregating the population by educational groups; and (2) when the estimated fertility of the corresponding educational groups is accumulated to produce an estimate for the total population. Finally, these two estimates will be compared to the figures commonly accepted by the IBGE to further assess their accuracy.

The results obtained from the previously mentioned calculations can be observed in Table A1 of the Annex. A more detailed comparison of the ASFR's can be seen in the graphs, from Figure 2 to Figure 5. To ensure a straightforward interpretation of the results, the term *P/F Total Population*, will indicate the results produced by using the Brass P/F Ratio Method applied on the aggregated data. In tandem, *Reconstituted Total Population* will indicate the results produced by aggregating the estimates of the composing educational groups.

Reviewing the fertility estimates, as well as Figure 2 to Figure 5, it is clear that the estimates are internally consistent. For 1970 the TFR's produced by applying the Brass P/F Ratio Method on the aggregated data and separately on the data disaggregated by educational groups produce estimates that differ by little over one hundredth of a child per woman (5.76 and 5.75 children per woman respectively). Moreover, Figure 2 reveals that the composition of the ASFR's is essentially the same regardless of the way the data is aggregated.

It is also important to mention that the results obtained align themselves closely with those the IBGE published for the 1970 census (5.76 children per woman).

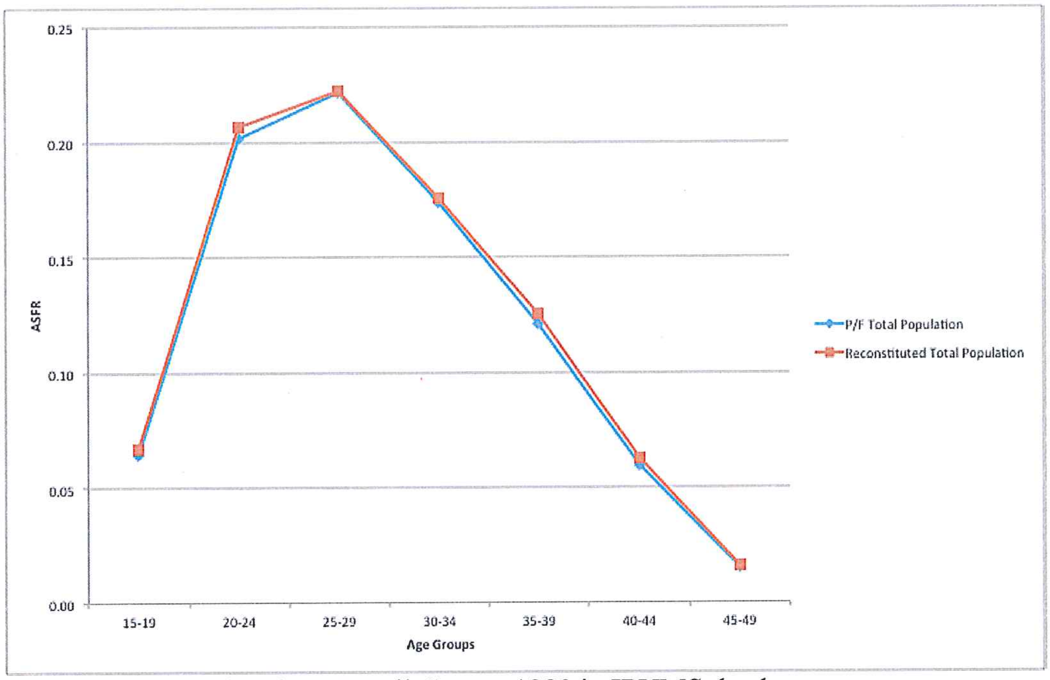
Figure 2: Age Specific Fertility Rates by method of estimation – Brazil 1970



Author's elaboration from Brazil Census 1970 in IPUMS database

The fertility estimates for 1980 also display strong evidence of internal consistency. The difference between the *P/F Total Population* estimate and the *Reconstituted Total Population* estimate diverges by less than one tenth of a child per woman (4.28 and 4.37 children per woman, respectively). Referring to Figure 3 we observe that the difference between the two estimates is due to slightly higher ASFR's in the ages 20-24 as well as 30-44. The apex of the fertility curve outlined by both sets of estimates coincides at age group 25-29 and exhibits roughly the same level. Hence, the higher TFR produced by the *Reconstituted Total Population* estimate can be attributed to a more bell-shaped functional form, which smoothers the curve in the sections that precede and follow the apex (at age group 25-29 years). For the purpose of this study the differences noted above are not judged to impact the estimates of sibling relations in any significant manner. Nonetheless, it is reassuring to note, the TFR obtained using the *Reconstituted Total Population* is very close to the one endorsed by the IBGE from the 1980 Brazilian Census (4.35 children per woman).

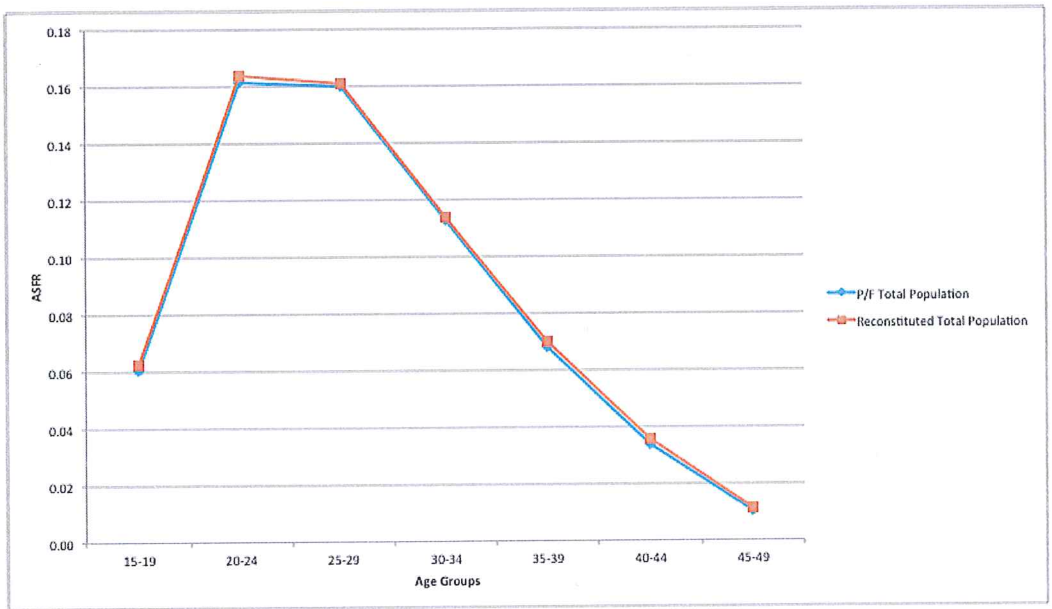
Figure 3: Age Specific Fertility Rates by method of estimation – Brazil 1980



Author's elaboration from Brazil Census 1980 in IPUMS database

Turning out attention to the results obtained from the 1991 Brazilian Census data, we find that *P/F Total Population* estimate reflects a slightly lower fertility level than the *Reconstituted Total Population* estimate (3.03 and 3.09 respectively). Considering the fact that we are generating two sets of completely independent estimates using indirect methods, it is encouraging to find that both results resemble each other so closely. Furthermore, Figure 4 shows how the functional forms of the ASFR's are very closely aligned. Once again this is encouraging, because it suggests that the trends in the reproductive behavior of the total population are not distorted when disaggregated by educational groups; the independent estimates of fertility for these groups are found to be consistent with that of the total population.

Figure 4: Age Specific Fertility Rates by method of estimation – Brazil 1991



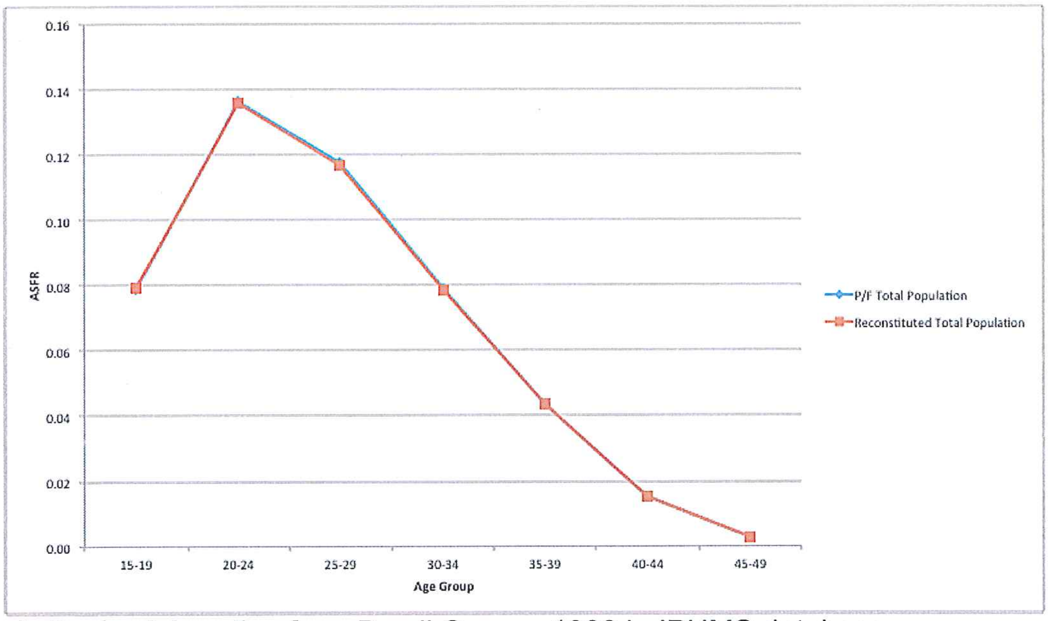
Author's elaboration from Brazil Census 1980 in IPUMS database

The most salient aspect of the fertility estimates for 1991 is the fact that both sets of results calculated in this study appear to slightly over estimate the TFR with regards to the IBGE estimate of 2.85 children per woman. Upon closer examination, it was noted that if the P/F ratio correction factor was not applied to the sets of estimates generated by the author, the resulting TFR's would coincide with those accepted by the IBGE. In addition, without applying any correction factor to the ASFR as reported for the last 12 months, the *P/F Total Population* and the *Reconstituted Total Population* estimates, both would provide a TFR of 2.86 (they differ by less than 0.001 children per woman).

The decision to dispense the use of a P/F ratio correction coefficient could be associated to the manner in which the information on recent fertility was collected. In the 1991 Brazilian Census the census asked the respondent to report the year of the last live birth, instead of asking the number of births in a predetermined reference period. Considering the assumptions and caveats proper to the original Brass P/F Ratio Method, it is theoretically plausible that the errors attributed to reports on recent fertility could be adequately addressed through other computational means. Consequently, by adapting the question aimed at recording recent fertility information, and having confidence that respondents are capable of accurately reporting this event; the need for a coefficient of correction can be remedied.

In the case of 2000, the fertility estimates also proved to be internally consistent and accurate. The difference between the *P/F Total Population* estimates and the *Reconstituted Total Population* estimates differed by 0.01 (2.37 and 2.36 children per woman, respectively). As seen in Figure 5 the ASFR's are congruent in both level and distribution. In addition to being internally consistent, both sets of estimates are very close to reproducing the TFR commonly accepted by the IBGE, which is 2.38 children per woman.

Figure 5: Age Specific Fertility Rates by method of estimation – Brazil 2000



Author's elaboration from Brazil Census 1980 in IPUMS database

As mentioned in the section discussing the methodology, the data for 2010 presents a particular challenge when disaggregating by educational groups. In the 2010 Brazilian Census the way information regarding years of schooling was asked and recorded changed from the format utilized in previous censuses. This altered the manner in which the universe of respondents to this question was configured. Hence, the educational groups that are generated from these data —as collected in 2010—are not fully compatible with the groupings determined from the previous censuses.

Elza Berquó and Suzana Cavenaghi generated compatible education groups between 2010 and previous censuses to estimate fertility (Berquó & Cavenaghi, 2014). In the mentioned article the authors produce fertility estimates for Brazil, for years 2000 and 2010, disaggregated by education groups which have been adjusted for comparability with previous censuses, employing indirect methods of estimation—amongst the methods employed was the Brass P/F Ratio.

To avoid repeating this complex task of generating compatible education categories for the censuses, here it was decided to verify the consistency of the results put forth by Berquó and Cavenaghi for 2000 with those obtained in the author's own calculations. If the tendency reflected in Berquó and Cavenaghi 2000 estimates were consistent with the results obtained in this study, then the 2010 estimates of Berquó and Cavenaghi would be adopted in this study. To ensure that the fertility trends reported by Berquó and Cavenaghi follow the tendency outlined by the author's own estimates, the two sets of estimates for 2000 were compared, corroborating that the trends reported by Berquó and Cavenaghi were consistent with the results obtained in this thesis work (comparisons not shown).

Summarizing, on the basis of all considerations as discussed above, it is safe to conclude that the disaggregated fertility estimates obtained by education groups and for years 1970, 1980, 1991 and 2000 are accurate and internally consistent, and they are consistent with Berquó and Cavenaghi's estimates for 2000 and 2010; hence the 2010 Berquó and Cavenaghi estimates were adopted. Moving forth, the next section will present and discuss the fertility trends observed when decomposing the estimates by year and educational group.

3.1.2 Analysis of Fertility Trends

Figures A 1-9 in the Annex present graphs of the ASFR of the population subgroups generated and subsequently grouped by education level or reference census. Depending on the focus of the comparison it may be more appropriate to compare different education groups in the same year or to follow the same group as time changes. The most salient feature of the fertility results is a clear educational gradient. This is by no means surprising, considering the existing theoretical and empirical research on the matter. Therefore, the results observed over the demographic transition in Brazil simply support the theory that education and fertility are negatively correlated. This negative correlation is consistent throughout the time period analyzed in this study. The educational gradient observed in fertility persists as the TFR of the total population shifted from high to under-replacement fertility levels.

Analogous to the educational gradient observed, there is a marked tendency of fertility decline in every educational group, across all decades in the study period. Once again this is expected, given that this period is paradigmatic of the demographic transition in Brazil. Notwithstanding, it is important to note that fertility declined in every education group between 1970 and 2010. Albeit all the education groups conform to an overall trend of fertility decline, certain differentiating nuances can be observed.

In the case of education groups *0-3* and *4-8* years of education, the pace and timing of the fertility decline resemble each other more closely. Granted, the magnitude of the decline is greater for the group *0-3* years of education; yet the decline is sustained from the beginning to the end of the period. The education group *9-11* years stands out because the results display an increase in the TFR between 2000 and 2010. This suggests a recovery in fertility levels during the last decade incorporated in the study. The behavior exhibited by the group *9-11* is not unprecedented. Cases do exist where the TFR of a population will drop well below replacement levels and subsequently recover to near replacement levels. Nevertheless, this point merits further exploration given that the fertility transition in Brazil is not complete.

The fertility results that stand out the most are the ones obtained for the education group *12+* years. This group presents a clearly distinct trend in the fertility decline. Even at the start of the study period the TFR is already below replacement level, and then it varies very little between 1970 and 1980 (1.62 and 1.68 children per woman, respectively). Subsequently, the TFR drops between 1980 and 2000 from 1.68 to 1.18 children per woman. After that the TFR remains constant between 2000 and 2010 (1,18 and 1,19 children per woman, respectively). It would appear that in this group the decline in fertility concentrated between 1980 and 2000. Considering just the study period of this thesis, the temporal span of the fertility decline occurred is half as long as the other groups. Obviously, given the TFR level, the decline in this group started much earlier than in the rest of the population. Since, the group *12+* years of education registers a fertility below replacement throughout the period studied, logically, the magnitude of the decline—in terms of absolute values—is much smaller than the other groups. It is remarkable that the TFR for the group with *12+* years of education was already below replacement level as early as 1970. This calls for further investigation and suggests that when studying the fertility trends of the most educated women in Brazil the relevant period of time should extend further back than 1970.

Prior to deepening the discussion of fertility trends, it is appropriate to outline certain properties associated to the construction of the education groups used and the implications they incur. As mentioned in the methodological section, the education groups are defined employing explicit and rigid upper and lower boundaries to discriminate and classify the population into categories. These boundaries are held constant throughout span of the study period. Hence, objectively speaking, the quantitative properties that define each group are immutable over time, even when the composition and relative significance of belonging to one or another group may change over time.

This is precisely what has happened in Brazil between 1970 and 2010. The period of demographic transition has coincided with powerful social and economic transformations in the country. One such process is the educational transition of the country. Examining the distribution of the total population by educational group we see that between 1970 and 2010 the group *0-3* years of education looses relative weight; in turn, the groups *9-11* and *12+* years of education gain weight. Rios Neto comments upon this subject and eloquently states “the differential in fertility rates by educational attributes of the mother ... would be determinant in the social composition of a cohort in a future period, however this would only occur if the composition of the mothers by education remained unaltered” (Rios Neto, 2005). This dynamic perfectly illustrates a process of ascendant educational mobility.

This is relevant because individuals from less educated social backgrounds can transit to higher education groups. The educational transition may occur relatively fast, when significant social investments are directed to improve education. In this situation, the process of ascendant educational mobility can out pace the decline in fertility; henceforth, a segment of the population may transit to higher education levels while retaining reproductive practices and attitudes which are characteristic of the social environment where they come from, which in general are of higher fertility. Under these circumstances the fertility decline in the higher education groups where people are moving into, because of rapidly expanding access to education, may reflect a relative slower decline—or even a temporary increase.

3.2 Mortality

As mentioned before, the very remarkable Brazilian fertility transition has been the subject of numerous studies. Notwithstanding, mortality during childhood has also experienced very steep declines in Brazil in last few decades. The study of early age mortality on the basis of Brazil’s 1970, 1980, 1991, 2000 and 2010 censuses reveals a steady and fast decline in mortality levels, benefiting all social groups. The analysis in this study focuses on the level and differentials in under-five mortality ($_5q_0$) by education groups. Classifying the population by level of education would produce indicators that closely describe the socio-economic differentials in a society.

The estimates of the mortality levels and trends have been done by utilizing William Brass's indirect mortality methods, which are based on census data, using the proportions of children ever born and children surviving, classified by mother's five-year age groups. As explained in the methodology section, the method generates estimates for the probability of dying from birth up to exact ages 1, 2, 3, 5, 10, 15 and 20 years of age, and their corresponding time location. In order to enable the analysis of the mortality levels and trends during the study period, these estimates have to be translated into unique indicator, which would allow to compare changes over time; for this study the $_5q_0$ was selected. Four time series of $_5q_0$ were obtained from each population census, from 1970 to 2000: one series for each education group (i.e. 0-3, 4-8, 9-11, 12 +). Hence a total of 16 time series estimates were obtained, four for each of the four censuses.

The estimates of under-five mortality revealed very rapid mortality declines in all education groups. In the earliest years of the calculated time series, the group with the lowest education (0-3 years) registered a very high level of mortality; $_5q_0$ for this least privileged group was higher than 180 per thousand around 1960. Then it registered a steep and continued decline, reaching a level around 44.7 per thousand by year 2000. Around 1960 the groups with 4-8, 9-11 and 12+ years of education had a $_5q_0$ equal to 110.8, 66.0 and 61.3 respectively; these three groups experienced a steady decline in under-five mortality, reaching very low levels by year 2000: 18.5, 15.4 and 10.2 per thousand respectively. As it could be expected, the groups that had higher mortality levels in the early years of the study period registered faster declines, thus narrowing the mortality gap with groups that have higher education levels and lower levels of mortality.

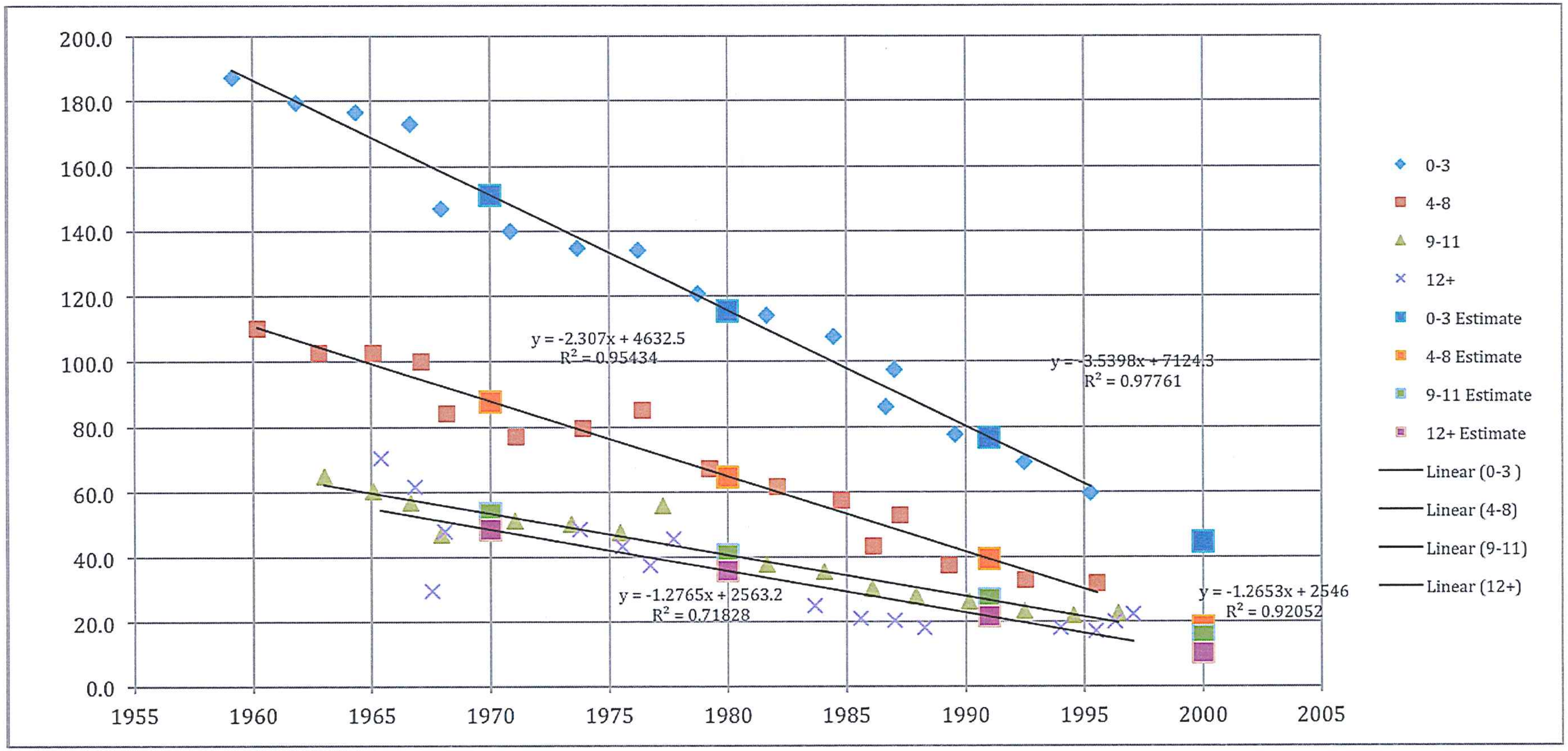
By analyzing the time series that show the estimated values of ${}_5q_0$ the reliability and consistency of these mortality estimates can be properly assessed. The methodology allows plotting these time series in an integrated graph, which facilitates the evaluation of these results and assessing the comparability of the estimates by education group within a census, as well as with the next census.

3.2.1 Evaluation of Internal Consistency of the Mortality Estimates

The under-five mortality indicators by education group were plotted in an integrated graph. The calendar dates are presented in the horizontal axis and the ${}_5q_0$ values for each year are represented in vertical axis, irrespective of the census were these estimates were obtained from. This provides a powerful tool to assess the consistency of the results: the level and trend can be compared for each of the education groups within the same census, exploring the consistency of the expected pattern of higher mortality for lower levels of education. On the other hand, since the ${}_5q_0$ time series derived from one census overlap with those derived from the next one, the continuity of trends as well as the consistency of the levels by education group can be compared over the whole time period under analysis. Hence, the levels and trends can be compared for all education groups over a long period of time, revealing the degree of consistency of all estimates obtained from different censuses. Because these are independent estimates, if they closely compare from one census to the next, they provide robust evidence that the estimates are consistent and reliable.

These results are presented in Figure 6. The analysis of the data in Figure 6 reveals remarkable internal consistency in the results from each of the censuses, as well as consistency in the level and trends for each education group from one census to the next. The consistency and coherence of these results gives us assurances that the level of mortality and the trends by education groups, obtained from the indirect estimation methods, are robust and constitute a valid basis for establishing the level of mortality, with the purpose of estimating differentials in the number of surviving sibling kin at different time periods within the four decades that span this study.

Figure 6: Indirect mortality estimates, $_5q_0$ by education groups and time location from the 1970, 1980, 1991 and 2000 censuses



Author's elaboration from Brazil Censuses 1970-2000 in IPUMS database and United Nations World Population Prospects 2015 Revision

3.2.2 Analysis of Under-five Mortality Trends

The results observed in the time series show some features, which are common to most mortality time series derived by applying indirect estimation methods based on information about children ever born and children surviving. The indicators derived from the reports of women in age groups 15-19 and 20-24 depart from the overall trend. Indicators from these two groups reveal the higher mortality level associated with the selectivity affecting these reporting groups: children born to mothers at very young ages are affected by higher mortality. This selective higher mortality emanates from very early ages at motherhood—and often also closely spaced births born to mothers in the age group 15-19. The estimate from group 20-24 is still affected by that selectivity, since it accumulates the births occurred at the very young ages in the previous interval, which still have a significant weight in the overall mortality of children born to women in the group 20-24. In older groups, as the age of the mother increases, their reports incorporate a fairer mix of birth orders and mother ages at birth, better representing the overall mortality in the population.

At the other extreme of the mother's age groups, the reports from older women provide estimates that most often fall below the overall trend line. This reveals some level of omission in the report of children who have died, probably those born further in the past, who died very soon after birth. Taking into account these two caveats, the mortality trend for each education group was obtained by fitting a minimum square strait line to the ${}_5q_0$ value series, which from 1960 to year 2000.

For year 2010 the estimation procedure was different. In first place, it was not possible to produce tabulations by education groups that are comparable to the classifications used in previous censuses. The questions used in the 2010 census were different than in previous censuses. However, given the consistency of the differentials by education groups, as assessed in the 1970, 1980, 1991, and 2000 censuses, the estimates of ${}_5q_0$ for 2010 were obtained by adopting the value of $_5q_0$ available from the Brazil's total population life tables for 2010, and applying the differentials in mortality level by education groups, as estimated from the $_5q_0$ time series evaluated for year 2000. The assumption is that the proportional differences observed in 2000 in the $_5q_0$ values for each education group, with respect to the $_5q_0$ for the total population, would be similar in 2010. This procedure would maintain the mortality level gradient, as we move from one education group to another, but keep the overall level as observed in 2010, thus giving a consistent higher mortality for lower levels of education, as observed during the whole study period.

The differential level coefficient, **k(*i*)**, was obtained by dividing the $_5q_0$ value for each education level group by the $_5q_0$ of the total population in 2000: $\mathbf{k}(j) = {_5q_0}(j) \,/\, {_5q_0}^{2000}$; where "*j*" indicates the corresponding education level. Then, this coefficient **k(*j*)** was used to derive the pertinent $_5q_0\,(j)$ for year 2010, by multiplying the $_5q_0^{2010}$ —for total population in year 2010—by the differential coefficient **k(*j*)** for the education group *j*. The $_5q_0$ values obtained for each educational level group for year 2010 are: 0.0454 group *0-3* years, 0.0206 group *4-8* years, 0.0157 group *9-11* years and 0.0114 group *12+* years.

3.2.3 Life Tables for Each Education Level Group for Female and both Sexes

The level of mortality for both sexes at each point in time by education group has been determined by the $_5q_0$ estimates as described in previous sections. Abridged life table measures were derived through a one-parameter logit life table system. In order to ensure close adherence to the age pattern of mortality observed for Brazilian populations, the standard adopted was the Brazil-both sexes and female life table respectively (United Nations World Population Prospects 2015 Revision), for both sexes and female corresponding to each of the reference dates in the study period. The value of the β parameter was set equal to 1, and the α value was calculated from the logit relation:

$$y^{t,j}(x) = \alpha + \beta\, y^{st}(x); \qquad (14)$$

Where x indicates the exact age in years, superscript t indicates the date for the life table, superscript j stands for the education group, superscript s indicates that it is the logit of the standard life table, and y is the logit transformation of the life table function l_x, where l_x represents the number of persons surviving from birth to exact age x.

The logit of lx is defined as: $\text{logit}(lx) = y(x) = -\tfrac{1}{2}\ln\{(lx)/(1-(lx))\}$ (15)

Therefore, as we have set the mortality level for both sexes on the basis of the estimated ${}_5q_0$ for each of the reference dates, first we need to establish the value of ${}_5q_0$, let say for year 1970 and education group 0-3 years: $l_5^{70,\,0\text{-}3} = 1 - {}_5q_0^{70,\,0\text{-}3}$; then, having the l_5 value we calculate the logit of l_5 : $\text{logit}(l_5) = y(5) = -\tfrac{1}{2}\ln\{(l_5)/(1-(l_5))\}$. Subsequently we need to calculate the logit of the l_5 value corresponding to the Brazil life table for 1970, both sexes, and using the logit of $l_5^{70,\,0\text{-}3}$ and the logit of the l^{st} value of Brazil 1970 life table, the alpha value (α) can be calculated from the equation (1):

$$y^{70,0\text{-}3}(x) = \alpha + 1^{*}\, y^{st}(x) \Rightarrow \alpha = y^{70,0\text{-}3}(x) - y^{st}(x) \qquad (16)$$

On the basis of the logit of the l^{st} values of the standard life table, for exact age x, and the estimated α value, the series of $l_x^{t,j}$ values—hence the whole life table—can be estimated for year 1970 and education group 0-3, by using the anti-logit relation:

$$l_x^{70,\,0\text{-}3} = \text{anti-logit}\{\, y^{70,0\text{-}3}(x)\,\} = 1 / \{1 + [1 / \exp\{-2\,(\alpha + y^{st}(x))\}]\} \qquad (17)$$

An adaptation of this procedure is utilized to derive female life tables for each point in time and each education group: the mortality sex differential for Brazil in the corresponding year is calculated by using female sex differential coefficients (in a similar manner as education differential coefficients were calculated before). The female sex differential coefficient is applied to the estimated ${}_5q_0$ –both sexes- for the corresponding year and education level.

Then, with the female ${}_5q_0$ derived in this way, the female l_x values, their logits and α, values can be calculated. Then, the abridged female life tables can be derived through the logit life table system, as described above.

By using these procedures, life table measures of mortality and survival for the years 1970, 1980,1990, 2000 and 2010, and for each education level, both sexes and female population, were calculated; that was a total of 40 sets of life table measures covering the entire period under study. These sets of life table parameters are presented in the annex in Tables A 2-11.

3.3 Kin relations

As discussed in the methodological section, kin relation estimates require an anchor that fix the results to a corresponding age of Ego as well as a time frame, when Ego reaches said age. In the case of this work, the component of the estimate related to the time frame when Ego reaches a set age is simplified, to a certain degree. Since the fertility function is defined for five-year interval groups, the birth of Ego is defined at the point where the interval starts or at the point where the previous interval finishes; so Ego would be born immediately after the five-year interval corresponding to fertility rates (older siblings born before Ego's birth), or immediately before the five-year interval corresponding to fertility rates (younger siblings born after Ego's birth). Then the numbers of siblings are estimated for calendar years about the Brazilian decennial census, for which the demographic functions were estimated—in other words, the Brazilian Census of 1970, 1980, 1991, 2000 and 2010. As a matter of fact, our results correspond to the stable equivalent population subjacent in the demographic functions as assessed from the respective census data (for the 1991 census the year 1990 was adopted as reference date). It is key to outline this point in order to properly interpret and understand the results that will be presented.

Proceeding with the discussion, the next point that needs to be clarified is the component of the estimates related with the age of Ego. This aspect is conditioned by the nature of the pre-requisite vital functions employed. As it was noted, before being able to estimate kin relations, fertility and mortality rates had to be defined for the composing education groups. This input information was estimated according to five-year intervals. As already mentioned, the age of Ego can only be fixed at multiples of five (i.e. 5, 10, 15 years of age and so forth), in order to produce results that are coherent with the input data used in the estimation procedure.

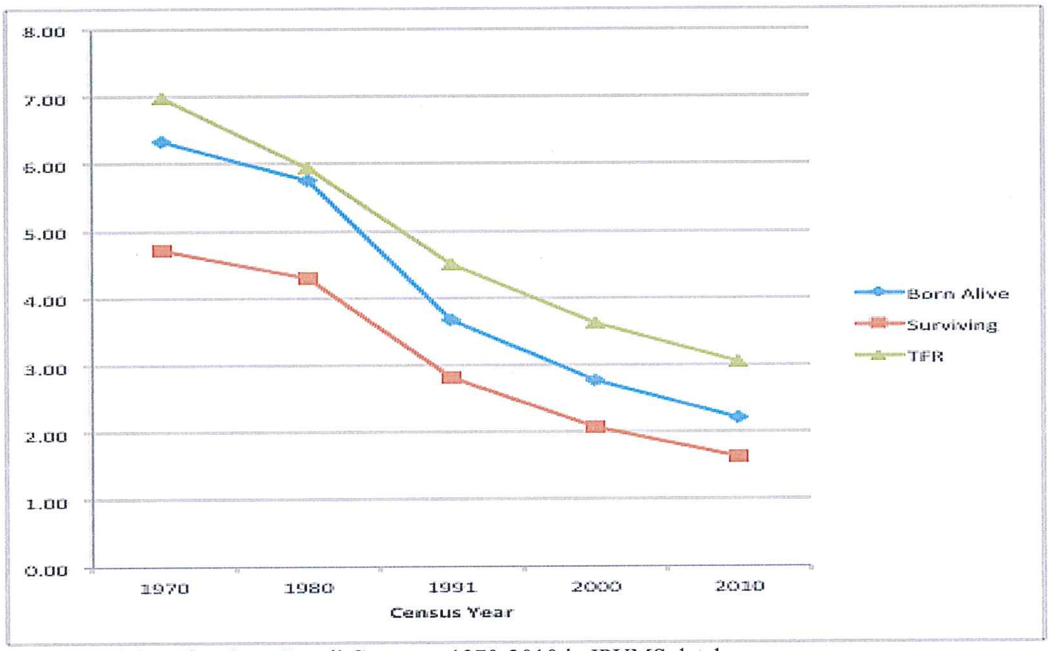
For the calculations presented here, Ego's age was set at 35 years in order to estimate the number of sibling kin relations. This age was chosen because it approximates the span of the female reproductive life. This is significant because once Ego reaches 35 years of age, she or he, will have no more siblings born. Furthermore, 35 years can serve as a rough approximation for the age difference between two successive generations. Hence, beyond this age of Ego the number of sibling surviving is only a function of the mortality at adult ages. The results obtained are presented in Table 1 and Figures 9-12.

Table 1: TFR and Mean number of Siblings Born Alive and Surviving when Ego reaches age 35 by Education Group and Census Year

		0-3	4-8	9-11	12+
1970	Born Alive	6.32	3.66	2.04	1.49
	Surviving	4.71	2.85	1.71	1.29
	TFR	6.97	3.97	2.33	1.62
1980	Born Alive	5.75	3.32	2.30	1.64
	Surviving	4.30	2.55	1.87	1.41
	TFR	5.93	3.63	2.20	1.68
1991	Born Alive	3.68	2.48	1.83	1.19
	Surviving	2.80	1.91	1.49	1.06
	TFR	4.52	2.93	1.94	1.52
2000	Born Alive	2.78	2.05	1.49	0.92
	Surviving	2.07	1.55	1.19	0.83
	TFR	3.62	2.67	1.65	1.18
2010	Born Alive	2.21	1.82	1.57	0.99
	Surviving	1.64	1.37	1.25	0.91
	TFR	3.04	2.58	1.80	1.19

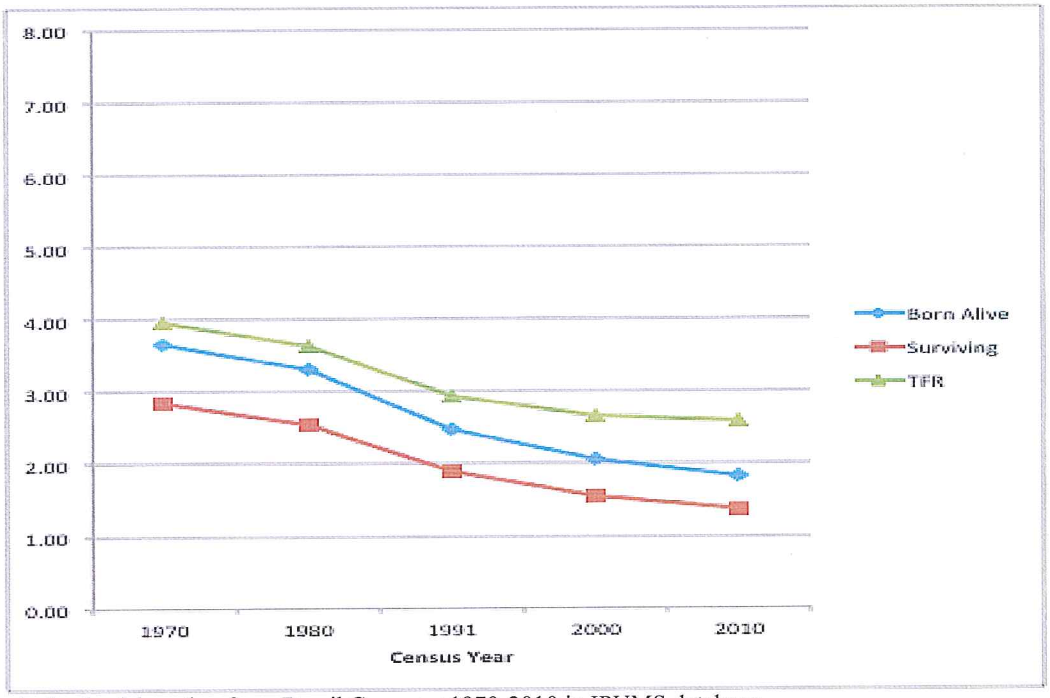
Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

Figure 7: Trends in TFR and Siblings Born Alive and Surviving when Ego reaches age 35 – Education Group 0-3



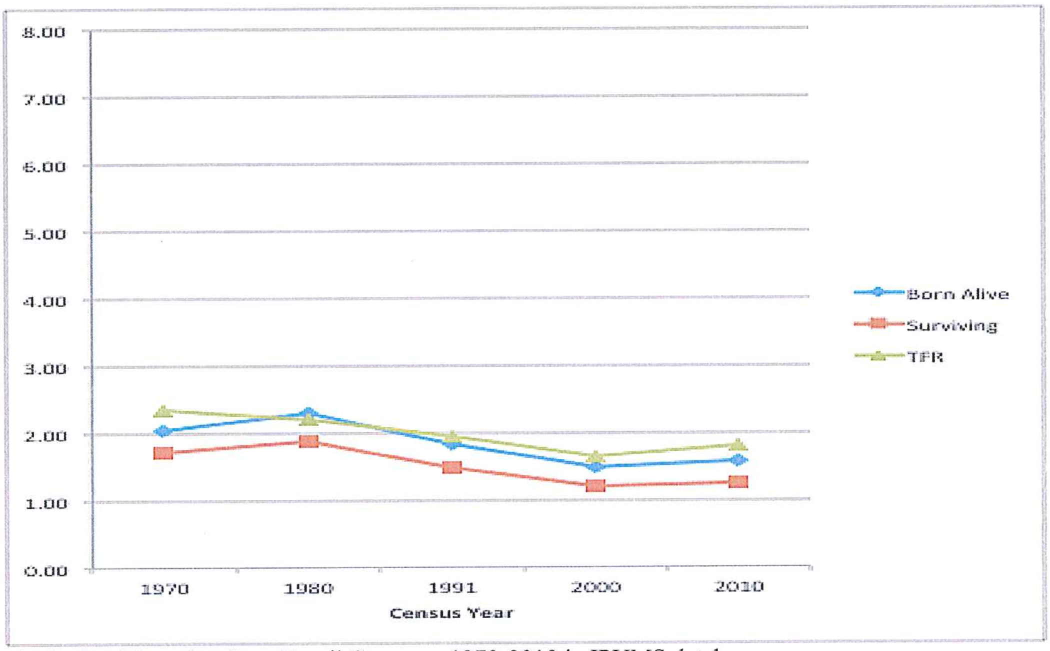
Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

Figure 8: Tends in TFR and Siblings Born Alive and Surviving when Ego reaches age 35 – Education Group 4-8



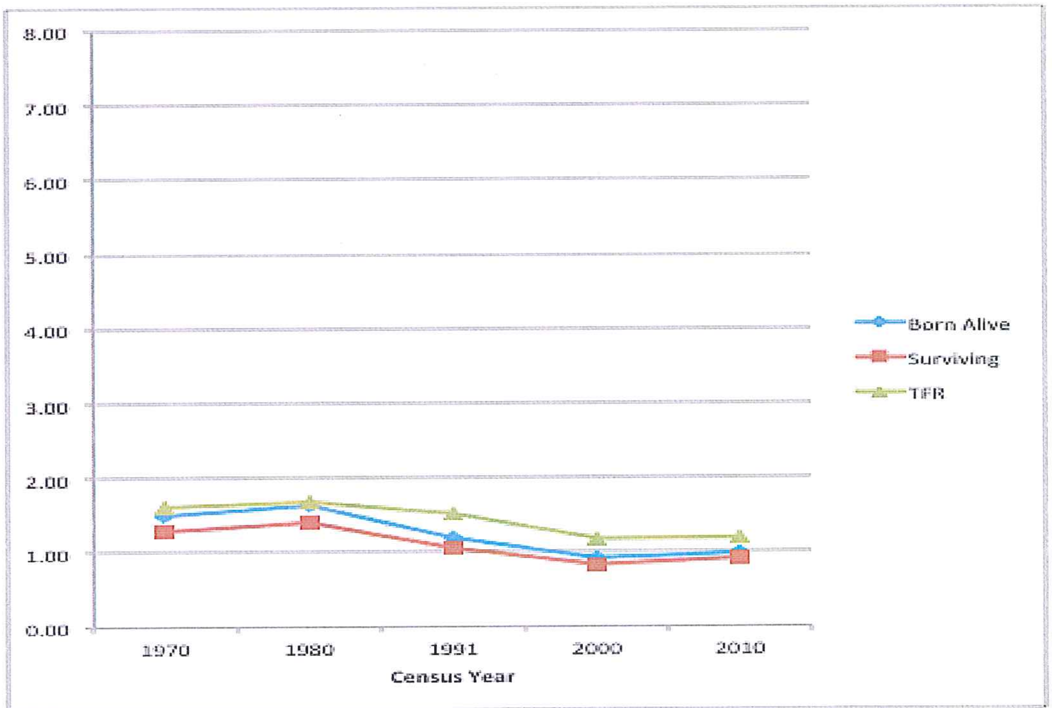
Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

Figure 9: Tends in TFR and Siblings Born Alive and Surviving when Ego reaches age 35 – Education Group 9-11



Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

Figure 10: Tends in TFR and Siblings Born Alive and Surviving when Ego reaches age 35 – Education Group 12+



Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

Figures 7-10 clearly show that there is a well defined trend of decline in the number of sibling kin, both born alive and surviving, for all education groups in Brazil between 1970 and 2010. The decline in the number of siblings clearly reflects the decline in TFR over the period studied. Similar to the findings described in the fertility and mortality section there is a clear educational gradient. This was to be expected since the fertility and mortality trends shape kin relations, and they present clear educational gradients. Another aspect that is immediately visible is the difference in the pace and magnitude of the decline in the number of siblings by education level. The difference in the pace of the decline in the number of siblings is driven by the decline in fertility levels between 1970 and 2010. Consequently, the difference by education group in the pace and magnitude of decline in the number of siblings, mirrors the one observed in the fertility trends.

Upon closer examination, we observe that the relation between TFR, born alive siblings and surviving siblings displays some similar patterns across educational groups. One observation is that the difference between the TFR and siblings born alive for Ego, at age 35, is not exactly one. At first this may seem counter-intuitive; if a woman has six children in total, then each of her children would have 5 siblings. However, the TFR does not compare directly to number of siblings, because women with no children are part of the denominator in the ASFR, while the probability of Ego having children is conditional to Ego's mother having become a mother. Therefore Ego's siblings are estimated for women who have become mothers, while TFRs are estimated for all women in reproductive ages; this relation gets more complex if more women with varying numbers of children are added to the mix.

Hence, the fundamental cause of this seeming paradox lies in the way the concept of TFR and mean number of siblings born alive are defined and calculated. When constructing the TFR measure, the groups of people exposed to the event of having a child are all women between the ages of 15 and 49. Women between ages 15 and 49 who did not have a child are still considered as part of the universe of women that are exposed to the risk of giving birth. In contrast, to be exposed to the risk of having a sibling, first, a person has had to be born. It is only after birth that a person begins to be subject to the risk of having a sibling kin. This observation seems self-evident, yet when considered in tandem with the concept of the TFR, this important difference emerges. When computing the TFR the experience of women without any children are included; when computing mean number of sibling kin the experiences of women without any children are not included. Hence, despite the common ground that both concepts share, the universe of individuals exposed to the risk of one event and the other are different.

Turning the focus of our discussion to the relation between siblings born alive and surviving to Ego, at age 35, we observe a convergence trend from 1970 towards 2010, for all education groups. This convergence is strictly shaped by the decline in mortality registered in this period. As mortality levels decline between 1970 and 2010 a progressively greater proportion of siblings born alive will be alive when Ego reaches age 35. The difference between siblings born alive and surviving displays an educational gradient. This directly reflects the behavior of the mortality estimates calculated by educational level. The most extreme instance of the convergence between the number of siblings born alive and surviving is observed in the educational group *12+* years in 2010. In this case almost all siblings remain alive when Ego reaches age 35. It is important to note that the survival of siblings when Ego reaches age 35 is predominantly determined by the mortality rates during infancy and childhood.

Over the demographic transition initial gains in life expectancy are mainly linked to declines in mortality levels at very young ages. As the transition progresses the decline in mortality rates extends to older ages. Furthermore, infant and childhood mortality have a particularly strong negative correlation with the mother's education. Therefore the population sub-group with *12+* years of education compounds a number of determinants of mortality that yield particularly low levels at young ages.

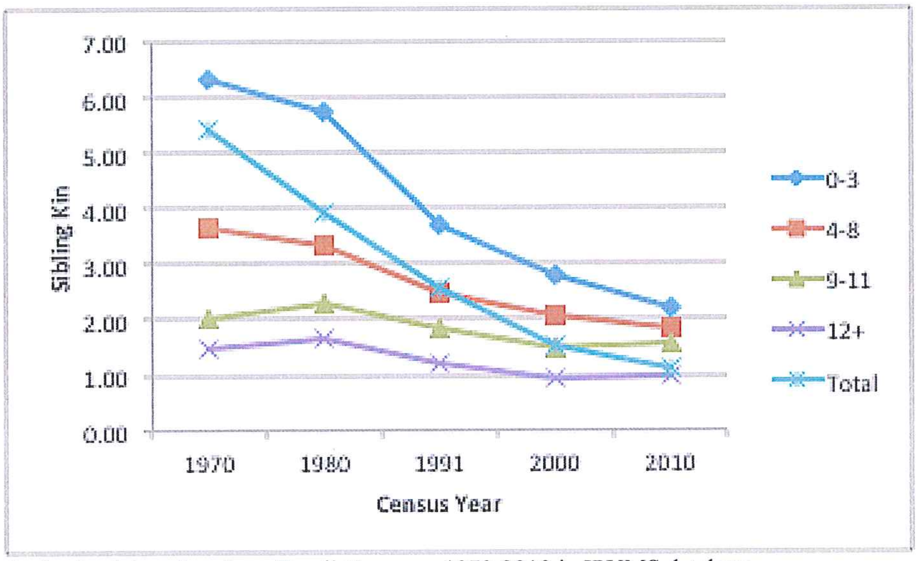
Another result that deserves to be highlighted is that the mean number of surviving siblings for Ego at age 35 practically never drops below one. The only exception to this is for education group *12+* in 2000 and 2010. Yet, even in these cases the mean number of surviving siblings remains close to one (0.83 and 0.91 surviving siblings, respectively). This is a significant result because it means that even when fertility levels drop below replacement, Ego (at age 35) can expect to have at least one surviving sibling, on average. This is another result that at first sight it may appear contradictory: after all, how is it that—on average—one can expect to have at least one sibling in a scenario where women, on average, have little over one child?

The answer to this question lies in the fact that in 2000 and 2010, for the education group *12+* years, a high proportion of women in reproductive ages had no children. Lets consider the results for the education group *12+* years in 2010 specifically, the mean number of siblings born alive is 0.99 and the TFR is 1.19 children per woman. Given these results we deduce that the women that actually had children had 1.99 children per woman on average (0.99 sibling plus Ego). Continuing with this line of thought, if the average number of children for all women—including those that had no children—is 1.19 (TFR), and the average number of children—for the women that gave birth—is 1.99, it would mean that approximately 60% of women in reproductive ages had children. The remaining 40% did not have children. The actual process to calculate the number of siblings is more complex than the simplified proportions, because it considers the age distribution of fertility rates and the age distribution of women who had children. However, the general principle behind the previous example is still valid.

One factor that can contribute to a particularly high proportion of women without children in the education group *12+* is the fact that higher educational attainment is linked with a postponement of childbearing to more advanced ages. Hence, one can expect a particularly high proportion of women without any children at the initial age groups of the reproductive period. Nonetheless, this factor alone does not account for such a high proportion of women without any children across the entire reproductive period. Consequently, it must be considered that aside from the postponement of childbearing produced by more years of schooling, other factors may be influencing the reproductive behavior of more educated women.

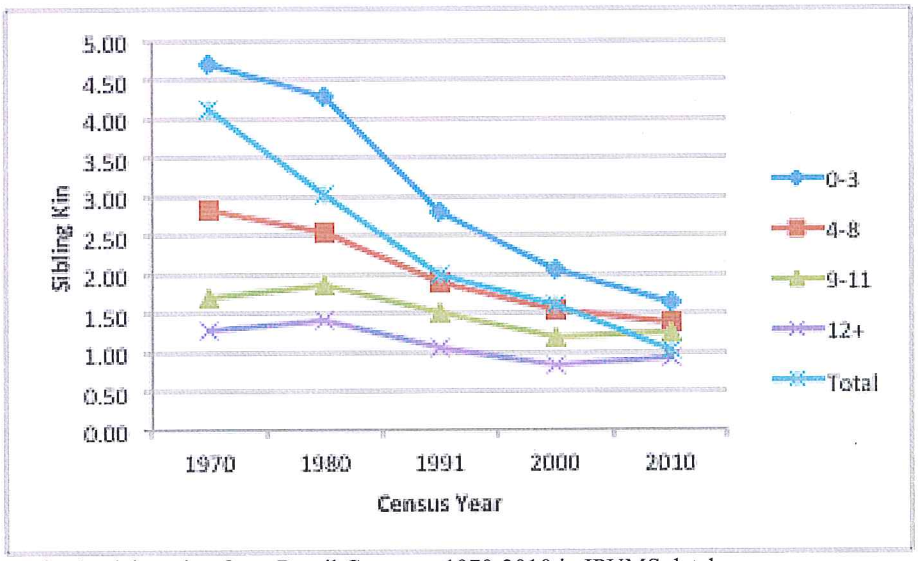
Perhaps the most important aspect of the estimates of kin relations that merits discussion is whether the demographic transition in Brazil has produced a convergence between education groups. If the fertility and mortality observed in the 1970 census remained constant by education group, then, the average individual in the education group *0-3* years, that reached age 35 would have 4.24 times more siblings born alive than equivalent average individual in education group *12+* years. In the case of surviving siblings, the average individual reaching age 35, in education group *0-3* years would have 3.65 times more surviving siblings than the one in education group *12+*. Moreover, if the fertility and mortality observed in the 2010 census remained constant by education group, then, the average individual that reached age 35 in education group *0-3* years would have 2.23 times more siblings born alive than the one in education group *12+* years. Considering surviving siblings, the average individual in education group *0-3* years that reached age 35 would have 1.80 times more surviving siblings than the one in education group *12+*. Therefore, the demographic transition in Brazil, has produced a significant degree of convergence in the number of siblings, between the most educated and least educated groups in the population. This finding holds important implications for several social and economic factors that deserve special studies and I will only start to address in my concluding remarks. In order to provide a clear comparison of the tendencies in the number of siblings born alive, surviving and the TFR over the period of demographic transition in Brazil, Figures #-# display this by education groups. A more detailed evolution of the differential in the number of siblings by education groups can be observed in Figures #-#, where the differential is expressed in relation to the highest education group (*12+* years of education).

Figure 11: Number of Siblings Born Alive when Ego reaches Age 35 by Education Group and Aggregated – Brazil 1970, 1980, 1991, 2000 and 2010



Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

Figure 12: Number of Surviving Siblings when Ego reaches Age 35 by Education Group and Aggregated – Brazil 1970, 1980, 1991, 2000 and 2010



Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

Figure 13: TFR by Educational Groups and Aggregated – Brazil 1970, 1980, 1991, 2000 and 2010

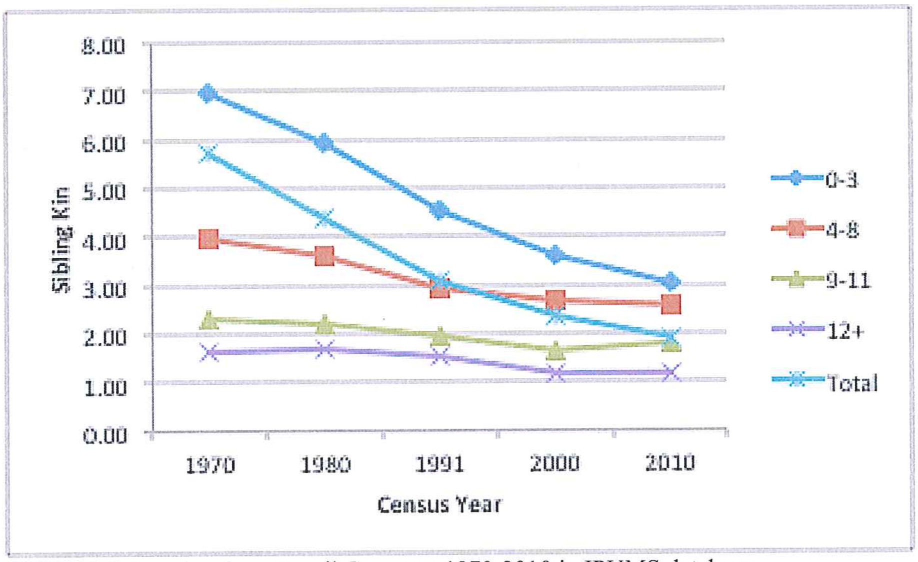


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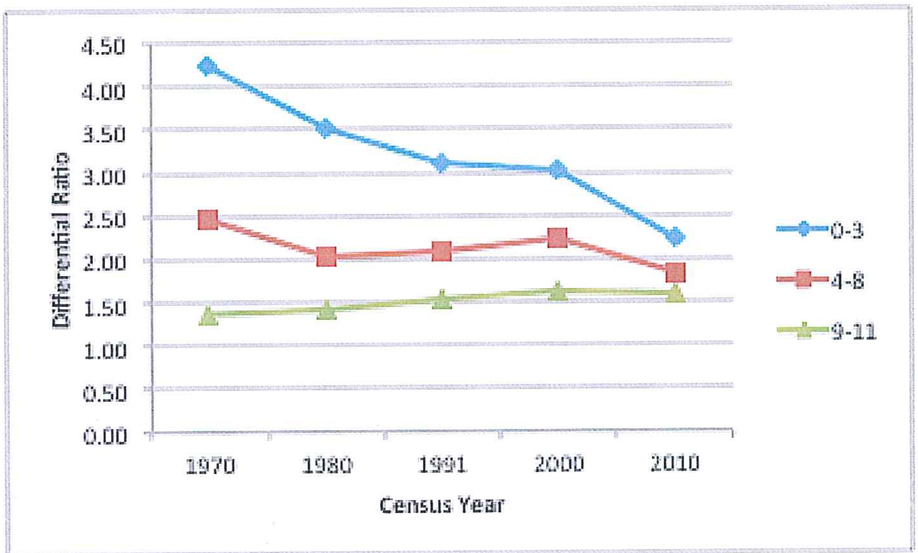
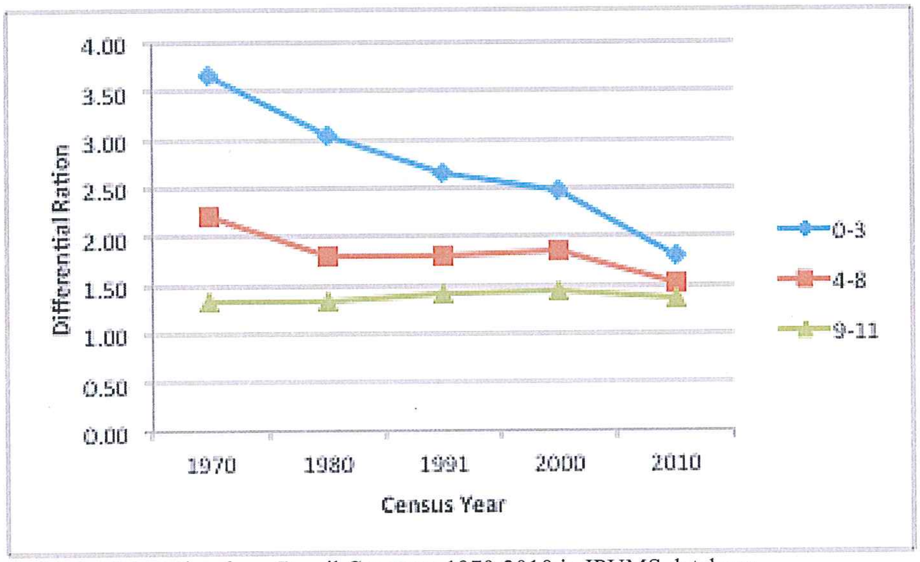
Figure 14: Differential by Education Group in the number of Surviving Siblings when Ego reaches Age 35 – Brazil 1970, 1980, 1991, 2000 and 2010



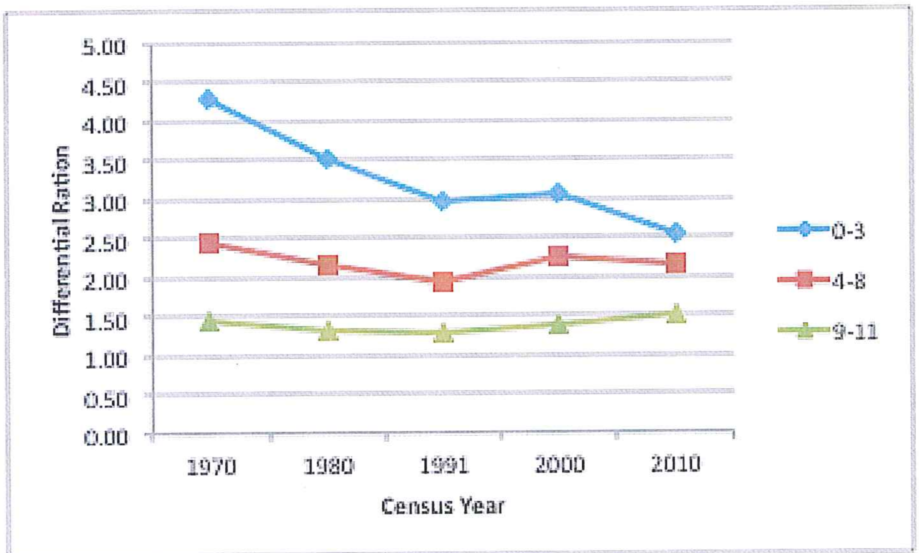
Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

Figure 15: Differential by Education Group in the number of Surviving Siblings when Ego reaches Age 35 – Brazil 1970, 1980, 1991, 2000 and 2010



Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

Figure 16: Differential by Education Group in the TFR – Brazil 1970, 1980, 1991, 2000 and 2010



Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

5 CONCLUDING REMARKS

The fact that the demographic transition in Brazil has lead to a convergence between education groups in the number of siblings is significant for several economic and social factors. One aspect deserves special attention: kin relations form the core of the network that structures intergenerational transfers. As discussed previously, age 35 represents a particularly meaningful juncture in an individual's life. Around this age individuals are consolidating their own families, yet maintaining the bonds with elder kin, primarily parents. Thus, having surviving sibling estimates at age 35 offers a sound platform to explore intergenerational transfers. From older generations this materializes, mainly, in the form of bequests and inheritance. In juxtaposition, ascendant intergenerational transfers generally adopt the form of caring for elderly kin (mostly parents). The number of surviving siblings by age 35 is an indicator of the share of the burden of care on the one hand and the share of inheritance transfers on the other.

A simple exercise shows the importance of estimating kin relations. If we assume that capital is equality distributed among the elderly, what would be the fraction received by the average individual of each education group when parents die? Table 2 presents the expected number of surviving siblings, including Ego, represented by n, and the expected share of inheritance under the assumption that bequests were the same magnitude for each education group (1 divided by n).

Table 2: Total Surviving Siblings (including Ego) and Share Ratio of Inheritance, for Ego´s age 35

		0-3	4-8	9-11	12+
1970	n	5.71	4.66	2.71	2.29
	1/n	18%	21%	37%	44%
1980	n	5.30	3.55	2.87	2.41
	1/n	19%	28%	35%	42%
1991	n	3.80	3.48	2.49	2.06
	1/n	26%	29%	40%	49%
2000	n	3.07	3.05	2.19	1.83
	1/n	33%	33%	46%	55%
2010	n	2.64	2.37	2.25	1.91
	1/n	38%	42%	44%	52%

Author's elaboration

Very consistent patterns are apparent in this table. First, for each education group the expected total number of surviving siblings, when Ego is 35, decreases from 1970 to 2010. This trend is consistent over the whole study period for all education groups, except in the group 9-11 years education, from 1970 to 1980, when it increased from 2.71 to 2.87; and for education level 12+, from year 1970 to 1980 and from 2000 to 2010, when it increased from 2.71 to 2.87 and from 1.83 to 1.91, respectively. In the case of education group 12+ years these variations correlate with increases in the TFR; in the case of education level 9-11 years, the increase is not a response to variations in the TFR, but rather it seems to be a consequence of changes in the age structure of the maternity function.

The most salient patterns observed in Table 2 are the steady decrease in the expected number of surviving siblings, during the forty years covered by the study period. The declining trend is stronger in education group 0-3 years, followed by the group 4-8 years, decreasing from 5.71 expected sibling surviving at Ego´s age 35, to 2.64 and from 4.66 to 2.37 respectively in these groups. This reduction in the number of expected surviving siblings impacts by increasing the expected share of inheritance from 18 per cent per sibling in 1970 in group 0-3, to 38 per cent in 2010. In the group 4-8 years of education, the share went from 21 per cent in 1970 to 42 percent in 2010. In education groups 9-11 and 12+ the general trend of surviving siblings is also declining;

yet, since the fertility level is very low during the whole study period (below replacement since 1970 in group 12+, and below replacement since 1990 in group 9-11), the reduction in the expected number of surviving siblings is small and registers some fluctuations.

Another salient feature is the steady and consistent decreasing gradient in the expected number of surviving siblings, from the lower education level groups to higher education levels, which prevails in all the reference years during the study period. These variations can be seen as we move from one education level to the next within the same reference year. The differences are much larger at the initial stages of the transition; in 1970 the expected number of surviving siblings is 5.71 in education group 0-3 and 2.29 in education group 12+; that is about 3.5 more siblings in the lower education group. Although the differential persists, the magnitude is much smaller in 2010: 0.75 more surviving siblings in group 0-3, than in group 12+ education years.

The large differences in the percentage share of the inheritance transfers observed from the lower education groups to the higher education is even more striking when considering that higher education is correlated with higher income and higher savings and capital accumulation capacity. So not only the inheritance share is diluted at the lower education groups, but also the amount of inheritance transfers would also be lower. For instance, if we consider that capital accumulation may increase from one education level to the next by 50 per cent, assuming we start with one unit of capital accumulation in education level 0-3, this would be 1.5 in education level 4-8, 2.25 in education level 9-11 and 3.375 in the group 12+. Considering the ratio of inheritance shares by education groups in 1970, it would mean that a person in education group 12+, even assuming a relatively modest higher saving capacity and capital formation as in our assumption, would be expected to receive 8.25 times the amount of inheritance transfer than a person in education group 0-3 would receive. This large differential is mostly due to the larger expected number of surviving siblings in the group 0-3. A person in education level 9-11 would receive 4.63 times higher the amount of transfer than in group 0-3, and someone in group 4-8 would be expected to receive 1.75 times the amount received by a person in the group 0-3 years of education.

In the year 2010, under the same assumptions of capital accumulation, persons in group 12+, 9-11, and 4-8 would be expected to receive 4.62, 2.61, and 1.66 times the share expected to be received by a person in the group of 0-3 years of education. The gap of 1 to 8.25 between the higher and lower education groups would be narrowed to 1 to 4.62 by means of the changes in the family structures brought about by the fertility transition.

On the other hand, having fewer siblings increases the share with respect to the burden of care of older kin. In this respect the lower education groups can spread the burden over a larger number of relatives. This exercise illustrates how demographic dynamics permeates and structures intergenerational transfers in both directions.

An important reflection emanating from this work is the wide implications of demographic dynamics. The differences in these dynamics by social group go beyond the specific dimension comprised by the number of siblings. Furthermore, it transcends the more frequent aspects analyzed in demographic studies. Socio-demographic dynamics can be a powerful catalyst of social development and upward social mobility. In many cases the demographic transition and the opportunity of a demographic dividend is studied at an aggregate level. In the case of Brazil, seen at the aggregate level it would appear that the period of transition is reaching its final stages. Nevertheless, relevant social sectors still have a considerable margin ahead to conclude the process of changes.

Therefore, the prospects for targeted policy interventions should be properly assessed. The perception that the transition has come to an end and that the window of opportunity has already passed may deter policy makers from undertaking additional social investments, which otherwise could prove catalytic propel underserved segments of the population past a threshold to overcome poverty and marginalization. Demographic studies disaggregated by critical socio-economic categories can provide a most relevant contribution for national policies.

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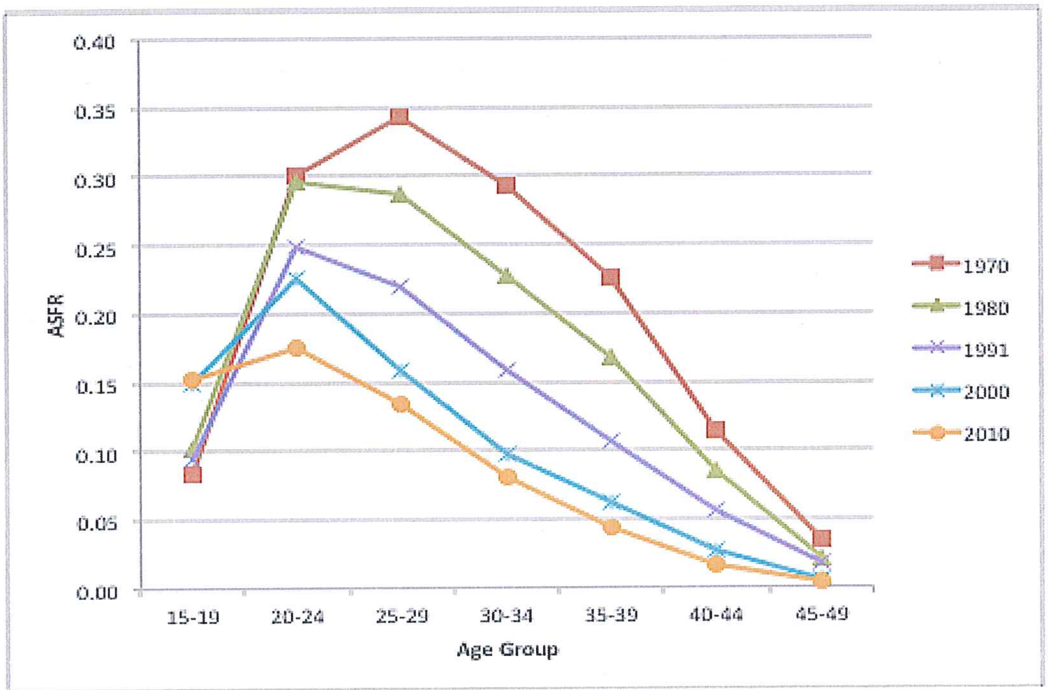
6 ANNEX

Table A1: Age Specific Fertility Rates by Education Groups

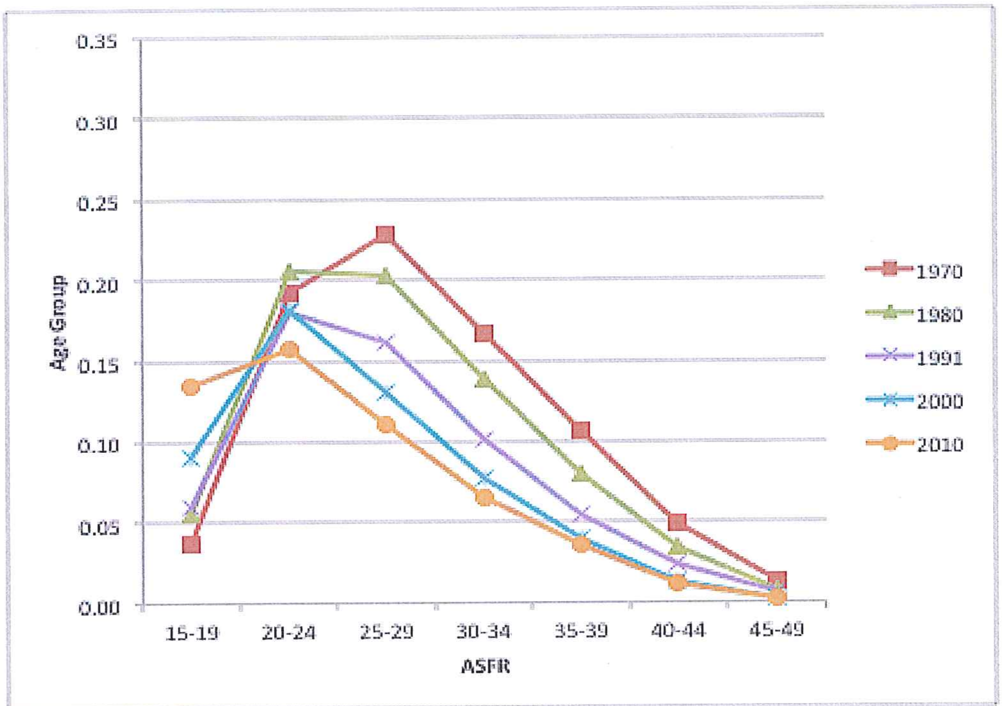
Age Groups	0-3 years of education				
	1970	*1980*	*1991*	*2000*	*2010*
15-19	0.0842	0.1020	0.0946	0.1500	0.1529
20-24	0.3009	0.2962	0.2493	0.2255	0.1747
25-29	0.3431	0.2875	0.2201	0.1580	0.1347
30-34	0.2931	0.2271	0.1583	0.0972	0.0810
35-39	0.2254	0.1673	0.1071	0.0616	0.0441
40-44	0.1134	0.0847	0.0563	0.0264	0.0165
45-49	0.0347	0.0215	0.0172	0.0051	0.0034
TFR	**6.97**	**5.93**	**4.52**	**3.62**	**3.04**
Age Groups	**4-8 years of education**				
	1970	*1980*	*1991*	*2000*	*2010*
15-19	0.0372	0.0563	0.0603	0.0910	0.1346
20-24	0.1923	0.2054	0.1808	0.1813	0.1579
25-29	0.2285	0.2035	0.1613	0.1302	0.1111
30-34	0.1661	0.1389	0.1006	0.0775	0.0654
35-39	0.1072	0.0800	0.0543	0.0395	0.0351
40-44	0.0490	0.0341	0.0230	0.0127	0.0110
45-49	0.0133	0.0071	0.0060	0.0022	0.0016
TFR	**3.97**	**3.63**	**2.93**	**2.67**	**2.58**
Age Groups	**9-11 years of education**				
	1970	*1980*	*1991*	*2000*	*2010*
15-19	0.0087	0.0167	0.0228	0.0372	0.0461
20-24	0.0732	0.0913	0.0901	0.0852	0.1045
25-29	0.1584	0.1429	0.1231	0.0949	0.0944
30-34	0.1246	0.1108	0.0879	0.0671	0.0677
35-39	0.0734	0.0563	0.0439	0.0340	0.0354
40-44	0.0243	0.0181	0.0160	0.0097	0.0103
45-49	0.0039	0.0044	0.0035	0.0012	0.0015
TFR	**2.33**	**2.20**	**1.94**	**1.65**	**1.80**
Age Groups	**12 + years of education**				
	1970	*1980*	*1991*	*2000*	*2010*
15-19	0.0017	0.0103	0.0090	0.0147	0.0103
20-24	0.0311	0.0443	0.0417	0.0304	0.0312
25-29	0.1097	0.1145	0.0950	0.0655	0.0592
30-34	0.1017	0.1007	0.0942	0.0740	0.0756
35-39	0.0500	0.0507	0.0454	0.0415	0.0482
40-44	0.0253	0.0118	0.0155	0.0095	0.0128
45-49	0.0050	0.0045	0.0027	0.0011	0.0013
TFR	**1.62**	**1.68**	**1.52**	**1.18**	**1.19**

Figure A1: Age Specific Fertility Rates for Education Group 0-3 years – Brazil 1970, 1980, 1991, 2000, 2010



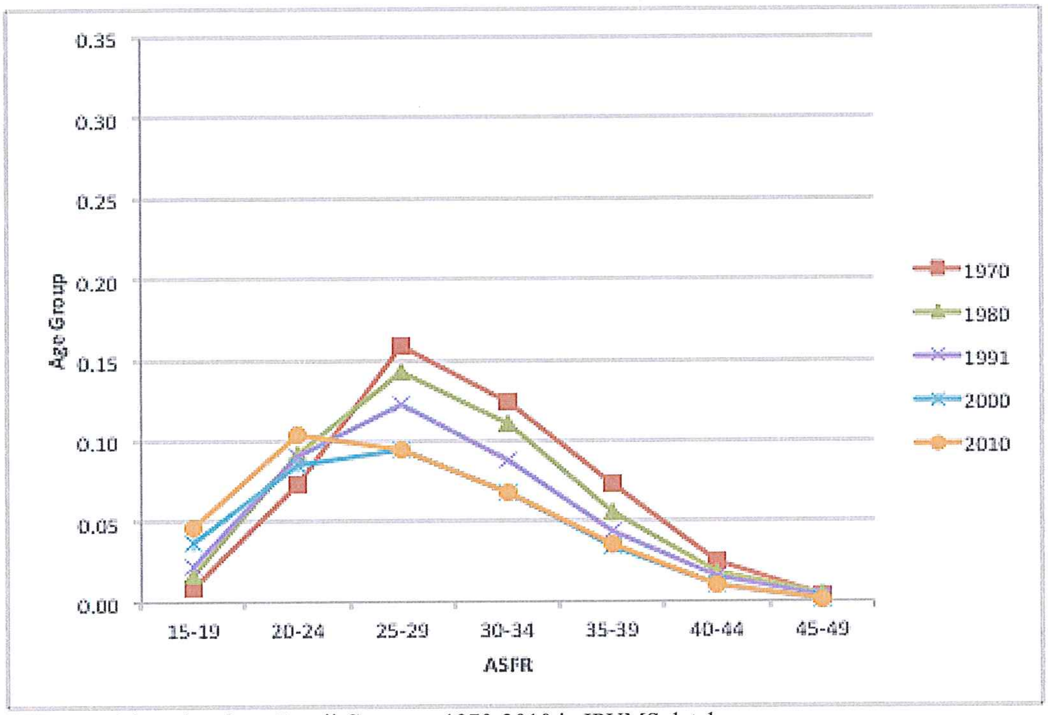
Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

Figure A2: Age Specific Fertility Rates for Education Group 4-8 years – Brazil 1970, 1980, 1991, 2000, 2010



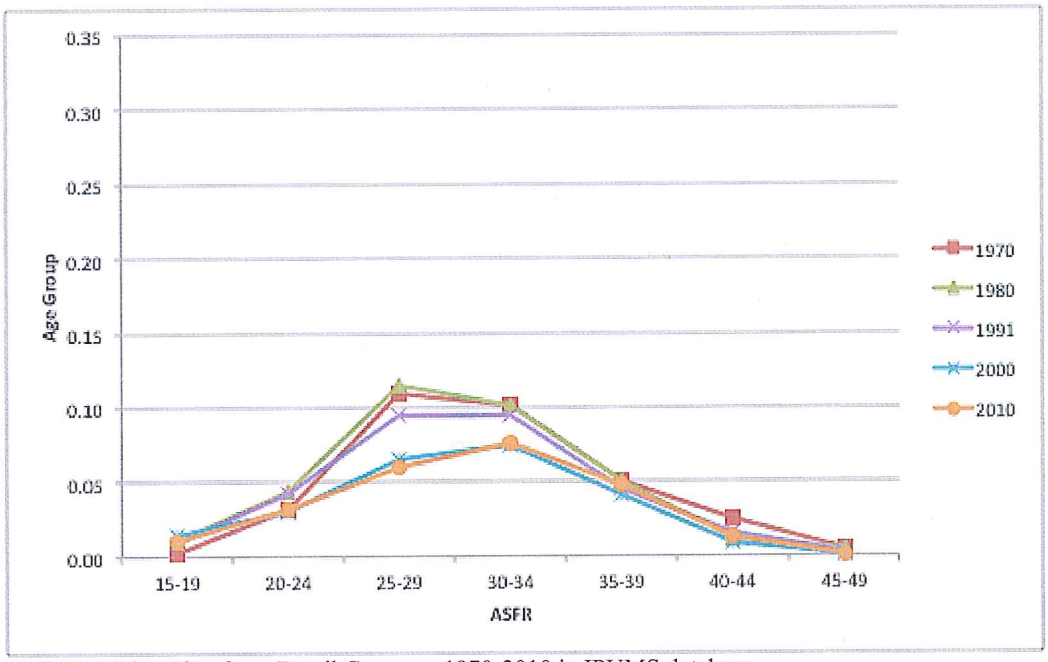
Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

Figure A3: Age Specific Fertility Rates for Education Group 9-11 years – Brazil 1970, 1980, 1991, 2000, 2010



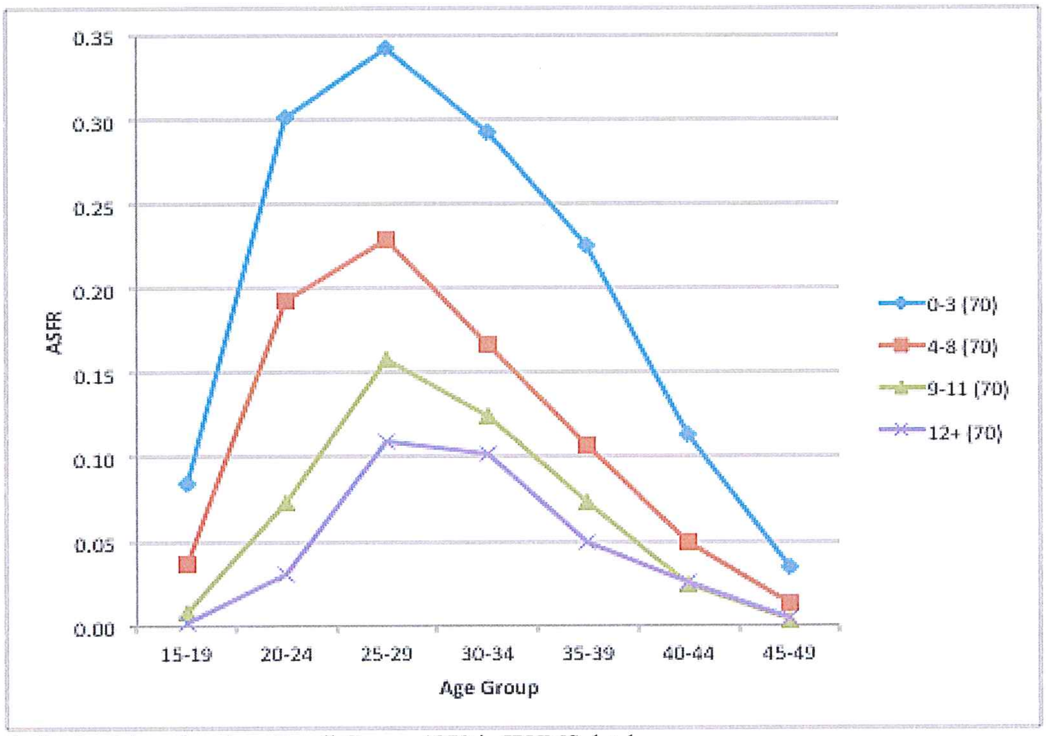
Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

Figure A4: Age Specific Fertility Rates for Education Group 12+ years – Brazil 1970, 1980, 1991, 2000, 2010



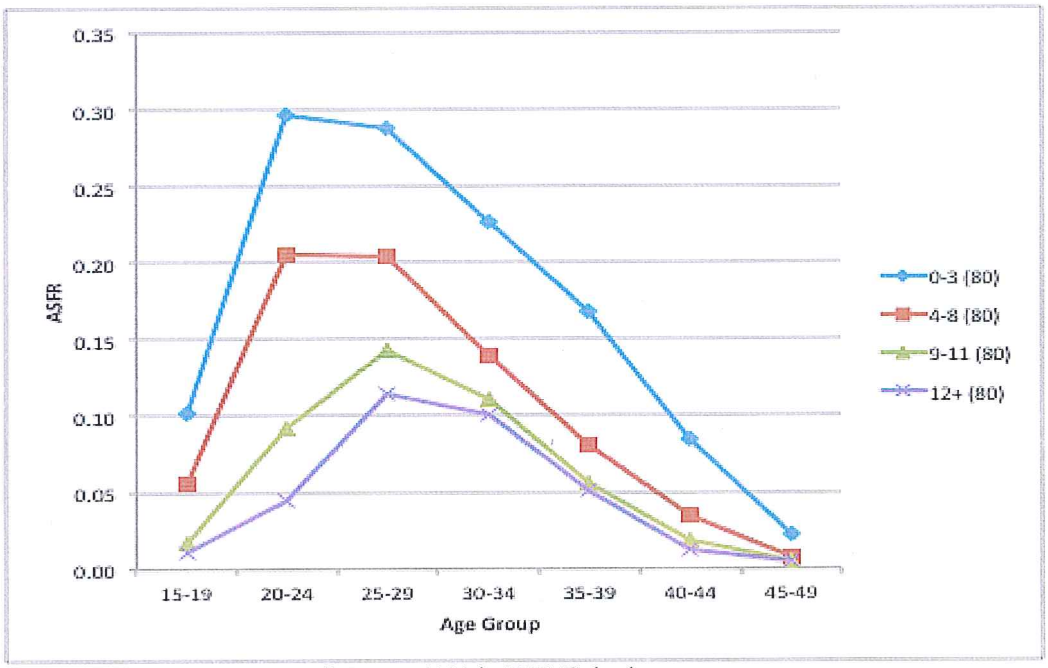
Author's elaboration from Brazil Censuses 1970-2010 in IPUMS database

Figure A5: Age Specific Fertility Rates by Education Groups – Brazil 1970



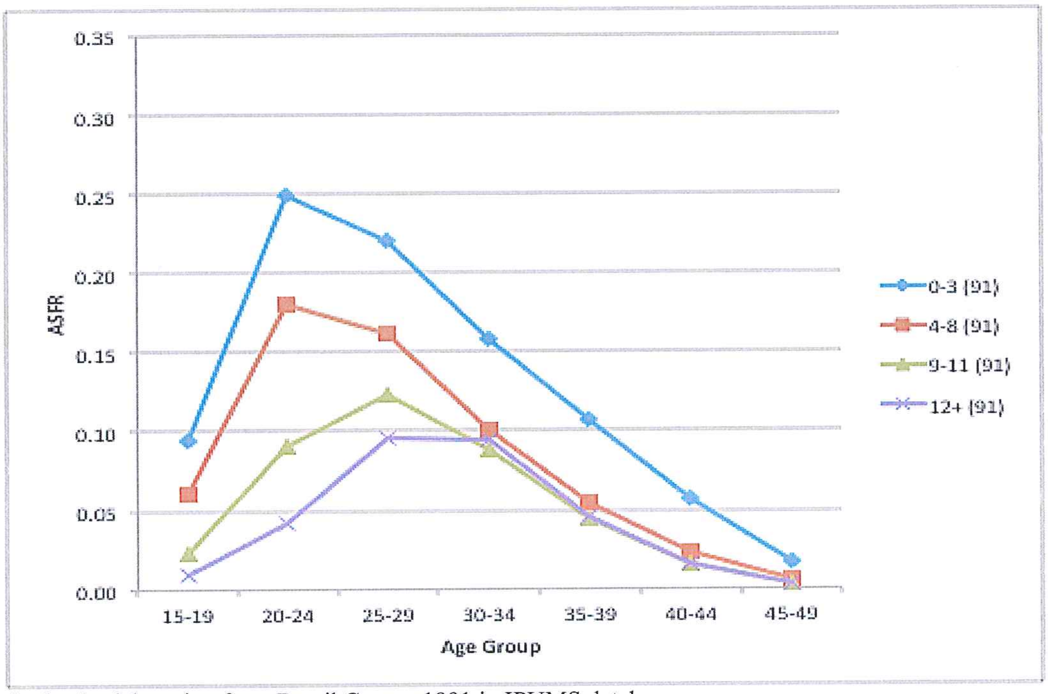
Author's elaboration from Brazil Census 1970 in IPUMS database

Figure A6: Age Specific Fertility Rates by Education Groups – Brazil 1980



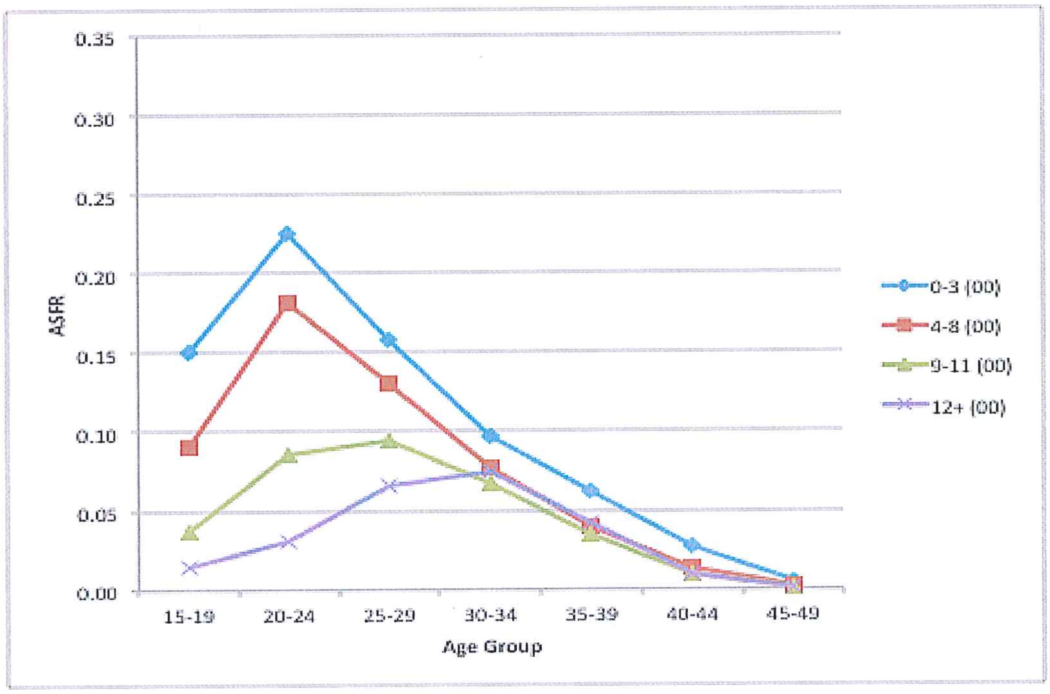
Author's elaboration from Brazil Census 1980 in IPUMS database

Figure A7: Age Specific Fertility Rates by Education Groups – Brazil 1991



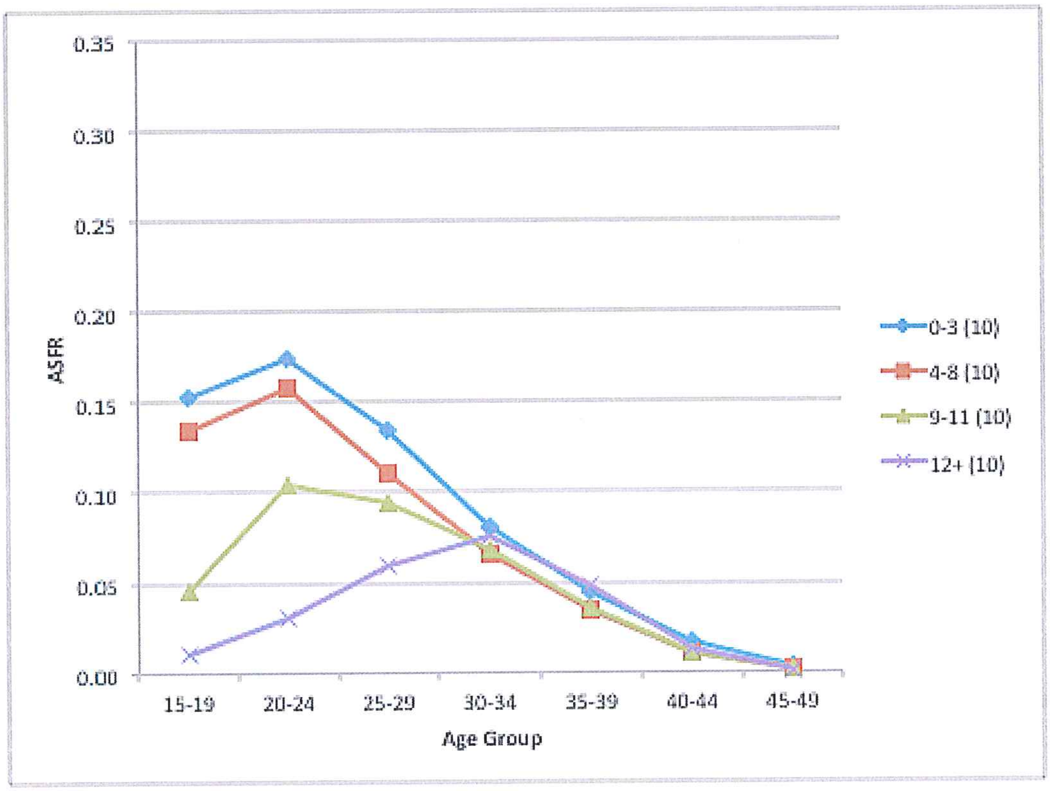
Author's elaboration from Brazil Census 1991 in IPUMS database

Figure A8: Age Specific Fertility Rates by Education Groups – Brazil 2000



Author's elaboration from Brazil Census 2000 in IPUMS database

Figure A9: Age Specific Fertility Rates by Education Groups – Brazil 2010



Author's elaboration from Brazil Census 2010 in IPUMS database

Table A2: Survival and Person Years lived to exact age x by Education Group, both sexes – Brazil 1970

x	n	Standard	0-3		4-8		9-11		12+	
		l_x	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$
0	1	1.0000	1.0000	0.9242	1.0000	0.9783	1.0000	0.9841	1.0000	0.9852
1	4	0.9081	0.8852	3.4445	0.9344	3.6811	0.9605	3.8073	0.9641	3.8251
5	5	0.8783	0.8491	4.2267	0.9123	4.5497	0.9466	4.7257	0.9515	4.7507
10	5	0.8720	0.8416	4.1966	0.9076	4.5307	0.9437	4.7137	0.9488	4.7397
15	5	0.8682	0.8370	4.1682	0.9047	4.5128	0.9418	4.7024	0.9471	4.7293
20	5	0.8625	0.8303	4.1258	0.9004	4.4857	0.9391	4.6851	0.9446	4.7135
25	5	0.8539	0.8201	4.0661	0.8939	4.4473	0.9349	4.6604	0.9408	4.6909
30	5	0.8423	0.8064	3.9891	0.8850	4.3970	0.9292	4.6279	0.9356	4.6611
35	5	0.8277	0.7893	3.8938	0.8738	4.3337	0.9219	4.5865	0.9289	4.6231
40	5	0.8096	0.7683	3.7763	0.8597	4.2539	0.9127	4.5337	0.9204	4.5745
45	5	0.7869	0.7423	3.6270	0.8418	4.1496	0.9008	4.4634	0.9094	4.5098
50	5	0.7572	0.7086	3.4296	0.8180	4.0062	0.8846	4.3647	0.8945	4.4185
55	5	0.7164	0.6633	3.1658	0.7845	3.8048	0.8613	4.2215	0.8729	4.2853
60	5	0.6609	0.6031	2.8179	0.7374	3.5200	0.8273	4.0092	0.8412	4.0865
65	5	0.5855	0.5241	2.3732	0.6706	3.1203	0.7764	3.6907	0.7934	3.7849
70	5	0.4868	0.4252	1.8394	0.5775	2.5798	0.6999	3.2168	0.7206	3.3291
75	5	0.3662	0.3106	1.2572	0.4544	1.8999	0.5869	2.5390	0.6110	2.6615
80	5	0.2339	0.1923	0.7054	0.3056	1.1498	0.4287	1.6654	0.4536	1.7742
85	5	0.1124	0.0899	0.2957	0.1544	0.5140	0.2374	0.8044	0.2561	0.8715
90	5	0.0361	0.0284	0.0843	0.0512	0.1527	0.0844	0.2526	0.0925	0.2772

Author's elaboration from Brazil Census 1970 in IPUMS database

Table A3: Survival and Person Years lived to exact age *x* by Education Group, both sexes – Brazil 1980

x	n	Standard	0-3		4-8		9-11		12+	
		l_x	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$
0	1	1.0000	1.0000	0.9349	1.0000	0.9803	1.0000	0.9857	1.0000	0.9871
1	4	0.9283	0.9014	3.5605	0.9453	3.7560	0.9657	3.8468	0.9699	3.8656
5	5	0.9156	0.8845	4.4099	0.9354	4.6693	0.9593	4.7916	0.9643	4.8171
10	5	0.9118	0.8795	4.3855	0.9324	4.6548	0.9574	4.7822	0.9626	4.8088
15	5	0.9082	0.8747	4.3553	0.9296	4.6367	0.9555	4.7705	0.9610	4.7984
20	5	0.9025	0.8674	4.3089	0.9251	4.6087	0.9527	4.7522	0.9584	4.7823
25	5	0.8940	0.8562	4.2433	0.9184	4.5687	0.9482	4.7261	0.9545	4.7591
30	5	0.8823	0.8412	4.1587	0.9091	4.5163	0.9422	4.6914	0.9491	4.7284
35	5	0.8676	0.8223	4.0531	0.8974	4.4496	0.9344	4.6470	0.9422	4.6889
40	5	0.8491	0.7989	3.9207	0.8825	4.3638	0.9244	4.5891	0.9333	4.6374
45	5	0.8253	0.7694	3.7509	0.8631	4.2502	0.9112	4.5111	0.9216	4.5676
50	5	0.7937	0.7310	3.5282	0.8370	4.0945	0.8932	4.4017	0.9055	4.4694
55	5	0.7508	0.6803	3.2335	0.8008	3.8761	0.8675	4.2434	0.8823	4.3261
60	5	0.6918	0.6131	2.8488	0.7497	3.5677	0.8298	4.0090	0.8481	4.1118
65	5	0.6115	0.5264	2.3659	0.6774	3.1379	0.7738	3.6600	0.7966	3.7876
70	5	0.5063	0.4200	1.8009	0.5777	2.5640	0.6902	3.1485	0.7184	3.3012
75	5	0.3781	0.3004	1.2027	0.4479	1.8551	0.5692	2.4337	0.6020	2.5985
80	5	0.2380	0.1807	0.6525	0.2942	1.0893	0.4043	1.5401	0.4373	1.6814
85	5	0.1100	0.0803	0.2588	0.1416	0.4615	0.2117	0.6999	0.2352	0.7815
90	5	0.0326	0.0232	0.0675	0.0430	0.1253	0.0682	0.1994	0.0774	0.2263

Author's elaboration from Brazil Census 1980 in IPUMS database

Table A4: Survival and Person Years lived to exact age x by Education Group, both sexes – Brazil 1991

x	n	Standard	0-3		4-8		9-11		12+	
		l_x	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$
0	1	1.0000	1.0000	0.9770	1.0000	0.9837	1.0000	0.9883	1.0000	0.9899
1	4	0.9572	0.9227	3.6607	0.9591	3.8203	0.9731	3.8817	0.9775	3.9010
5	5	0.9505	0.9111	4.5447	0.9527	4.7574	0.9688	4.8400	0.9738	4.8659
10	5	0.9480	0.9068	4.5222	0.9503	4.7449	0.9672	4.8315	0.9725	4.8588
15	5	0.9453	0.9021	4.4868	0.9476	4.7249	0.9654	4.8181	0.9710	4.8474
20	5	0.9397	0.8926	4.4249	0.9423	4.6897	0.9618	4.7943	0.9680	4.8273
25	5	0.9306	0.8773	4.3378	0.9336	4.6394	0.9559	4.7600	0.9630	4.7984
30	5	0.9187	0.8578	4.2322	0.9222	4.5771	0.9481	4.7173	0.9564	4.7621
35	5	0.9047	0.8351	4.1082	0.9087	4.5023	0.9388	4.6655	0.9485	4.7180
40	5	0.8876	0.8082	3.9573	0.8922	4.4083	0.9274	4.5995	0.9387	4.6616
45	5	0.8657	0.7747	3.7645	0.8711	4.2835	0.9124	4.5104	0.9259	4.5851
50	5	0.8359	0.7311	3.5116	0.8423	4.1111	0.8917	4.3846	0.9081	4.4762
55	5	0.7946	0.6736	3.1809	0.8021	3.8697	0.8621	4.2026	0.8824	4.3168
60	5	0.7367	0.5988	2.7617	0.7457	3.5342	0.8189	3.9379	0.8444	4.0814
65	5	0.6574	0.5059	2.2596	0.6679	3.0824	0.7562	3.5580	0.7882	3.7358
70	5	0.5534	0.3980	1.7043	0.5650	2.5068	0.6670	3.0313	0.7061	3.2408
75	5	0.4261	0.2838	1.1469	0.4377	1.8298	0.5455	2.3420	0.5902	2.5639
80	5	0.2845	0.1750	0.6462	0.2942	1.1149	0.3913	1.5187	0.4354	1.7101
85	5	0.1458	0.0834	0.2770	0.1517	0.5103	0.2162	0.7369	0.2487	0.8536
90	5	0.0501	0.0274	0.0818	0.0524	0.1570	0.0786	0.2364	0.0928	0.2798

Author's elaboration from Brazil Census 1991 in IPUMS database

Table A5: Survival and Person Years lived to exact age *x* by Education Group, both sexes – Brazil 2000

x	n	Standard	0-3		4-8		9-11		12+	
		l_x	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$
0	1	1.0000	1.0000	0.9828	1.0000	0.9909	1.0000	0.9929	1.0000	0.9947
1	4	0.9718	0.9557	3.7996	0.9800	3.9096	0.9847	3.9309	0.9890	3.9502
5	5	0.9658	0.9465	4.7250	0.9757	4.8753	0.9814	4.9046	0.9866	4.9311
10	5	0.9639	0.9436	4.7108	0.9744	4.8686	0.9804	4.8994	0.9859	4.9274
15	5	0.9621	0.9408	4.6830	0.9731	4.8555	0.9794	4.8893	0.9851	4.9201
20	5	0.9566	0.9325	4.6306	0.9691	4.8306	0.9764	4.8701	0.9829	4.9061
25	5	0.9483	0.9198	4.5636	0.9631	4.7982	0.9717	4.8451	0.9795	4.8878
30	5	0.9388	0.9056	4.4874	0.9562	4.7608	0.9663	4.8160	0.9756	4.8666
35	5	0.9277	0.8893	4.3964	0.9481	4.7153	0.9601	4.7804	0.9710	4.8404
40	5	0.9140	0.8692	4.2803	0.9380	4.6556	0.9521	4.7336	0.9652	4.8059
45	5	0.8955	0.8429	4.1268	0.9243	4.5740	0.9413	4.6692	0.9572	4.7580
50	5	0.8705	0.8079	3.9254	0.9053	4.4620	0.9263	4.5799	0.9460	4.6911
55	5	0.8367	0.7623	3.6620	0.8794	4.3063	0.9056	4.4540	0.9304	4.5955
60	5	0.7905	0.7025	3.3247	0.8431	4.0901	0.8760	4.2758	0.9078	4.4577
65	5	0.7290	0.6274	2.9075	0.7930	3.7925	0.8343	4.0241	0.8753	4.2578
70	5	0.6483	0.5356	2.4076	0.7241	3.3836	0.7753	3.6649	0.8278	3.9615
75	5	0.5440	0.4274	1.8355	0.6294	2.8276	0.6907	3.1509	0.7568	3.5131
80	5	0.4143	0.3068	1.2206	0.5017	2.0923	0.5697	2.4210	0.6485	2.8219
85	5	0.2616	0.1815	0.6529	0.3352	1.2496	0.3987	1.5112	0.4803	1.8638
90	5	0.1216	0.0797	0.2565	0.1646	0.5381	0.2058	0.6783	0.2652	0.8857

Author's elaboration from Brazil Census 2000 in IPUMS database

Table A6: Survival and Person Years lived to exact age x by Education Group, both sexes – Brazil 2010

x	n	Standard	0-3		4-8		9-11		12+	
		l_x	l_x	${}_nL_x$	l_x	${}_nL_x$	l_x	${}_nL_x$	l_x	${}_nL_x$
0	1	1.0000	1.0000	0.9846	1.0000	0.9920	1.0000	0.9938	1.0000	0.9954
1	4	0.9797	0.9619	3.8295	0.9828	3.9230	0.9869	3.9411	0.9905	3.9576
5	5	0.9757	0.9546	4.7665	0.9794	4.8941	0.9843	4.9190	0.9886	4.9416
10	5	0.9742	0.9520	4.7538	0.9782	4.8882	0.9833	4.9144	0.9880	4.9382
15	5	0.9729	0.9495	4.7276	0.9771	4.8759	0.9824	4.9050	0.9873	4.9314
20	5	0.9685	0.9416	4.6773	0.9733	4.8521	0.9796	4.8866	0.9852	4.9180
25	5	0.9617	0.9294	4.6136	0.9675	4.8216	0.9751	4.8630	0.9820	4.9008
30	5	0.9542	0.9161	4.5421	0.9611	4.7868	0.9701	4.8360	0.9784	4.8811
35	5	0.9454	0.9008	4.4559	0.9536	4.7440	0.9643	4.8027	0.9741	4.8567
40	5	0.9342	0.8816	4.3444	0.9440	4.6873	0.9568	4.7583	0.9686	4.8240
45	5	0.9190	0.8562	4.1950	0.9309	4.6088	0.9465	4.6965	0.9610	4.7782
50	5	0.8979	0.8218	3.9960	0.9126	4.4996	0.9321	4.6096	0.9503	4.7132
55	5	0.8689	0.7766	3.7332	0.8872	4.3465	0.9118	4.4863	0.9350	4.6198
60	5	0.8283	0.7167	3.3956	0.8514	4.1335	0.8827	4.3113	0.9129	4.4850
65	5	0.7734	0.6415	2.9776	0.8020	3.8405	0.8418	4.0645	0.8811	4.2897
70	5	0.6994	0.5496	2.4764	0.7342	3.4382	0.7840	3.7129	0.8348	4.0011
75	5	0.6007	0.4410	1.9064	0.6411	2.8967	0.7012	3.2154	0.7657	3.5703
80	5	0.4747	0.3215	1.3050	0.5176	2.1992	0.5850	2.5304	0.6625	2.9297
85	5	0.3235	0.2005	0.7440	0.3621	1.3949	0.4272	1.6740	0.5094	2.0441
90	5	0.1702	0.0971	0.3257	0.1959	0.6698	0.2424	0.8374	0.3082	1.0814

Author's elaboration from Brazil Census 2010 in IPUMS database

Table A7: Survival and Person Years lived to exact age x by Education Group, female – Brazil 1970

x	n	Standard	0-3		4-8		9-11		12+	
		l_x	l_x	${}_nL_x$	l_x	${}_nL_x$	l_x	${}_nL_x$	l_x	${}_nL_x$
0	1	1.0000	1.0000	0.9813	1.0000	0.9831	1.0000	0.9900	1.0000	0.9913
1	4	0.9204	0.8965	3.5097	0.9478	3.7511	0.9750	3.8804	0.9788	3.8986
5	5	0.8974	0.8675	4.3233	0.9321	4.6526	0.9672	4.8320	0.9722	4.8574
10	5	0.8927	0.8618	4.2987	0.9289	4.6389	0.9656	4.8252	0.9708	4.8516
15	5	0.8895	0.8577	4.2742	0.9267	4.6253	0.9645	4.8183	0.9698	4.8457
20	5	0.8848	0.8520	4.2389	0.9234	4.6054	0.9628	4.8082	0.9685	4.8371
25	5	0.8781	0.8436	4.1894	0.9187	4.5774	0.9604	4.7939	0.9664	4.8249
30	5	0.8688	0.8322	4.1237	0.9122	4.5396	0.9571	4.7746	0.9636	4.8084
35	5	0.8566	0.8173	4.0392	0.9036	4.4902	0.9527	4.7490	0.9598	4.7864
40	5	0.8409	0.7984	3.9316	0.8925	4.4259	0.9469	4.7152	0.9548	4.7574
45	5	0.8208	0.7743	3.7934	0.8779	4.3407	0.9392	4.6697	0.9482	4.7182
50	5	0.7943	0.7431	3.6123	0.8584	4.2247	0.9287	4.6061	0.9391	4.6634
55	5	0.7586	0.7018	3.3706	0.8315	4.0613	0.9138	4.5136	0.9262	4.5830
60	5	0.7094	0.6464	3.0465	0.7931	3.8253	0.8917	4.3731	0.9070	4.4601
65	5	0.6410	0.5722	2.6192	0.7371	3.4806	0.8576	4.1520	0.8770	4.2642
70	5	0.5476	0.4755	2.0837	0.6552	2.9852	0.8032	3.7959	0.8286	3.9425
75	5	0.4267	0.3580	1.4663	0.5389	2.3050	0.7151	3.2167	0.7484	3.4020
80	5	0.2834	0.2286	0.8426	0.3831	1.4657	0.5715	2.3137	0.6124	2.5150
85	5	0.1397	0.1085	0.3577	0.2032	0.6827	0.3539	1.2322	0.3936	1.3852
90	5	0.0457	0.0346	0.1028	0.0699	0.2085	0.1390	0.4189	0.1605	0.4855

Author's elaboration from Brazil Census 1970 in IPUMS database

Table A8: Survival and Person Years lived to exact age x by Education Group, female – Brazil 1980

x	n	Standard	0-3		4-8		9-11		12+	
		l_x	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$
0	1	1.0000	1.0000	0.9803	1.0000	0.9844	1.0000	0.9898	1.0000	0.9911
1	4	0.9376	0.9111	3.5973	0.9542	3.7919	0.9742	3.8827	0.9784	3.9015
5	5	0.9244	0.8931	4.4522	0.9444	4.7148	0.9686	4.8387	0.9736	4.8645
10	5	0.9206	0.8878	4.4278	0.9415	4.7013	0.9669	4.8309	0.9722	4.8578
15	5	0.9173	0.8833	4.4023	0.9390	4.6872	0.9654	4.8226	0.9710	4.8509
20	5	0.9131	0.8776	4.3684	0.9358	4.6682	0.9636	4.8115	0.9694	4.8415
25	5	0.9073	0.8698	4.3222	0.9314	4.6421	0.9610	4.7962	0.9672	4.8285
30	5	0.8993	0.8591	4.2602	0.9254	4.6067	0.9575	4.7753	0.9642	4.8108
35	5	0.8887	0.8450	4.1788	0.9173	4.5594	0.9527	4.7471	0.9601	4.7869
40	5	0.8747	0.8266	4.0728	0.9065	4.4965	0.9462	4.7093	0.9546	4.7547
45	5	0.8562	0.8026	3.9339	0.8921	4.4118	0.9375	4.6576	0.9472	4.7106
50	5	0.8314	0.7710	3.7500	0.8726	4.2952	0.9255	4.5851	0.9370	4.6484
55	5	0.7976	0.7290	3.5036	0.8455	4.1308	0.9085	4.4798	0.9224	4.5576
60	5	0.7505	0.6725	3.1728	0.8068	3.8935	0.8834	4.3216	0.9007	4.4198
65	5	0.6842	0.5966	2.7354	0.7506	3.5470	0.8452	4.0759	0.8672	4.2028
70	5	0.5919	0.4975	2.1837	0.6682	3.0474	0.7852	3.6875	0.8139	3.8518
75	5	0.4688	0.3760	1.5395	0.5507	2.3540	0.6898	3.0695	0.7269	3.2725
80	5	0.3161	0.2398	0.8776	0.3909	1.4846	0.5380	2.1349	0.5822	2.3453
85	5	0.1549	0.1112	0.3626	0.2029	0.6734	0.3160	1.0758	0.3560	1.2244
90	5	0.0487	0.0338	0.0989	0.0664	0.1951	0.1143	0.3381	0.1338	0.3968

Author’s elaboration from Brazil Census 1980 in IPUMS database

Table A9: Survival and Person Years lived to exact age x by Education Group, female – Brazil 1991

x	n	Standard	0-3		4-8		9-11		12+	
		l_x	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$
0	1	1.0000	1.0000	0.9807	1.0000	0.9867	1.0000	0.9909	1.0000	0.9925
1	4	0.9620	0.9277	3.6801	0.9638	3.8397	0.9777	3.9013	0.9821	3.9205
5	5	0.9555	0.9158	4.5696	0.9577	4.7833	0.9739	4.8662	0.9790	4.8923
10	5	0.9534	0.9120	4.5507	0.9556	4.7733	0.9726	4.8600	0.9779	4.8872
15	5	0.9513	0.9083	4.5277	0.9537	4.7611	0.9714	4.8522	0.9769	4.8809
20	5	0.9482	0.9028	4.4946	0.9508	4.7434	0.9695	4.8411	0.9754	4.8719
25	5	0.9439	0.8951	4.4493	0.9466	4.7190	0.9669	4.8256	0.9733	4.8593
30	5	0.9380	0.8847	4.3886	0.9410	4.6859	0.9633	4.8046	0.9704	4.8422
35	5	0.9300	0.8708	4.3073	0.9334	4.6409	0.9585	4.7757	0.9665	4.8187
40	5	0.9192	0.8522	4.1974	0.9230	4.5786	0.9518	4.7354	0.9610	4.7858
45	5	0.9040	0.8268	4.0466	0.9085	4.4906	0.9424	4.6778	0.9533	4.7385
50	5	0.8824	0.7919	3.8393	0.8878	4.3642	0.9287	4.5935	0.9421	4.6689
55	5	0.8514	0.7438	3.5557	0.8579	4.1806	0.9087	4.4678	0.9255	4.5643
60	5	0.8063	0.6784	3.1765	0.8143	3.9138	0.8785	4.2777	0.9002	4.4038
65	5	0.7412	0.5922	2.6925	0.7512	3.5323	0.8326	3.9897	0.8613	4.1557
70	5	0.6499	0.4848	2.1172	0.6618	3.0076	0.7633	3.5590	0.8010	3.7729
75	5	0.5282	0.3620	1.4900	0.5412	2.3241	0.6603	2.9292	0.7082	3.1865
80	5	0.3760	0.2340	0.8764	0.3884	1.5092	0.5113	2.0567	0.5664	2.3179
85	5	0.2065	0.1166	0.3932	0.2153	0.7409	0.3114	1.0957	0.3608	1.2859
90	5	0.0772	0.0407	0.1233	0.0811	0.2471	0.1269	0.3897	0.1536	0.4737

Author's elaboration from Brazil Census 1991 in IPUMS database

Table A10: Survival and Person Years lived to exact age x by Education Group, female – Brazil 2000

x	n	Standard	0-3		4-8		9-11		12+	
		l_x	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$	l_x	$_nL_x$
0	1	1.0000	1.0000	0.9856	1.0000	0.9932	1.0000	0.9951	1.0000	0.9969
1	4	0.9758	0.9597	3.8172	0.9841	3.9276	0.9888	3.9490	0.9931	3.9684
5	5	0.9706	0.9512	4.7499	0.9806	4.9006	0.9863	4.9300	0.9915	4.9566
10	5	0.9692	0.9488	4.7390	0.9796	4.8961	0.9856	4.9268	0.9911	4.9546
15	5	0.9679	0.9468	4.7247	0.9788	4.8902	0.9851	4.9226	0.9907	4.9520
20	5	0.9656	0.9431	4.7025	0.9773	4.8810	0.9840	4.9161	0.9901	4.9479
25	5	0.9625	0.9379	4.6730	0.9751	4.8687	0.9825	4.9073	0.9891	4.9425
30	5	0.9583	0.9313	4.6336	0.9723	4.8521	0.9805	4.8955	0.9879	4.9351
35	5	0.9526	0.9222	4.5791	0.9685	4.8289	0.9777	4.8789	0.9862	4.9247
40	5	0.9446	0.9095	4.5003	0.9631	4.7947	0.9738	4.8544	0.9837	4.9092
45	5	0.9325	0.8907	4.3859	0.9548	4.7438	0.9679	4.8177	0.9800	4.8860
50	5	0.9149	0.8637	4.2244	0.9427	4.6691	0.9591	4.7634	0.9744	4.8514
55	5	0.8896	0.8261	4.0013	0.9250	4.5601	0.9462	4.6834	0.9662	4.7999
60	5	0.8535	0.7745	3.6989	0.8991	4.4008	0.9271	4.5643	0.9538	4.7219
65	5	0.8022	0.7051	3.3022	0.8612	4.1684	0.8986	4.3861	0.9350	4.6023
70	5	0.7311	0.6158	2.8005	0.8062	3.8288	0.8559	4.1157	0.9060	4.4137
75	5	0.6332	0.5044	2.1857	0.7254	3.3226	0.7904	3.6886	0.8595	4.0967
80	5	0.4989	0.3698	1.4892	0.6037	2.5862	0.6850	3.0110	0.7792	3.5400
85	5	0.3310	0.2258	0.8260	0.4308	1.6585	0.5194	2.0535	0.6368	2.6232
90	5	0.1653	0.1046	0.3423	0.2326	0.7811	0.3020	1.0307	0.4125	1.4496

Author's elaboration from Brazil Census 2000 in IPUMS database

Table A11: Survival and Person Years lived to exact age x by Education Group, female – Brazil 2010

x	n	Standard	0-3		4-8		9-11		12+	
		l_x	l_x	${}_nL_x$	l_x	${}_nL_x$	l_x	${}_nL_x$	l_x	${}_nL_x$
0	1	1.0000	1.0000	0.9871	1.0000	0.9941	1.0000	0.9958	1.0000	0.9973
1	4	0.9832	0.9654	3.8447	0.9864	3.9388	0.9904	3.9570	0.9941	3.9736
5	5	0.9799	0.9588	4.7883	0.9837	4.9162	0.9885	4.9411	0.9929	4.9638
10	5	0.9788	0.9565	4.7781	0.9828	4.9120	0.9879	4.9382	0.9926	4.9619
15	5	0.9779	0.9547	4.7646	0.9820	4.9065	0.9874	4.9343	0.9922	4.9595
20	5	0.9761	0.9512	4.7435	0.9806	4.8979	0.9864	4.9282	0.9916	4.9558
25	5	0.9737	0.9463	4.7153	0.9786	4.8862	0.9849	4.9200	0.9907	4.9506
30	5	0.9704	0.9398	4.6775	0.9759	4.8705	0.9830	4.9088	0.9895	4.9437
35	5	0.9660	0.9311	4.6247	0.9723	4.8483	0.9805	4.8930	0.9879	4.9339
40	5	0.9596	0.9187	4.5472	0.9670	4.8150	0.9767	4.8693	0.9856	4.9190
45	5	0.9498	0.9001	4.4332	0.9590	4.7649	0.9710	4.8333	0.9820	4.8965
50	5	0.9352	0.8731	4.2707	0.9470	4.6906	0.9623	4.7796	0.9766	4.8625
55	5	0.9140	0.8352	4.0454	0.9293	4.5819	0.9495	4.7001	0.9684	4.8117
60	5	0.8834	0.7830	3.7404	0.9035	4.4231	0.9305	4.5819	0.9562	4.7349
65	5	0.8392	0.7132	3.3414	0.8658	4.1922	0.9022	4.4057	0.9377	4.6176
70	5	0.7765	0.6234	2.8390	0.8111	3.8564	0.8600	4.1397	0.9093	4.4336
75	5	0.6879	0.5122	2.2316	0.7315	3.3645	0.7958	3.7272	0.8641	4.1306
80	5	0.5631	0.3804	1.5614	0.6143	2.6756	0.6951	3.1008	0.7881	3.6246
85	5	0.4040	0.2441	0.9209	0.4559	1.8122	0.5452	2.2254	0.6617	2.8096
90	5	0.2294	0.1242	0.4242	0.2690	0.9474	0.3449	1.2379	0.4621	1.7150

Author's elaboration from Brazil Census 2010 in IPUMS database