

# Ten Years of Fertility Decline in Brazil: Where, Why and How Fast



Jeronimo Oliveira Muniz



## Data

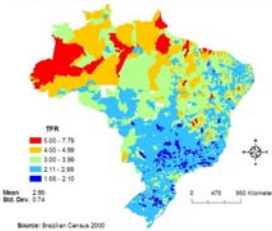
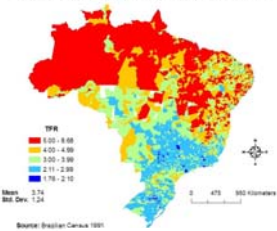
- Brazilian Atlas of Human Development \* (based on the Brazilian Censuses of 1991, 2000)
- \* Available at [www.pnud.org.br/atlas/](http://www.pnud.org.br/atlas/)

## Research Questions

1) What is the spatial (variability) and temporal (change) pattern of fertility in Brazil?

Total Fertility Rates, Brazilian Counties, 1991

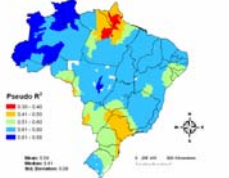
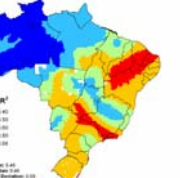
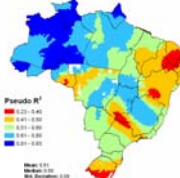
Total Fertility Rates, Brazilian Counties, 2000



Pseudo-R<sup>2</sup> values, 1991

Pseudo-R<sup>2</sup> values, 2000

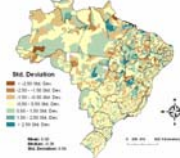
Pseudo-R<sup>2</sup> values, changes of TFR from 1991 to 2000



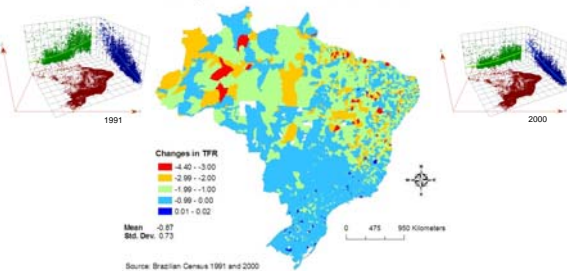
Std. Deviation of the Unstandardised Residuals, 1991

Std. Deviation of the Unstandardised Residuals, 2000

Std. Deviation of the Unstd. Res., Change in the TFR from 1991 to 2000



Changes of TFR from 1991 to 2000

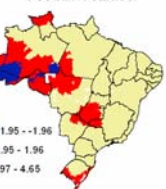
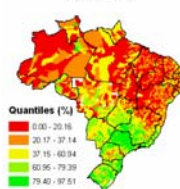


% people living in households with TV, 1991

Observed

Parameter

Pseudo-t values

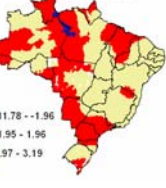
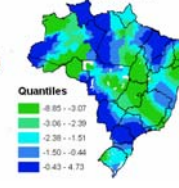
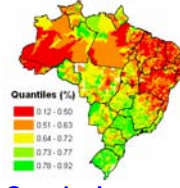


Human development Index - Education, 1991

Observed

Parameter

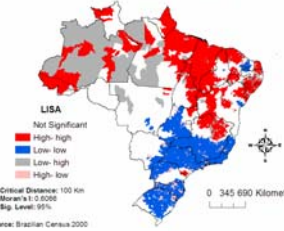
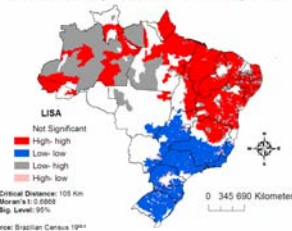
Pseudo-t values



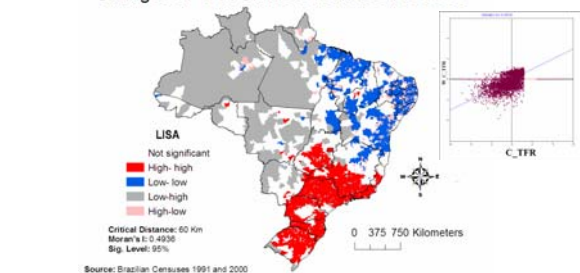
2) Where are the "hot" and "cold" spots in which levels of fertility are clustered?

TFR Clusters, Brazilian Counties, 1991

TFR Clusters, Brazilian Counties, 2000



Changes of TFR Clusters from 1991 to 2000



3) What are the factors accounting for these patterns?

To answer this question, three Geographic Weighted Regression (GWR) models will be estimated to take into account spatial heterogeneity and non-stationary coefficients. These offer an excellent way to look at the spatial variability of social phenomena, which are often mediated by spatial processes that cannot be quantified:

$$Y_i = \beta_{0i} + \beta_{1i}X_{1i} + \beta_{2i}X_{2i} + \dots + \beta_{ki}X_{ki} + \varepsilon_i$$

$$\text{where } \hat{\beta}_i = (X^T W_i X)^{-1} X^T W_i Y_i$$

$W_i$  is a matrix of weights specific to location  $i$  such that observations nearer to  $i$  are given greater weight than observations further away.

Variables in the models include child mortality, sex ratio of people older than age 15, urbanization rate, human development index of education, female labor force participation (in 2000), percentage of whites, percentage of teenage mothers, and demographic density.

## Conclusions

- GIS helps to identify those geographic areas in which government policy could intervene to ensure the maintenance of declining fertility, which appears to have a tendency to spread to nearby counties.
- The maps show significant variability in Brazil when TFRs are disaggregated by counties. Lower fertility is clustered in the south and southeast, and higher fertility is clustered in the northeast and few areas in the north. The critical distances (the ones giving higher Moran's I) were 105km in 1991, 100km in 2000 and 60km for TFR changes between these two periods.
- TFRs declined more in areas where fertility was higher in 1991. Highest fertility is the most important variable in explaining the decline in fertility rates over the decade.
- GWR models are more appropriate than classical OLS, OLS with spatial lag, or error because they account for spatial heterogeneity and non-stationary coefficients. They also provide normally distributed, non-autocorrelated and low residuals in space according to the Akaike information criterion. The GWR models show, therefore, that the variables associated with TFRs have different effects in space.

## Acknowledgments

This research was sponsored by CAPES (Grant #BEX1759/02-7). Direct correspondence to [jmuniz@wisc.edu](mailto:jmuniz@wisc.edu)

## References

- Anselin, L. 1992a. *Spatial data analysis with GIS: an introduction to application in the social sciences*. [Santa Barbara, Calif.]: National Center for Geographic Information and Analysis.
- Anselin, L., and Getis, A. 1992b. "Spatial statistical analysis and geographic information systems." *Annals of Regional Science* 26:19-33.
- Anselin, L.A.G., D. A. 1988. "Do spatial effects really matter in regression analysis?" *Papers, Regional Science Association* 65:11-34.
- Axinn, W.G., J. S. Barber and O. J. Ghimire. 1997. "The Neighborhood History Calendar: A Data Collection Method Designed for Dynamic Multilevel Modeling." *Sociological Methodology* 07:355-392.
- Barbara Entwisle, R.R.R., Stephen J. Walsh, Tom P. Evans, Sara R. Curran. May, 1997. "Geographic Information Systems, Spatial Network Analysis, and Contrastive Choice." *Demography* 34(2):171-187.
- Caldwell, J.C. 1982. *Theory of Fertility Decline*. New York: Academic.
- Cleland, J., Wilson, Chirs. 1987. "Demand Theories of Fertility Decline: An Iconoclastic View." *Population Studies* 41:5-31.
- Entwisle, B., Ronald R. Rindtous, Stephen J. Walsh, Tom P. Evans, Sara R. Curran. May, 1997. "Geographic Information Systems, Spatial Network Analysis, and Contrastive Choice." *Demography* 34(2):171-187.
- Getis, A. 1995. "Spatial filtering in a regression framework: examples using data on urban crime, regional inequality, and government expenditures." *pp. 172-185 in New Directions in Spatial Econometrics*, edited by L.A.R.J.G.M. Florax. Berlin: Springer.
- Griffith, D.A.L. Anselin, and Institute of Mathematical Geography. 1990. *Spatial statistics, past, present, and future: proceedings from a Symposium of the same name held on the campus of Syracuse University from March to June 1988*. Ann Arbor, Mich.: Institute of Mathematical Geography.
- Guimoteo, C.Z., Rajan, Irudaya S. Dec., 2001. "Spatial Patterns of Fertility Transition in Indian Districts." *Population and Development Review* 27(4):713-738.
- John Weeks, X.Y., Arthur Getis, M. Saad Gadalla, and Allan G. Hill. May, 2002. "Spatial Patterns as Predictors of Fertility Change in Rural Egypt." Presented at the 2002 Annual Meeting of the Population Association of America, Atlanta, GA.
- Loflin, C., Ward K., Saily, Feb., 1993. "A Spatial Autocorrelation Model of the Effects of Population Density on Fertility." *American Sociological Review* 48(1):121-126.
- Pandolfi, R., and William J. Lloyd. 1996. "Issues related to handling of spatial data." Presented at Australian Veterinary Association Second Pan Veterinary Conference, Christchurch.
- Scott, L.M., and William J. Lloyd. "Spatial Analysis in a GIS Environment: Employment Patterns in Greater Los Angeles, 1980-1990." 2005(6:24). Available at <http://www.spatial.miami.edu/gis/stepscott/Vicent.html>
- Tolnay, S.E. Apr., 1995. "The Spatial Diffusion of Fertility: A Cross-Sectional Analysis of Counties in the American South, 1940." *American Sociological Review* 60(2):299-308.
- Watkins, S.C. 1991. *From Provinces to Nations. Demographic Integration in Western Europe 1870-1960*. Princeton, NJ: Princeton University Press.
- Weeks, J.R. August, 2001. "The Role of Spatial Analysis in Demographic Research." in *Spatially Integrated Social Science: Examples in Best Practices*, edited by M.F.O.A.D.G. Jenelle. New York: Oxford University Press.
- Weeks, J.R., M. Saad Gadalla, Tarek Rashed, James Stanforth and Allan G. Hill. 2000. "Spatial Variability in Fertility in Menoufia, Egypt, Assessed Through the Application of Remote-Sensing and GIS Technologies." *Environment and Planning A* 32:695-714.