A PERIOD DECOMPOSITION OF FERTILITY DECLINE IN BRAZIL: PURE FERTILITY INDEX, TEMPO AND PARITY COMPOSITION EFFECTS

Vania Candida da Silva[*]
vaniacan@cedeplar.ufmg.br
Adriana de Miranda-Ribeiro[*]
adriana@cedeplar.ufmg.br
Eduardo L. G. Rios-Neto[♦]
eduardo@cedeplar.ufmg.br

Brazil has experienced a steady fertility decline during the last thirty years. The Brazilian Census Bureau figures indicate a decline in total fertility rate (TFR): 6.3 (1960), 5.8 (1970), 4.4 (1980), 2.9 (1991), and 2.3 (2000). The 2003 Brazilian National Household Survey (PNAD) gives a replacement level TFR for the country as a whole. A paper by Goldani (2002), presented at a recent UN Population Division seminar, contrasted official projections of TFR at replacement level only in year 2025 with several expert predictions suggesting below replacement fertility already in 2005.

In spite of the good quality of the Brazilian census data, the debate on future fertility trends and its political/ economic consequences has been limited by the lack of good quality birth histories and vital registration. The only empirical evidence used by the experts is the measurement of period TFRs (incidence rates). Demographers know that the median age at marriage has been remarkably stable at around 22.5. They also know that the relative distribution of period ASFRs have been increasingly concentrated among women less than 25 years of age. The share of the 15-24 ASFR in TFR increased from 30% in 1973 to 45% in 1988 (Rios-Neto, 2000). The Census Bureau calculated the following increase in the share of 15-19 ASFR in TFR: 9.1% (1980), 15.3% (1991) and 19.4% (2000). These figures are consistent with the observed high prevalence of female sterilization in Brazil, which leads to a pattern of reduced birth spacing combined with termination by parity.

The use of incidence rates may mislead inferences, as pointed by Ortega and Kohler (2002). Not a great deal is known about some dimensions of fertility in Brazil, such as birth intervals, parity progression rates, tempo effects, and mean age by parity. This paper will apply an alternative methodology for the reconstruction of birth histories in Brazil, constructing a birth history from 1986 to 2000, based on the 1991 and 2000 demographic census microdata. The birth history reconstruction will be combined with the Kohler & Ortega method to disentangle the following period effects: tempo, parity composition, and quantum. This exercise will clarify the nature of the strong fertility decline observed in Brazil.

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[*] PhD students at Cedeplar, *Universidade Federal de Minas Gerais* (UFMG) / Brazil.

[♦] Professor, Demography Departament and Cedeplar, *Universidade Federal de Minas Gerais* (UFMG), Brazil.

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It will show that the quantum effect dominates the Brazilian fertility transition, while the parity composition effect was positive and much more important than the tempo effect, so that the Brazilian fertility decline would be larger without it.

Methods

The basic idea of the methodology consists in the reconstruction of birth histories[1], based on the censuses' family structure. The data requirement from the censuses, conditioned on the allocation of children to their presumable mothers, is the following:

1. Relationship of mothers and children to the family head.
2. Sex of children.
3. Age (of mother and children).
4. Parity or number of children ever born.
5. Number of dead children.

A major data limitation prevalent in most demographic censuses in developing countries is the absence of information on birth order and age of dead children. Thus, some restrictions must be applied in order to reconstruct birth histories:

1. Use only women with no dead children (remove women with dead children).
2. Use information about family composition to allocate present children under the age of 15 to the women in the family of ages 15 to 59, keeping only women whose allocation is presumably correct (remove women whose children allocation is not possible).

Removing these women from the analysis could potentially lead to biased estimates. In order to correct for the selection process we use a two-stage Inverse Probability Weight (IPW) procedure. The two subsequent weight corrections ensure "parity and age" and "temporal" representation respectively:

To ensure representation by parity and age, we correct the original weight by the ratio between two matrixes: the matrix of sum of weight factors of women by parity and age in the original data, divided by the equivalent matrix for the derived data (the data containing only women with no dead children). The matrixes cells values are the sum of the weight factors, by age and parity, for the original sample and the selected sample, respectively.

To ensure temporal representation, we control, within each parity and age category, for the probability of no dead children, based on the characteristics of the women (region of residence) and the children (sex, age and region of residence of each of the allocated children). These probabilities are based on external estimates, derived from life tables (in our case generated by Cedeplar). This correction is important since otherwise women with relatively young children, who would have lower probabilities of having any dead child, would be overrepresented. This would lead to inaccurate time trends.

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[1] See MIRANDA-RIBEIRO and SILVA (2005).

See also CHO, RETHERFORD and CHOE (1986), LUTHER and CHOE (1988).

The next step consists in the application of the Kohler & Ortega method. Based on the weighted birth histories, we obtain the parity and age distribution of women. For every year, we have the number of births by parity and age, and compute the birth intensities. Finally, the computed birth intensities are used to analyze fertility trends. The application of Kohler & Ortega decomposition leads to estimates of tempo, parity, and quantum effects of fertility. The formulas developed below are based on Ortega and Kohler (2002).

Birth intensities are defined as the number of births of order "i" divided by the number of women of parity "ï-1", as defined in (1):

$$\boxed{m_c(a) = \frac{B_c(a)}{E_c(a)}} \qquad (1)$$

$B_c(a)$ are births of women aged a and class c.
$E_c(a)$ are women aged a and class c (parity "ï-1").

Incidence rates generate the age specific fertility rates:

$$\boxed{f_c(a) = \frac{B_c(a)}{E\ \ (a)}} \qquad (2)$$

$B_c(a)$ are births of women aged a and class c.
$E\ \ (a)$ are women aged a.

The tempo effect ($r_j(a)$) of parity "j" at age a is:

$$\boxed{r_j(a) = \gamma_j + \delta_j(a - \bar{a}_j)} \qquad (3)$$

γ_j and δ_j are the parameters gamma and delta, calculated interactively following Kohler e Philipov (2001).

Gamma is the change in the mean age at childbearing.
Delta is the proportional change in the standard deviation.
$\bar{a}_j$ is the mean age at the adjusted fertility function.

Adjusted functions follow the two formulas below.

For intensities:

$$\boxed{m_j'(a) = \frac{m_j(a)}{1 - r_j(a)}} \qquad (4)$$

For incidences:

$$\boxed{f_j'(a) = \frac{f_j(a)}{1 - r_j(a)}} \qquad (5)$$

TFR and TFR_C(classe c) are calculated by the formulas below:

$$\boxed{TFR_C = \sum_a f_c(a)} \qquad (6)$$

$$\boxed{TFR = \sum_c TFRc = \sum_a f(a)} \qquad (7)$$

A fertility table is built following the formulas below.

The age and parity specific probability of birth:

$$\boxed{q_j(a) = 1 - \exp[-m_j(a)]} \qquad (8)$$

The birth probabilities are the basis for the other measures of the table.

$$\boxed{b_j(a) = D_j(a).q_j(a)} \qquad (9)$$

$D_j(a)$ is the number of women of parity j and exact age a.

$b_j(a)$ is the number of births of parity j to the women at age a.

An interactive procedure using formulas (9) and (10) allows the calculation of the number of women and births.

$$\boxed{D_j(a+1) = D_j(a) - b_j(a) + b_{j-1}(a)} \qquad (10)$$

For parity J, the last parity, including parities J and above, the two interactive formulas are:

$$\boxed{b_J(a) = D_j(a).f_J(a)} \qquad (11)$$

$$\boxed{D_J(a+1) = D_J(a) + b_{J-1}(a)} \qquad (12)$$

The number of women at the initial condition of the table (radix), that is to say age "α" and parity "j=0", is N. At the exact age "α" and parity "j>0" the number of women is null.

The mean number of births for women in the synthetic cohort is defined by (13).

$$\boxed{b_{j1,j2}(a_0, a_1) = \sum_{a=a0}^{a1} \sum_{j=j1}^{j2} b_j(a)} \qquad (13)$$

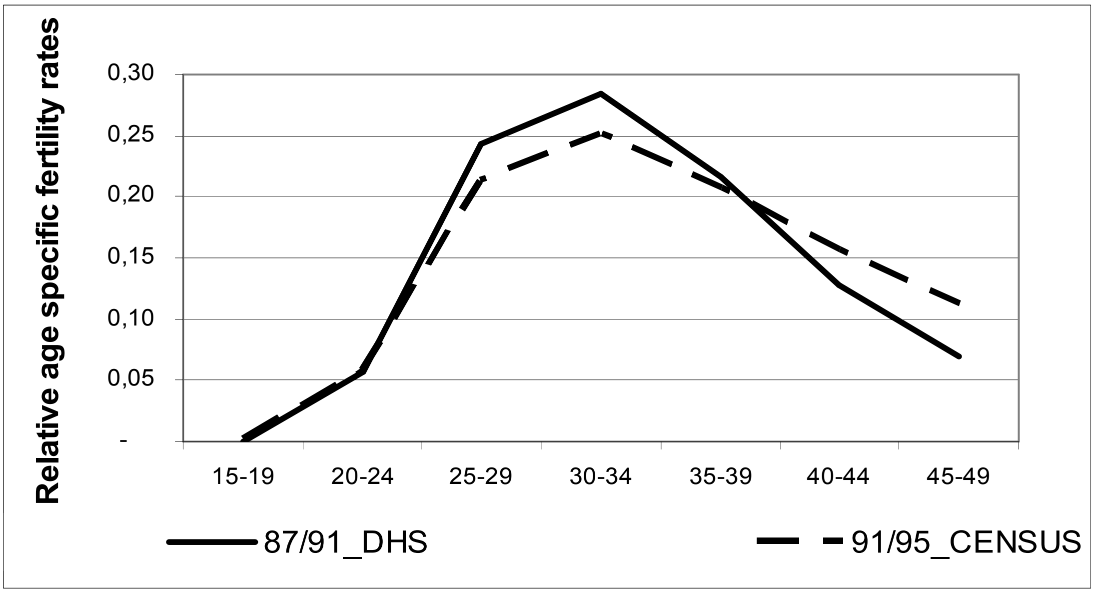
The completed fertility of the fertility table corresponds to (14) and is also called Parity and Age Total Fertility Rate (PATFR) as in Rally and Toulemon (1993). When PATFR is built based on tempo adjusted intensities, it is free from both tempo and parity compositional effects.

$$b_{0,J}(\alpha, \omega) / N = b_{0,J}(\alpha) / N \qquad (14)$$

A Consistency Check for the Methodology

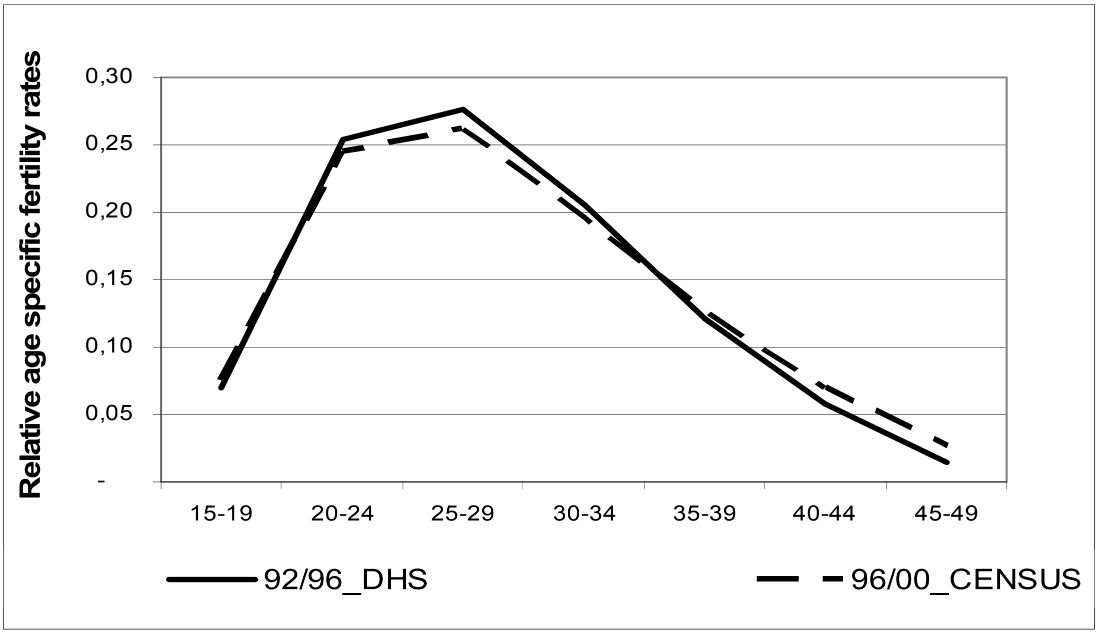
In order to check the methodology regarding the reconstruction of birth histories based on the censuses' family structure, we calculated the total fertility rate and the age specific fertility rates, based on the 1996 DHS and 2000 Census birth histories. The Figures 1 and 2 shows the relative age specific rates for 1987/1991 and 1992/1996, using DHS, and for 1991/1995 and 1996/2000, using Census data.

Figure 1: Brazil: relative age specific fertility rates, based on 1996 DHS and 2000 Demographic Census – 1987/1991, 1991/1995



Sources: BENFAM: Brazilian DHS, 1996
IBGE: Brazilian Demographic Census, 2000

Figure 2: Brazil: relative age specific fertility rates, based on 1996 DHS and 2000 Demographic Census – 1992/1996 and 1996/2000



Sources: BENFAM: Brazilian DHS, 1996
IBGE: Brazilian Demographic Census, 2000

The TFRs calculated with birth histories from DHS and the 2000 demographic census seem to be consistent, as indicated in Table 1. The traditionally calculated TFR for the 1991 and 2000 demographic censuses are also presented for comparison.

Table 1: Brazil: Birth Histories and Traditional Total Fertility Rates based on 1996 DHS, 1991 and 2000 Demographic Censuses

TFR					
Birth Histories				Traditional	
DHS	CENSUS	DHS	CENSUS	CENSUS	CENSUS
1987/1991	1991/1995	1992/1996	1996/2000	1991	2000
3,10	2,76	2,50	2,36	2,76	2,36

Sources: BENFAM: Brazilian DHS, 1996 and IBGE: Brazilian Demographic Census, 1991 and 2000

* TFR Tradicional: observed TFR using tradicional Brass techniques.

Empirical Results: Trends

Results presented in Tables 2 to 5 give a complete picture of tempo, parity, and quantum effects of Brazilian fertility in 1987, 1991, 1996 and 2000. Focusing on the estimation of the tempo effect, the 1987 adjusted TFR was slightly lower than the observed TFR (2.95 and 3.22), indicating a negative tempo effect of 9.6 percent. In 1991, the tempo effect continued slightly negative, with adjusted TFR lower than observed TFR (2.73 and 2.80). A relatively larger negative tempo effect was observed in 1996, around 10.2 percent, adjusted TFR was 2.34 contrasted with 2.58 in observed TFR. The size of the negative tempo effect in year 2000 is smaller than in 1996, around 8.1 percent, adjusted TFR is near replacement (2.08) while observed TFR is slightly above replacement level. Figure 3 depicts observed and adjusted TFR in the four years analyzed, including observed TFR in the two censuses using traditional Brass techniques.

Table 2: Tempo and Parity Composition Effects on Fertility – Brazil 1987

	Parities					
	0	1	2	3	4+	Total
TFR	0,859	0,734	0,493	0,297	0,846	3,229
TFR Adjusted	0,829	0,664	0,433	0,249	0,771	2,946
Mean Tempo Effect (%)	(3,59)	(10,51)	(13,83)	(19,45)	(9,68)	(9,59)
PATFR	0,910	0,801	0,517	0,259	0,030	2,517
PATFR Adjusted	0,864	0,669	0,318	0,109	0,005	1,965
Parity Composition Effect (%)	(4,04)	(0,69)	36,28	128,77	13.971,70	49,97
Mean Age Stable Dist.	24,03	26,83	28,85	30,39	35,12	-
Mean Age Frequency Sched.	24,77	28,92	31,28	32,91	36,91	-

Source: Birth History Reconstruction from the Brazilian Demographic Census, 1991.

Table 3: Tempo and Parity Composition Effects on Fertility – Brazil 1991

	Parities					
	0	1	2	3	4+	Total
TFR	0,890	0,706	0,421	0,226	0,561	2,802
TFR Adjusted	0,872	0,706	0,404	0,215	0,529	2,727
Mean Tempo Effect (%)	(1,97)	0,08	(4,26)	(4,81)	(5,95)	(2,77)
PATFR	0,900	0,755	0,429	0,188	0,016	2,289
PATFR Adjusted	0,879	0,688	0,319	0,118	0,006	2,010
Parity Composition Effect (%)	(0,76)	2,61	26,67	82,46	8.192,57	35,65
Mean Age Stable Dist.	23,61	26,38	28,35	29,84	34,74	-
Mean Age Frequency Sched.	24,03	27,60	29,61	30,44	34,01	-

Source: Birth History Reconstruction from the Brazilian Demographic Census, 1991.

Table 4: Tempo and Parity Composition Effects on Fertility – Brazil 1996

	Parities					
	0	1	2	3	4+	Total
TFR	0,875	0,703	0,407	0,206	0,391	2,582
TFR Adjusted	0,844	0,710	0,328	0,157	0,304	2,344
Mean Tempo Effect (%)	(3,57)	0,93	(24,02)	(31,03)	(28,59)	(10,16)
PATFR	0,901	0,749	0,394	0,160	0,012	2,216
PATFR Adjusted	0,837	0,611	0,227	0,070	0,002	1,747
Parity Composition Effect (%)	0,92	16,05	44,51	124,69	13.234,57	34,12
Mean Age Stable Dist.	23,93	26,93	28,96	30,68	34,73	
Mean Age Frequency Sched.	24,59	28,70	30,38	31,41	35,12	

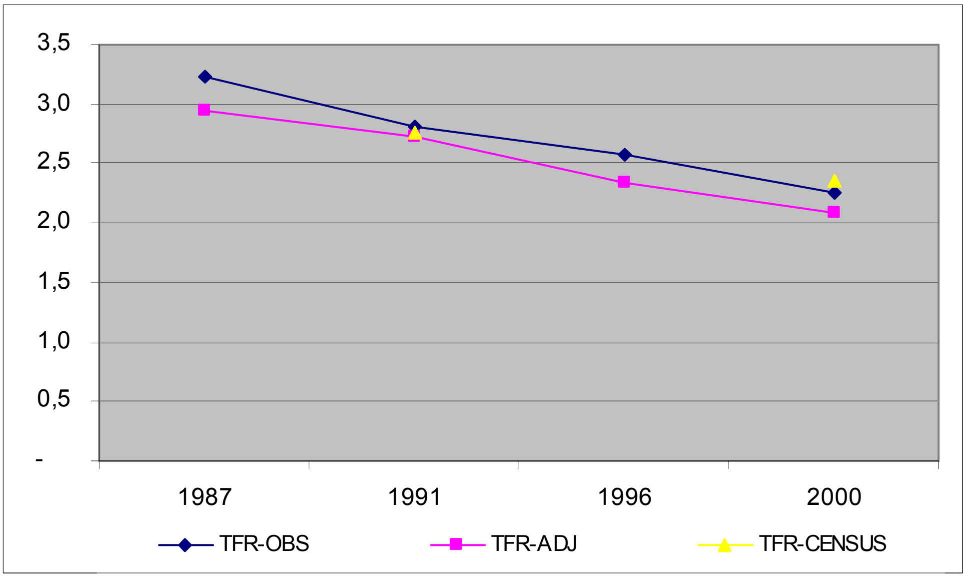
Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Table 5: Tempo and Parity Composition Effects on Fertility – Brazil 2000

	Parities					
	0	1	2	3	4+	Total
TFR	0,824	0,630	0,354	0,168	0,273	2,249
TFR Adjusted	0,748	0,612	0,347	0,152	0,221	2,081
Mean Tempo Effect (%)	(10,15)	(3,06)	(1,98)	(10,33)	(23,10)	(8,09)
PATFR	0,870	0,670	0,316	0,122	0,007	1,984
PATFR Adjusted	0,823	0,556	0,228	0,077	0,003	1,687
Parity Composition Effect (%)	(9,10)	9,94	52,52	98,00	8.010,51	23,35
Mean Age Stable Dist.	23,48	26,74	28,46	29,81	33,91	
Mean Age Frequency Sched.	24,12	27,89	28,92	29,93	33,31	

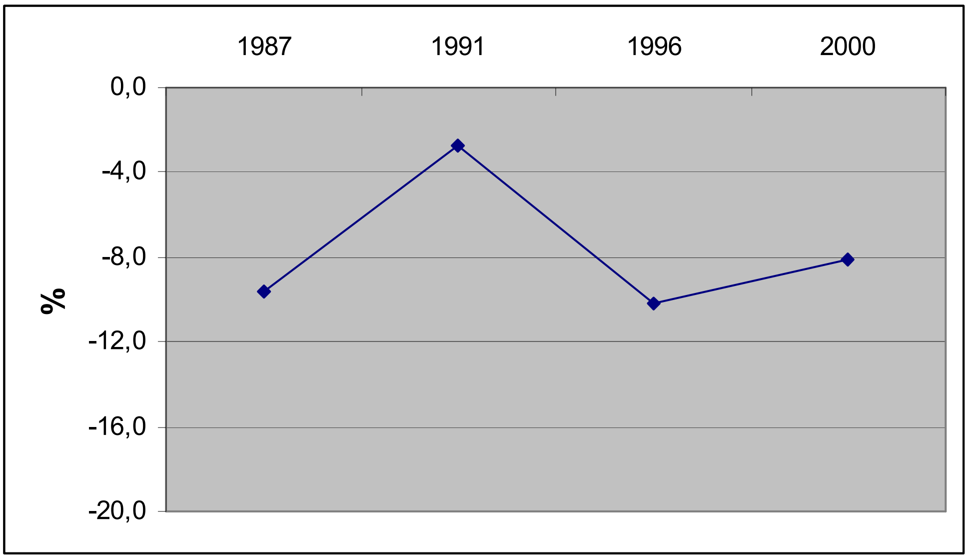
Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Figure 3: Brazil: Observed and Adjusted Total Fertility Rate – 1987 – 2000



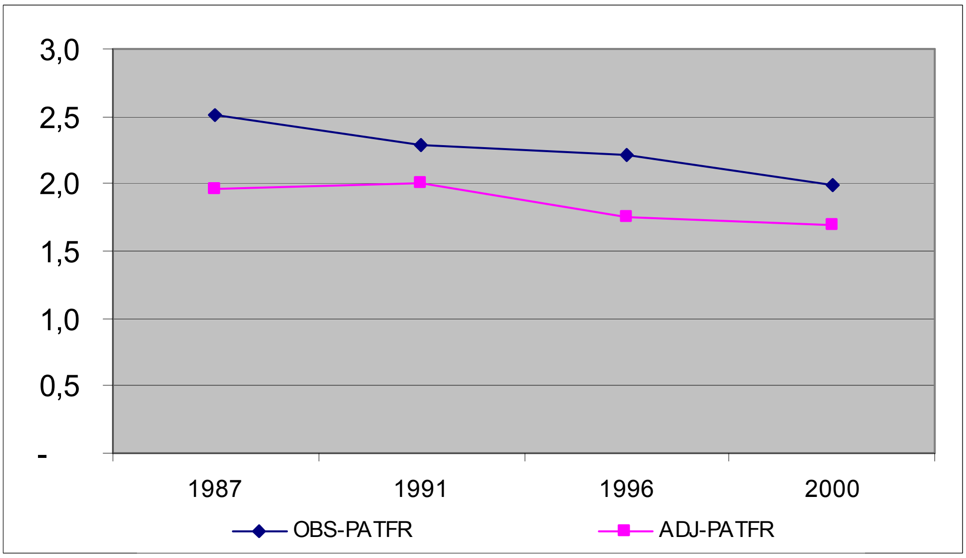
Source: Birth History Reconstruction from the Brazilian Demographic Censuses, 1991 and 2000.

Figure 4: Brazil: Fertility Tempo Effect – 1987 - 2000



Source: Birth History Reconstruction from the Brazilian Demographic Censuses, 1991 and 2000.

Figure 5: Brazil: Observed and Adjusted Parity and Age Specific Fertility Rate – 1987 – 2000



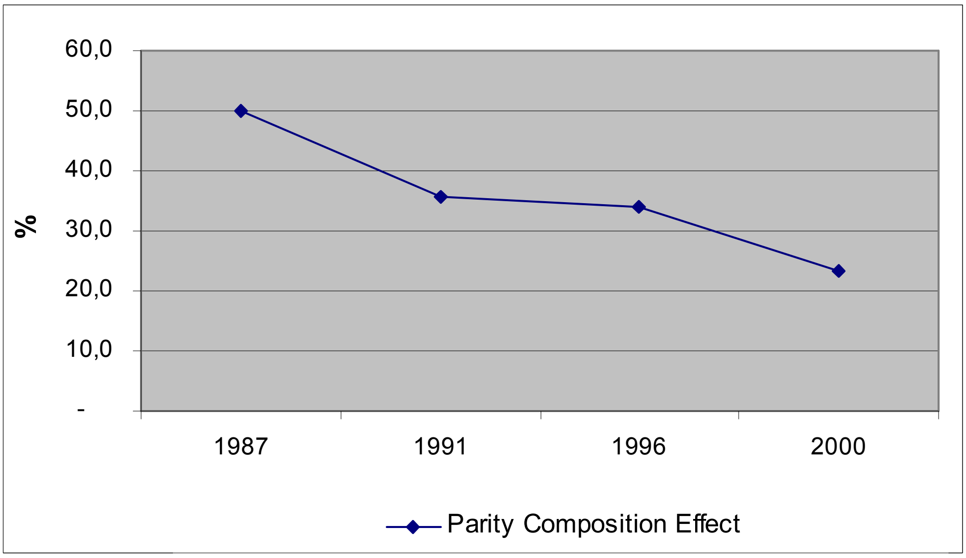
Source: Birth History Reconstruction from the Brazilian Demographic Censuses, 1991 and 2000.

Two important remarks should be highlighted regarding the findings just described. First, the Brazilian case is interesting because the fertility transition towards replacement level took place without the presence of a positive and significant tempo effect – there was a small and negative tempo effect. Figure 4 may suggest a transition towards a positive tempo effect, although this is just a speculation. In such situation, Brazilian observed TFR could still pass for a positive tempo effect, reaching levels that are only observed in the group of countries classified as lowest low fertility.

Ortega and Kohler (2002) remind that adjusted PATFR is the pure index of fertility, since it is free from tempo and compositional distortions. This index of fertility is the pure quantum effect, free from all non-behavioral effects. Results from Tables 2 to 5 suggest that the "pure quantum component" was already below replacement in 1987, remaining constant around 2 in 1991. Pure fertility declined to 1.74 in 1996, reaching 1.68 in 2000. The trend depicted in Figure 5 is not strong enough for letting someone to predict a pure quantum at the lowest low fertility level in the short run. What makes adjusted TFR different from the pure quantum index (adjusted PATFR) is the parity and age distribution of fertility.

The parity composition effect is calculated in Tables 2 to 5 and also displayed in Figure 6. They indicate that the parity composition effect is strong during all four years estimated, it favored a TFR higher than the one observed in the pure quantum index. Contrasting the parity composition positive impact in TFR with the tempo positive impact we can see that the former is much more important. Nevertheless, there is a strong decline in the size of the parity composition effect, comparing the first period between 1987 and 1991 (from 50.0% to 35,7%) and the second period between 1996 and 2000 (from 34.1% to 23.3%). It is important to remind that the parity composition effect is derived from the comparison between adjusted TFR and adjusted PATFR. The former measure is affected by the parity composition derived from past behavior, while the latter is a summary index derived solely from the current set of birth probabilities at parity and age. Thus, if fertility behavior does not change for a long time adjusted PATFR is the quantum to be observed.

Figure 6: Brazil: Parity Composition Effect Net of Tempo Effect –1987-2000



Source: Birth History Reconstruction from the Brazilian Demographic Censuses, 1991 and 2000.

Empirical Results: Differentials

This session will explore results for 1996 and 2000 regarding two important social economic characteristics: race and education. The fertility concepts previously discussed are dichotomized by race between white and black (black and brown) women in accordance with the Brazilian censuses' skin color categories. Three educational strata of women are also devised for the calculation of fertility: low educated (0-3 years of education), middle education (4-8 years of education), and high (9 or more years of education).

The results in Tables 6 to 9 indicate that the negative tempo effect is higher among black than white women. Surprisingly, the slight positive trend in the tempo effect between 1996 and 2000 is observed only among black women. The parity composition effect is much higher among black women in both periods, which fact suggests that black women present a more recent fertility decline in quantum fertility. The pure fertility index among white women is near constant during this period, around 1.6, while that of black women declined from 1.89 to 1.76.

Table 6: Tempo and Parity Composition Effects on Fertility – Black Women – Brazil 1996

	Parities					
	0	1	2	3	4+	Total
TFR	0,868	0,738	0,483	0,278	0,635	3,002
TFR Adjusted	0,825	0,749	0,390	0,202	0,501	2,667
Mean Tempo Effect (%)	(5,26)	1,48	(23,78)	(37,17)	(26,77)	(12,54)
PATFR	0,909	0,785	0,484	0,233	0,024	2,435
PATFR Adjusted	0,844	0,658	0,287	0,093	0,004	1,885
Parity Composition Effect (%)	(2,29)	13,90	36,01	118,42	12.453,27	41,47
Mean Age Stable Dist.	23,30	26,07	28,16	30,12	34,78	
Mean Age Frequency Sched.	24,15	28,08	30,27	31,74	35,54	

Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Table 7: Tempo and Parity Composition Effects on Fertility – Black Women – Brazil 2000

	Parities					
	0	1	2	3	4+	Total
TFR	0,808	0,655	0,407	0,223	0,420	2,513
TFR Adjusted	0,741	0,625	0,401	0,209	0,341	2,317
Mean Tempo Effect (%)	(9,04)	(4,81)	(1,64)	(6,44)	(23,14)	(8,46)
PATFR	0,873	0,700	0,372	0,161	0,012	2,119
PATFR Adjusted	0,819	0,571	0,258	0,102	0,005	1,755
Parity Composition Effect (%)	(9,58)	9,36	55,44	104,92	7.002,00	31,98
Mean Age Stable Dist.	22,85	25,84	27,65	29,31	33,96	-
Mean Age Frequency Sched.	23,50	27,20	28,55	29,68	33,07	-

Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Table 8: Tempo and Parity Composition Effects on Fertility – White Women – Brazil 1996

	Parities					
	0	1	2	3	4+	Total
TFR	0,877	0,670	0,345	0,149	0,210	2,251
TFR Adjusted	0,864	0,694	0,273	0,120	0,160	2,111
Mean Tempo Effect (%)	(1,59)	3,47	(26,11)	(23,95)	(31,33)	(6,63)
PATFR	0,896	0,721	0,330	0,109	0,006	2,061
PATFR Adjusted	0,836	0,591	0,190	0,055	0,001	1,673
Parity Composition Effect (%)	3,29	17,42	44,00	120,75	11.342,57	26,19
Mean Age Stable Dist.	24,40	27,69	29,89	31,61	34,90	
Mean Age Frequency Sched.	24,93	29,22	30,84	31,78	35,45	

Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Table 9: Tempo and Parity Composition Effects on Fertility – White Women – Brazil 2000

	Parities					
	0	1	2	3	4+	Total
TFR	0,834	0,607	0,309	0,122	0,156	2,029
TFR Adjusted	0,754	0,600	0,305	0,106	0,130	1,895
Mean Tempo Effect (%)	(10,68)	(1,20)	(1,28)	(15,51)	(19,92)	(7,07)
PATFR	0,866	0,646	0,272	0,089	0,004	1,878
PATFR Adjusted	0,824	0,548	0,204	0,056	0,001	1,633
Parity Composition Effect (%)	(8,49)	9,50	49,71	90,07	8.891,44	16,06
Mean Age Stable Dist.	23,97	27,55	29,37	30,70	34,10	-
Mean Age Frequency Sched.	24,60	28,60	29,62	30,46	33,84	-

Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Table 10: Tempo and Parity Composition Effects on Fertility – Low Educated Women – Brazil 1996

	Parities					
	0	1	2	3	4+	Total
TFR	0,864	0,851	0,666	0,444	1,113	3,939
TFR Adjusted	0,760	0,803	0,562	0,352	0,956	3,433
Mean Tempo Effect (%)	(13,72)	(6,10)	(18,50)	(26,09)	(16,41)	(14,74)
PATFR	0,925	0,857	0,661	0,411	0,071	2,925
PATFR Adjusted	0,856	0,734	0,440	0,197	0,018	2,245
Parity Composition Effect (%)	(11,23)	9,39	27,79	78,59	5.357,72	52,95
Mean Age Stable Dist.	21,61	24,19	26,56	28,75	33,78	
Mean Age Frequency Sched.	22,15	26,15	29,14	31,17	34,85	

Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Table 11: Tempo and Parity Composition Effects on Fertility – Low Educated Women – Brazil 2000

	Parities					
	0	1	2	3	4+	Total
TFR	0,742	0,733	0,573	0,375	0,828	3,251
TFR Adjusted	0,698	0,705	0,539	0,349	0,713	3,003
Mean Tempo Effect (%)	(6,37)	(3,91)	(6,35)	(7,45)	(16,18)	(8,24)
PATFR	0,865	0,756	0,507	0,274	0,033	2,436
PATFR Adjusted	0,826	0,658	0,369	0,163	0,012	2,027
Parity Composition Effect (%)	(15,44)	7,14	46,02	114,32	5.857,83	48,17
Mean Age Stable Dist.	21,03	23,82	25,92	27,92	33,28	-
Mean Age Frequency Sched.	21,71	25,40	27,50	29,57	32,99	-

Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Table 12: Tempo and Parity Composition Effects on Fertility – Mid-Educated Women – Brazil 1996

	Parities					
	0	1	2	3	4+	Total
TFR	1,001	0,837	0,492	0,234	0,293	2,857
TFR Adjusted	0,935	0,786	0,379	0,172	0,209	2,481
Mean Tempo Effect (%)	(7,05)	(6,42)	(29,83)	(36,27)	(40,22)	(15,15)
PATFR	0,951	0,846	0,502	0,208	0,019	2,526
PATFR Adjusted	0,899	0,704	0,287	0,082	0,003	1,975
Parity Composition Effect (%)	4,04	11,72	32,00	108,55	6.510,43	25,59
Mean Age Stable Dist.	22,48	25,96	28,70	31,09	34,59	
Mean Age Frequency Sched.	22,68	27,62	30,25	32,02	35,71	

Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Table 13: Tempo and Parity Composition Effects on Fertility – Mid-Educated Women – Brazil 2000

	Parities					
	0	1	2	3	4+	Total
TFR	0,872	0,786	0,471	0,209	0,225	2,563
TFR Adjusted	0,834	0,753	0,438	0,174	0,179	2,377
Mean Tempo Effect (%)	(4,56)	(4,33)	(7,57)	(20,31)	(26,11)	(7,81)
PATFR	0,930	0,781	0,418	0,161	0,012	2,302
PATFR Adjusted	0,907	0,691	0,322	0,112	0,006	2,039
Parity Composition Effect (%)	(8,10)	8,93	36,00	55,07	3.014,96	16,61
Mean Age Stable Dist.	22,22	25,67	28,05	29,90	33,37	
Mean Age Frequency Sched.	22,36	26,77	28,77	29,83	33,09	

Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Table 14: Tempo and Parity Composition Effects on Fertility – High Educated Women – Brazil 1996

	Parities					
	0	1	2	3	4+	Total
TFR	0,834	0,552	0,208	0,085	,,,	1,679
TFR Adjusted	0,771	0,569	0,165	0,061	,,,	1,566
Mean Tempo Effect (%)	(8,28)	3,04	(25,78)	(38,50)	,,,	(7,20)
PATFR	0,852	0,612	0,192	0,038	,,,	1,694
PATFR Adjusted	0,759	0,476	0,108	0,020	,,,	1,363
Parity Composition Effect (%)	1,53	19,52	52,84	209,51	,,,	14,91
Mean Age Stable Dist.	26,66	30,11	32,49	34,51	,,,	-
Mean Age Frequency Sched.	27,42	31,20	32,74	33,30	,,,	

Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

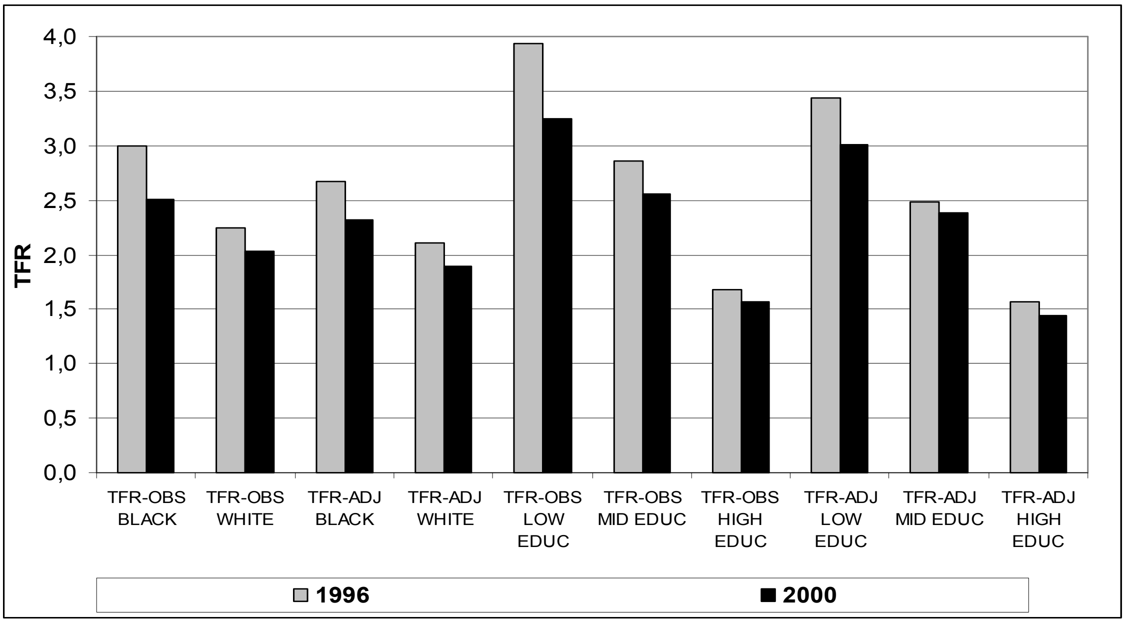
Table 15: Tempo and Parity Composition Effects on Fertility – High Educated Women – Brazil 2000

	Parities					
	0	1	2	3	4+	Total
TFR	0,829	0,499	0,175	0,067	...	1,569
TFR Adjusted	0,734	0,483	0,172	0,059	...	1,448
Mean Tempo Effect (%)	(12,93)	(3,27)	(1,64)	(12,76)	...	(8,36)
PATFR	0,825	0,548	0,158	0,034	...	1,564
PATFR Adjusted	0,769	0,473	0,144	0,034	...	1,419
Parity Composition Effect (%)	(4,45)	2,13	19,00	76,04	...	2,03
Mean Age Stable Dist.	26,01	29,89	31,82	33,67	...	
Mean Age Frequency Sched.	26,69	30,65	31,56	31,63	...	

Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

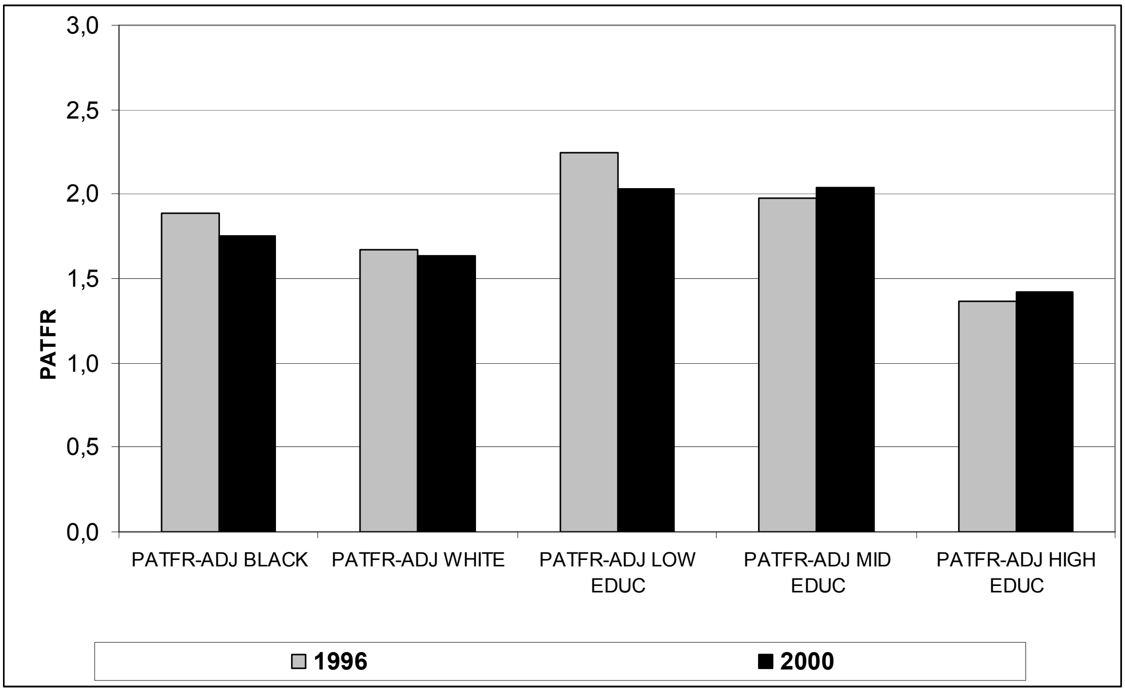
The results from Tables 10 to 15 and Figures 7 and 8 indicate that the negative tempo effect is larger among low and mid educated women, compared with high educated women. Although this result would be expected, it is surprising that the pattern for low and mid-educated women do not differ much. These two groups present decline in the magnitude of the tempo effect between 1996 and 2000. The tempo effect of high educated women had the smallest negative magnitude in 1996, but it remained almost constant until 2000. Low educated women had a fertility quantum (pure fertility index) of 2.2 in 1996, declining to 2.03 in 2000 (below replacement level). The fertility quantum of mid-educated women was already below replacement in 1996 (2.0), remaining constant until 2000. High educated women had a fertility quantum around 1.4 in the two periods, this is near the TFR threshold necessary to define the lowest-low fertility level (1.3) in developed countries (see Figure 8). Thus, the most recent decline in the Brazilian fertility index (1996 to 2000) is primarily due to the decline observed among low educated women. The parity composition effect is quite strong among low educated women, presenting small decline during the period (53% and 48%). This parity composition effect is much lower among mid-educated women (26% and 17%), and it is much lower in 1996, almost disappearing among high educated women (see Figure 9). This small parity composition effect among high educated women indicates that this group has experienced a transition towards low fertility some time ago.

Figure 7: Brazil: Observed and Adjusted Total Fertility Rates – 1996 – 2000



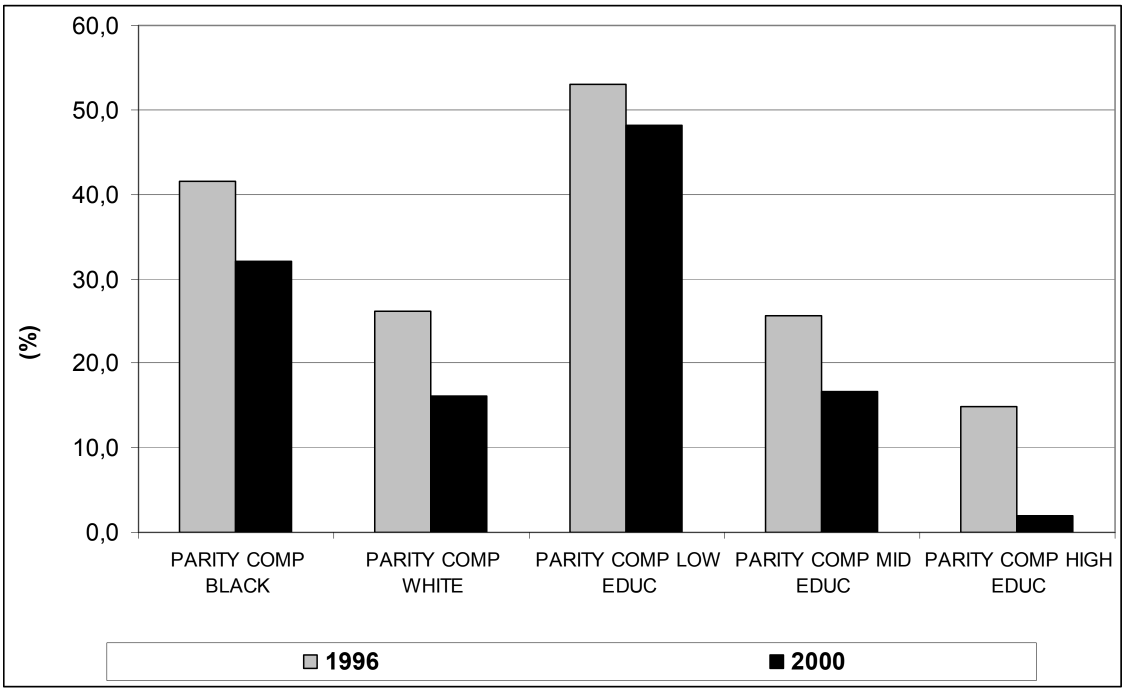
Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Figure 8: Brazil: Adjusted PATFR – 1996-2000



Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Figure 9: Brazil: Parity Composition Effect – 1996-2000



Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Explaining findings: The Brazilian case

The empirical analysis indicated that Brazilian TFR declined from 3.2 in 1987 to 2.3 in 2000. Contrasting with the recent experience of developed countries, this decline is not favored by a positive tempo effect, on the contrary, the tempo effect was low but negative. More importantly, the parity composition effect was strong and positive. Consequently, observed TFR was higher than the long run fertility indicated by the pure fertility index (quantum). The pure fertility index was already below replacement in 1987 (2.0), declining to 1.7 in 2000. The analysis of differentials by socioeconomic characteristics also indicated that the quantum fertility was already around or below replacement in all racial and educational groups. Thus, the differentials found in observed TFRs were primarily due to the parity composition effect and to a smaller extent to the negative tempo effect. Furthermore, the bulk of the Brazilian fertility decline is due to a quantum effect.

A review of Brazil's fertility decline between 1965 and 1995 along with its determinants can be accessed in Martine (1996), indicating a decline in TFR from 6.0 to 2.5 during this period. As shown by Martine, the speed of this decline is comparable to that found in large developing countries with the implementation of explicit family planning programs – faster than the decline in Mexico, India, and Bangladesh, slower than that in China and Thailand. It is important to notice that Brazil has not had an explicit family planning program during this entire period.

Among the proximate determinants of fertility, Martine shows that the role of age at marriage is negligible during this period, marital instability may have some importance, but it will be discussed below. He stresses the role played by abortion, particularly during the onset of the decline (late 1960s and early 1970s), his hypothesis is that female sterilization replaced illegal abortion from mid-seventies on. He mentions the great divergence on estimations about current abortion levels, but he points that there is no doubt that abortion was an important factor behind fertility decline in Brazil.

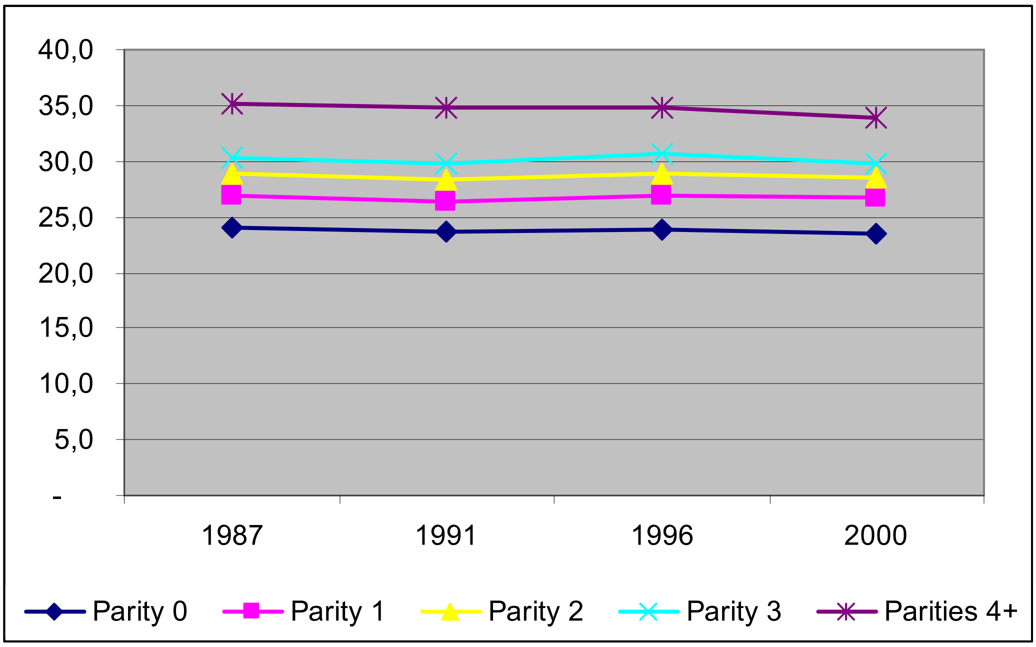
Martine (1996) talks about the high prevalence of contraceptives among women in a marital union, but recent figures are even more striking. Data from the last two DHS-BEMFAM surveys indicated that this prevalence rose form high 69% in 1986 to almost 80% in 1996. A recent survey, similar to DHS, conducted in two Brazilian major cities, indicated that the prevalence of contraceptives among women in marital union was 83.7% in Belo Horizonte and 82.6% in Recife (Miranda-Ribeiro, Caetano and Santos, 2004). Female contraceptive sterilization and pill are responsible for more than two thirds of contraceptives used by women in Brazil. The proportion of all contraception corresponding to female sterilization, among women in marital union, grew from 41% in 1986 to 52% in 1996 (Potter, 1999). More importantly, the median age at sterilization declined from 31.4 in 1986 to 28.9 in 1996 (Perpétuo and Wong, 2003).

Martine (1996) describes the correlation between sterilization and the high rates of cesarean sections at childbirth. This process is wonderfully explained by Potter (1999). He shows how the lack of other contraceptive means availability, besides the pill, coincided with a major transformation of the Brazilian medicine and public health policy, prioritizing hospital based curative care. For the doctor, surgical delivery was better paid than vaginal delivery, in accordance with governmental social insurance payment regulations. This economic argument for the doctor side, combined with the legal restrictions for the sole practice of female sterilization, contributed for the inter-linkage between cesarean sections and female sterilization. Such a "medicalization" of contraception was profitable for both patient and provider. The increasing returns of this practice and its diffusion led to a "lock in" situation in terms of the Brazilian contraceptive regime. Another mechanism of spreading sterilization through procedures outside surgery took place by the exchange of private sterilization for votes in the poor areas of the Brazilian Northeast (Caetano, 2000). A law to regulate the provision of sterilization procedures in the public health system was passed in 1997, aiming to control its premature adoption and to promote the availability of other contraceptives (Potter, 1999). Potter argues that the diffusion mechanism just described and its path dependence may have led to a sub-optimal outcome in terms of contraceptive mix. In a former version of his published paper he named this process as the "dark side of diffusion" in Brazil.

Another factor correlated with this spread of female sterilization is the role of "quantum fertility" in the observed fertility decline in Brazil as shown in this paper. Female sterilization is a contraceptive mean associated with termination, rather than spacing. In other words, female sterilization is associated with the "quantum" rather than the "tempo" effect. It is beyond our purpose to solve the causality issue between the Brazilian quantum fertility decline and the rise in sterilization, that is to say, whether sterilization was primarily driven by the demand for termination associated with the behavioral quantum fertility or the macro level "sterilization culture" also favored the quantum fertility decline in the lack of spacing alternatives available other than pill and condom. It suffices to show the coherence of this correlation in the Brazilian case.

The age structure of Brazilian fertility remained almost constant until 1980, when there was a steady decline in the mean age of the fertility schedule. The fertility mean age declined 2.6 years between 1991 and 2000, when the fertility rate for the 15-19 age group remained constant while the older age groups presented a strong decline (Perpétuo and Wong, 2003). The share of the 15-24 ASFR in TFR increased from 30% in 1973 to 45% in 1988 (Rios-Neto, 2000). The Census Bureau calculated the following trend in the share of 15-19 ASFR in TFR: 9.1% (1980), 15.3% (1991), and 19.4% (2000). Figure 10 depicts a clear picture reinforcing the finding about the importance of a pure quantum effect behind the Brazilian fertility decline. The timing of having a child by parity has been remarkably constant between 1987 and 2000, thus Brazilian fertility is turning younger more due to a quantum decline and change in parity composition than due to a decline in the mean age at parity.

Figure 10: Brazil: Mean Age at Parity – Fertility Table - 1987- 1991- 1996-2000



Source: Birth History Reconstruction from the Brazilian Demographic Censuses, 1991 and 2000.

The pure fertility index was already below replacement in 1987 (2.0), declining to 1.7 in 2000. Is this consistent with the ideal family size in Brazil? The 1986 and 1996 DHS-BEMFAM surveys portray that the ideal family size declined from 2.8 in

1986 to 2.3 in 1996. This variable did not present large socioeconomic differentials (Perpétuo and Wong, 2003). Wong (1998) calculated total, wanted, and unwanted fertility rates for Brazil, based on the DHS-BEMFAM survey. TFR was 2.42, while wanted fertility was 1.64 and unwanted fertility 0.79 (36.2% of TFR). The estimated wanted fertility is very similar to the fertility index for 1996 (1.8) and 2000 (1.7). Once the pure fertility index or fertility quantum is the truly behavioral component of aggregate fertility, it is important that these numbers are not very different from the wanted fertility. Miranda-Ribeiro (2004) calculated these rates for two Brazilian capitals, Belo Horizonte and Recife, based on a 2002 household survey. TFR was around 1.78 in Belo Horizonte and 1.8 in Recife, while wanted fertility was 1.44 in Belo Horizonte and 1.36 in Recife. The percentage of unwanted fertility in TFR is also declining, it was 19% in Belo Horizonte and 25% in Recife. When controlling for mother schooling, wanted fertility is higher among low educated women in Belo Horizonte, but much lower in the case of Recife. High educated women (nine years or more of schooling, incomplete high school or higher) present wanted fertility below the lowest-low fertility threshold (1.3). In sum, these notional or desired fertility rates are clearly in accordance with the pure fertility index, furthermore, they are approaching the lowest-low fertility thresholds.

Table 16: Total, Unwanted and Wanted Fertility Rates in Belo Horizonte and Recife by Mothers' Education - 2002

TOTAL WOMEN	BH	RECIFE
TFT	1,78	1,80
TFT-UNWANTED	0,34	0,45
TFT-WANTED	1,44	1,36
UNW/TOT	0,19	0,25
0-4 STUDY YEARS		
TFT	3,43	2,55
TFT-UNWANTED	1,20	1,42
TFT-WANTED	2,23	1,13
UNW/TOT	0,35	0,56
5-8 STUDY YEARS		
TFT	2,48	2,76
TFT-UNWANTED	0,97	1,13
TFT-WANTED	1,51	1,63
UNW/TOT	0,39	0,41
9 + STUDY YEARS		
TFT	1,28	1,21
TFT-UNWANTED	0,10	0,22
TFT-WANTED	1,17	0,99
UNW/TOT	0,08	0,18

Source: Miranda-Ribeiro, Paula, 2004.

It is beyond our goals to discuss the determinants of fertility decline in Brazil, particularly that of the quantum fertility. Martine (1996) presents an excellent review on the array of hypotheses explaining this decline. In addition to the standard explanations linked to modernization and socioeconomic factors, there are hypothesis associated with the unintended role of state policies, "medicalization", the televised media, consumption aspirations, and poverty. It is interesting to notice that most of these explanations are more akin to quantum fertility rather than factors associated with spacing and life cycle planning.

Explaining findings: The below replacement literature

Our main goal in this item is to situate the Brazilian case in the below replacement debate. However, it is beyond our purpose to discuss the figures on below replacement in developed countries or the different views on below replacement, the second demographic transition, the lowest-low fertility countries, and the determinants of all these factors.

In order to situate Brazilian fertility, it is important to initiate with a quote from Lesthaege and Willems (1999)[2]:

> *We can roughly distinguish three phases in the development and prolongation of below replacement fertility in the European Union. During the initial phase, there is no postponement effect, but a decline in fertility at all ages and birth orders, and hence a* ***dominant quantum effect*** *. During the second phase, gains in female education and female labor force participation, continued ideational change, and further increases in union instability foster* ***major tempo drift****. This is the intermediate phase of fertility postponement... During the third phase, postponement would stop, but the recuperation of fertility at older ages (say, past ages 28-30) would be less than complete. In this eventuality, the quantum effect would again become dominant, and that would prevent the overall PTFR from rising to the level of the Bongaarts-Feeney adjusted PTFR.*

Another quote from Bongaarts (2002) will help us to build the argument and situate the Brazilian case:

> *Changes over time in the mean age at childbearing are the result of two demographic factors. The first is the* ***decline in higher-order births*** *that occurs as countries move through their fertility transitions. Fertility declines are observed at all orders but they are usually far larger at higher than at lower orders... As a result, the* ***mean age at childbearing declines even if there is no change in the timing of births at each order*** *. The second factor is the* ***change in the timing of births of specific orders*** *. The net effect of these two factors varies among countries. In* ***many contemporary developing countries the decline in higher-order births is occurring more rapidly than the rising in the timing of individual births*** *, so that the mean age at childbearing is declining... In contrast, in* ***most contemporary industrialized countries the rise in the mean age at first and higher-order births is occurring so rapidly that their effect exceeds any birth-order composition effect*** *. The mean age at childbearing has therefore risen over the past two decades in most developed countries...*

We apologize for the two lengthy quotes above, but they situate the Brazilian case as being one of the first phase in the development of a below replacement fertility, that is to say, a phase characterized by a dominant quantum effect. Furthermore, it is a case marked by a decline in higher-order births with a decline in the mean age at childbearing with no change in the timing of births at each order. Finally, in addition to the small tempo effect, the birth order (parity) composition effect is strong and positive.

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[2] All highlights in negrito are ours.

Thus, the dominant quantum effect could be even stronger if it were not the countervailing force of the parity composition effect.

Once the Brazilian case has been situated as being a typical first phase in the below replacement fertility and a radical developing country experience, with the pure quantum fertility well below the replacement level, then there is the question that will not disappear: Will Brazil enter the second phase observed in developed countries, when the "tempo drift" or the "change in the timing of births at each order" dominates?

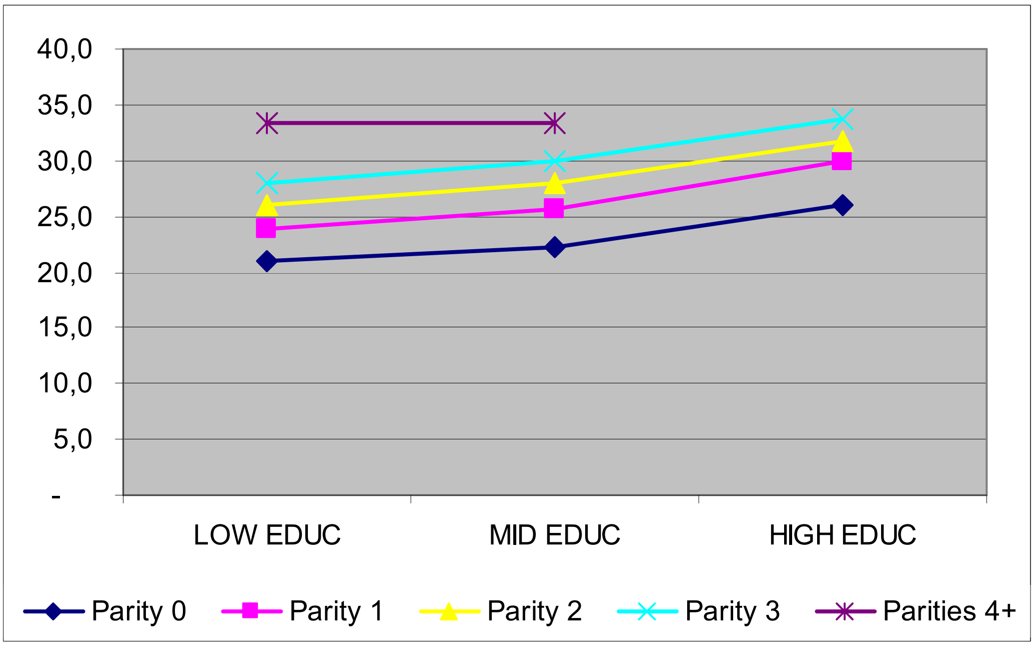
The answer can be only speculated. Focusing on the theories stressing value orientation, there is an important emphasis in the growth of divorce rates, preference for cohabitation over marriage, and delayed parenthood. Caetano and Leone (2002) discuss the role of marital instability in Brazilian fertility decline, concluding that this factor has favored an increase in TFR rather than the opposite. Although the prevalence of consensual unions has grown in the last two decades, not only these unions are rarely similar to the developed countries' cohabitation, but they are correlated with marital instability and higher fertility. The same can be said about the growing share of female headed households, although some small share of these arrangements are associated with emancipated skilled women, the majority of these arrangements are comprised by poor women as heads. The typical behavior associated with the value changes in the second demographic transition is not supported by current behavior, it could be incipient only among the highly educated women.

Education plays an important role favoring the postponement of marriage and parenthood. It seems that there is a slow process in motion, to the extent that the Brazilian education gender gap by cohort has been reversed recently, with younger adult cohorts presenting a positive gap of one schooling year. Figure 11 below shows that the mean age at parity is not very different among low and mid-educated women in 2000 (the same can be said for the pure fertility index), but the difference is around five years between the high educated women and the other two groups, particularly with respect to parities 0 and 1.

The major determinant of the entry in the second phase is the postponement of childbearing. Figure 10 has indicated strong stability and little evidence of postponement at any parity between 1987 and 2000. Adolescent fertility increased and was kept high between the 1980s and 1990s (Caetano and Leoni, 2002). Brazilian adolescent fertility is highly correlated with low educated women, although some preliminary studies indicate that adolescent women tend to drop out from school before they get pregnant.

The postponement of childbearing in Brazil could be initiated with a "supply shock" of schooling in Brazil, the last tem years have been marked by a steady increase in educational attainment in Brazil, to the extent that the young cohorts average 9 years or more of schooling, some postponement effect could be expected. Another possibility would be a diffusion of postponement based on a "trickle-down" effect from high to mid and low educated women. This latter option might not be reasonably expected, to the extent that the differentials already existed and have not sparked this "trickle-down" process. A third possibility centers on the economic theories explaining fertility change. Formal sector employment and high salaries are associated with high education, to the extent that the requirements for completed high school (11 years of schooling) or some college education (12 years or more of schooling) become more enforced, a competing transition between exit of the school system and entry into childbearing might cause a postponement of childbearing. A last possibility is associated with the responses to economic adjustments and high unemployment, it is possible that these economic hardships had been adjusted through quantum fertility, but once the quantum adjustment has been exhausted, the postponement transition might begin.

Figure 11: Mean Age at Parity by Mothers Education– Brazil -2000



Source: Birth History Reconstruction from the Brazilian Demographic Census, 2000.

Conclusions

This paper applied an alternative methodology to evaluate the tempo, parity distribution, and quantum effects of recent fertility experience in Brazil. The results indicated that the tempo effect was small and negative (as opposed to the large and positive effect found in developed countries, the parity distribution was large and positive (favoring high TFR, as opposed to the negative parity distribution effect found in developed countries), finally, the pure fertility index (quantum fertility) was the factor responsible for the observed fertility decline in Brazil. The quantum fertility in Brazil is already well below replacement, almost approaching the lowest-low fertility level. The main question now is whether the country will entry the postponement transition, if it enters it, the consequence may be a positive tempo effect and levels of observed TFR well below the lowest-low fertility threshold. Although this may be undesirable in macroeconomic terms (it may be a negative externality), it is clearly desirable on universal rights grounds to the extent that it is enhanced by an increase in schooling, a decline in adolescent fertility, and a more diverse supply of contraceptives. The Brazilian Government has just launched a new family planning program, promoting women sexual and reproductive rights in light of Cairo's propositions. If the program succeeds, it is almost sure that Brazil will be among the first developing countries entering the lowest-low fertility category.

References

BONGAARTS, John (2002). The end of the fertility transition in the developed world, *Population and Development Review,* 28(3), p.419, September.

CAETANO, André J. (2000). Sterilization for Votes in the Brazilian Northeast: The case of Pernambuco, *Ph.D. Thesis*, Department of Sociology, University of Texas at Austin, Austin.

CEDEPLAR (1999) Preliminary data for population projections, by sex and five years age groups, for Brazilian Regions, Brazil, 1990/2020. Pronex activities report (Restrictive Use).

CHO, L-J., R.D RETHERFORD, M.K. CHOE (1986). *The own-children method of fertility estimation*. [s.l]: East-West Center, c1986. 188p.

FEENEY,G. and J. YU (1987). Period parity progression measures of fertility in China. *Population Studies* 41 (1), 77-102.

GOLDANI, A.M. (2002) What will happen to Brazilian fertility? *Completing the fertility transition.* ESA/P/WP.172/Rev.1. UN Population Division, pp. 358-375.

KOHLER, H-P and D. PHILIPOV (2001). Variance effects in the Bongaarts-Feeney formula. *Demography* 38(1), 1-16.

KOHLER, H.-P. and J. A. ORTEGA (2002): "Tempo-Adjusted Period Parity Progression Measures, Fertility Postponement and Completed Cohort Fertility", *Demographic Research*, vol. 6(6), pp. 91-144.

KOHLER, H.P., F.C. BILLARI and J. A. ORTEGA (2002), The emergence of lowest-low fertility in Europe during the 1990s, *Population and Development Review*, 28(4), 641-680, December.

LESTHAEGHE, R. and WILLEMS, P. (1999). Is low fertility a temporary phenomenon in the European Union?, *Population and Development Review,* 25(2), p.211, June.

LEONE, T. and A. J. CAETANO (2002). Can the Level of Brazilian Fertility be even Lower?.In: PAA 2002 Annual Meeting, 2002, Atlanta.

LUTHER, N., L-J. CHOE (1988). Reconstruction of birth histories from census and household survey data. *Population Studies*. Great Britain, v.42, p.451-472.

MARTINE, George (1996), Brazil´s fertility decline, 1965-95: a fresh look at key factors, *Population and Development Review,* 22(1), p.47, March.

MIRANDA-RIBEIRO, Paula (2004), Inaugural Lecture at Cedeplar, 2004 academic year, powerpoint presentation (internal use).

MIRANDA-RIBEIRO, P., A. J. CAETANO and T. F. SANTOS (2004), *SRSR- Saúde Reprodutiva, Sexualidade e Raça/Cor – Relatório Descritivo*, UFMG; CEDEPLAR.

MIRANDA-RIBEIRO, A., SILVA. C. V. (2005). Reconstruction of Brazilian birth history based on the 2000 demographic census: tempo, parity and quantum effects.

Paper that will be presented in The Poster Sessions of the XXV IUSSP International Population Conference, Tours, France 18-23 July 2005.

ORTEGA, J.A. and H-P. KOHLER (2002) Measuring low fertility: rethinking demographic methods. Working Paper 2002-001, Max Planck Institute for Demographic Research, Rostock, Germany (Available at http://www.demogr.mpg.de).

PERPÉTUO, I.H.O. and L.R. WONG (2003). Programas y Políticas Nacionales que afectaron el curso de la fecundidad en el Brasil, Seminario " La Fecundidad em América Latina: Transición o Revolución?, CEPAL, Santiago de Chile, Junio.

POTTER, Joseph (1999). The persistence of outmoded contraceptive regimes: The cases of Mexico and Brazil, *Population and Development Review*, 25(4), p.703, December.

RIOS-NETO, E. L. G. (2000) Passado, presente e futuro da fecundidade: uma visão de idade, período e coorte. *Revista Brasileira de Estudos Populacionais*, vol. 17, pp. 5-15.

WOOLDRIDGE, J. M. (2002), Inverse probability weighted M-estimators for sample selection, attrition and stratification, *Portuguese Economic Journal*, vol. 1(2), pp. 117-139.

WONG, Laura Rodriguez (1998), Apontamentos sobre a tendência da fecundidade no médio prazo considerando as preferências reprodutivas, *XI Encontro Nacional de Estudos Populacionais*, ABEP, Caxambú.