Regional Growth Convergence in Colombia Using Social Indicators *

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Abstract. This paper investigates convergence in social indicators among Colombian departments from 1973 to 2005. We use census data and apply both the regression approach and the distributional approach (univariate and bivariate kernel density estimators). Using literacy rate as a proxy for education, we find convergence between 1973 and 2005, but persistence in the distribution between 1975 and 2000, when we use the infant survival rate and life expectancy at birth as proxies for health. Additionally, using data from Demographic and Health Surveys, we find convergence in the rate of children that are well-nourished between 1995 and 2005.

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1 Introduction

The majority of studies on convergence use macroeconomic aggregates to study whether poor countries are catching up with wealthier countries, and are particularly interested in the speed at which this process occurs, when it does occur. A large part of the empirical analysis of convergence is based on the neoclassical model developed by Solow (1956) and the estimation procedure suggested by Barro and Sala-i-Martin (1992a). Most of these studies use cross-sectional regressions based on per capita gross domestic product (GDP) to investigate if poor regions have higher rates of growth as they develop than wealthier areas.

In recent years, some authors have also tested if there is convergence in living standards, given that it is well-being that really matters, and arguing that per capita GDP is not the appropriate indicator for it.[1] For example, Neumayer (2003) and Kenny (2004) conclude that even in the absence of convergence in per capita GDP, there is convergence in living standards among poor and rich countries, a phenomenon praised by Neumayer as one of the greatest success stories of development in the last century.

This argument seems to be valid for cross-country analysis, but few studies exist investigating regional convergence in living standards in developing countries. Within a particular country, convergence analysis is important, not only to focus development assistance towards regions lagging behind in economic growth, but also to evaluate the efficiency and scope of public policies. Lack of convergence and the persistence of inequalities inside a country can lead to political instability, social unrest, and violence, given that people are concerned not only with their own improvements, but also with meeting the living standards of the wealthiest regions (Kenny, 2004). In Colombia, high regional inequality in living standards is one of the possible underlying causes of the ongoing domestic conflict, which is fueled by drug trafficking and corruption, particularly in isolated regions with a low level of governmental presence and a high incidence of poverty.

[1] In this paper, we will refer indistinctly to non-income indicators, social indicators, quality-of-life variables, and living standards.

Over the past 30 years, Colombia has witnessed important reforms in social areas, particularly in health care and education. These reforms were marked by increased governmental intervention during the mid seventies, such as the creation of a national health care system and vaccination campaigns to eradicate tropical diseases like malaria, and, in the early eighties, policy formulations to reduce mortality and increase primary education. At the beginning of the nineties, decentralization accelerated in order to reduce the fiscal burden on the central government, making municipalities more responsible for generating and administrating their own resources, and partially moving the provision of health services to the private sector (Hernández and Obregón, 2002).

The link between decentralization policies and the improvement in living standards in Colombia is a topic of extensive debate. While some researchers argue that the health policies have categorically failed, others conclude that they have been successful, although recognizing that there is still a large margin for improvement, particularly given that the system in place is still too recent to make a general judgement (Homedes and Ugalde, 2005; Barrera and Domínguez, 2006). Evidence shows that even though social spending increased considerably and reforms were designed to compensate municipalities with weak fiscal capacities, fiscal equalization has not been achieved.

Although Colombia has experienced improvements in living standard indicators at the national level, particularly those related to health, education, and access to public services, there is evidence of a heterogeneous distribution of improvements. Thus, investigating regional convergence in social indicators is relevant, as it is a relatively under-researched topic. Out of 20 research documents about regional convergence in Colombia produced in the last 15 years (Aguirre, 2008), only two published articles that deal with convergence in non-income indicators (Aguirre, 2005; Meisel and Vega, 2007).

The objective of this study is to analyze whether departments that were lagging behind in social indicators in the 1970s were able to catch up by the year 2000. We use both the regression approach suggested by Barro and Sala-i-Martin (1991), among others, and the distributional approach pioneered by Quah (1997) to test for convergence in three variables, based on census data. Using literacy rate as a proxy for education, we find regional convergence between 1973 and 2005, but persistence in the distribution between 1975 and 2000 when we use the infant survival rate and life expectancy at birth as proxies for health. Additionally, using data from Demographic and Health Surveys (DHS), we find convergence between 1995 and 2005 in the percentage of children that are well-nourished.

This paper is divided into six sections. After this introduction, we argue in section 2 that it is fundamental to focus upon indicators other than income and that the analysis of convergence at the department level is relevant for Colombia. We present two methods to empirically test for convergence in section 3. Section 4 describes the data used and the details of our empirical estimation. Results are presented in section 5 and discussed in section 6.

2 Motivation

The importance of analyzing social indicators, instead of focusing only upon income, has been extensively discussed in the work of Amartya Sen, who argues that *social opportunities* are one of the five types of instrumental freedoms that contribute to the overall freedom people have to live as they choose (Sen, 1999). Social opportunities are understood to be the arrangements that a society makes which influence the individual's substantive freedom to live better, such as providing education and health care, which are important, not only for the the citizens in the conduct of their private lives, but also for more effective participation in societal economic and political activities.

Public policies have a crucial influence on social opportunities (e.g., they can influence longevity through epidemiological policies and education through the provision of the corresponding facilities). Thus, it is important to shift attention to elements that affect individual well-being and freedom but which are not captured by income statistics (Sen, 1997).

Particular attention shall be given herein to health status when analyzing social inequalities. Sen (1998) argues that mortality is a key economic indicator, given that it mirrors the success or failure of a society. Indicators like the infant survival rate, which responds very rapidly to public health polices, are central to that kind of analysis (Mazumdar, 2003). Along the same lines, indicators referring to the level of nutrition reflect one of the most basic needs for survival, namely access to adequate food (Sen, 2002).

In Colombia, awareness of the influence and scope of the government on health and education gradually increased in the second half of the 20^{th} century, and has translated into programs, as well as legislation, aimed at achieving universal access to health care and primary education. Policies for both sectors experienced important changes in the last quarter of the century, reflecting the transition from a centralist system to a locally managed one.

In the seventies, polices on education focused upon reducing illiteracy and increasing the coverage of primary education, particularly in rural areas, where public schools and teachers were almost nonexistent.[2] However, rural areas continued to lag behind. Adult education and literacy campaigns continued through the eighties, together with the expansion of secondary and preschool education.

Due to macroeconomic imbalances at the end of the eighties, the government initiated a decentralization program to reduce the financial burden on the central government, and transferred substantial revenues and responsibilities to local administrations. The country has been praised as a leading example of fiscal decentralization, which policy had the objective of increasing social expenditures and efficiency in social sectors, as well as financially compensating territories with weak fiscal capacities. This process accelerated with the new constitution in 1991 (Rojas, 2003; Barrera and Domínguez, 2006). As a result, social spending increased from 7 to 15 % of GDP between 1991 and 2001. Concerning education, evidence shows that reforms were beneficial for the urban sector, but less so for the rural sector, which

[2] With society facing limited resources, secondary and tertiary education was left largely to the private sector under the argument that spending in public universities would favor middle and upper income groups.

lags behind the former on the issues of quality of education and net enrolment rates, particularly for secondary education (Velez, Harding, and Sarmiento, 2003).

Concerning health policies, by the mid seventies, the government had increased its role as a provider of health care and had implemented programs to improve neonatal care and nutrition, eliminate tropical diseases through mass vaccinations, and promote reproductive health. At the same time, coverage of public services in the country expanded. An important result of these campaigns was the reduction in infant mortality, due in part to better access to drinking water. This reduction led to higher life expectancy at birth (Profamilia, 2005).

In the nineties, the policy orientation shifted; the government increased the role of the private sector as health provider and tried to strengthen the national health care system through the decentralization of services at the local level. Implementation of a dual system, combining the contribution of formal sector employees with subsidies for the population outside the system, yielded an increase in health coverage, which attained 58% in 2000 (Hernández and Obregón, 2002).

Statistics on health and education at the national level show significant improvements in the last quarter of the 20^{th} century, and indicate that the country is a successful case within Latin America. Colombia ranks well within the Latin American average in many social indicators, or even slightly above. As an example, in 1970, the average adult literacy rate was 78% and increased to 93% in 2005, which is higher than the Latin American average of 90% (World Bank, 2008).[3] However, these gains do not seem to have been homogeneously distributed across society. Inequality is anchored within different levels - between departments (the main administrative units), between urban and rural areas, and also inside urban areas.[4] Given that Colombia is a land of contrasts, where one can find well-developed modern metropolitan areas with reasonable infrastructure and large underdeveloped low

[3] Similarly, in 1980, live expectancy at birth was 66 years, and in 2005, it reached 73 years, which is the average for the region. Infant mortality for each 1,000 live births fell from 68 deaths in 1970 to 17 in 2005, compared to a regional average of 23 (World Bank, 2008).

[4] As an example of inequality, the income Gini coefficient, which had modest decreases in the eighties, reached 0.56 in 2004, almost as high as the value for Brazil for the same year.

density areas, lacking even basic infrastructure, looking at variables at the national level clearly masks differences.

Colombia is divided into 32 departments and the capital district of Bogotá, a division that has existed formally since the 1991 constitutional reform, when nine former intendancies and commissariats, sparsely populated areas, were acknowledged as departments (Amazonas, Arauca, Casanare, Guainía, Guaviare, Putumayo, San Andrés y Providencia, Vaupés, and Vichada).[5] Departments are important political entities in Colombia, with elected local governments and separate department assemblies. Hence, it is relevant to analyze the performance in social indicators by department, investigating whether those that were lagging behind in the early seventies have been able to catch up in the year 2000.

In this paper, we test the hypothesis that among Colombian departments, there was convergence in social indicators in the period from 1973 through 2005. This hypothesis is based on the following facts. First, starting in the mid seventies, national policies aimed at reducing illiteracy and improving neonatal care were put into place. Second, decentralization reforms were conducted, starting in the late eighties, to increase the efficiency of spending on education and health care. Third, after decentralization, social spending, as a share of total gross domestic product, doubled. Fourth, as will be discussed later, social indicators are naturally bounded, which fact facilitates convergence if better-off departments are close to the upper bound in the initial year. Finally, empirical results obtained by Branisa and Cardozo (2009), using per capita gross disposable income [6] as a proxy for well-being, suggest slow convergence among Colombian departments between 1975 and 2000.

We explain in the next two sections the methods used to test for convergence and the variables included in the analysis.

[5] As it is often done in studies with Colombian data at the department level due to lack of data, we group them as one unit under the name Nuevos departamentos.

[6] IDBH is the abbreviation, based on the Spanish denomination Ingreso Departamental Bruto disponible de los Hogares (CEGA, 2006).

3 Methods for Measuring Convergence

We will consider two alternatives to empirically test for convergence. The first one is the *regression approach* (Magrini, 2004), also called the *classical approach to convergence analysis* (Sala-i-Martin, 1996), which is the most frequently used analysis in the literature. Robert Barro and Xavier Sala-i-Martin are among the best known authors associated with it (Barro and Sala-i-Martin, 1991, 1992a,b, 2004; Sala-i-Martin, 1996). The second alternative is the *distributional approach to convergence*, pioneered by, among others, Danny Quah (Quah, 1993a,b, 1996, 1997). Both approaches are presented briefly in this section.

Within the classical approach to convergence analysis, the concepts of beta-convergence and sigma-convergence are relevant. Beta-convergence is related to the mean-reversion of the variable of interest. This is typically done by regressing the average growth rate of the variable of interest at the initial level.[7] If the regression coefficient is negative and statistically significant, this means that the variable tends to grow more quickly in regions that lagged behind at the beginning of the period considered.

A reduction over time in the dispersion of the variable of interest across entities (in our case, departments) indicates a more equitable distribution and is known as sigma-convergence. Testing for sigma-convergence is performed by checking the evolution of the standard deviation over time, or the coefficient of variation if the mean of the variable changes. The existence of beta-convergence tends to generate sigma-convergence. Beta-convergence is a necessary, but not a sufficient condition for observing sigma-convergence. Sigma-convergence is an indicator of dispersion of departments, but does not tell much about the mobility of each one.

Quah (1997) criticizes the classical approach to convergence analysis, arguing that neither beta-convergence nor sigma-convergence can deliver useful answers to the question of whether poor countries or regions are catching up to wealthy ones. Quah argues that the classical approach does not provide any information about

[7] To be precise, we are discussing here *absolute* or unconditional beta-convergence, which assumes that regions are structurally similar.

mobility, stratification, or polarization, and suggests analyzing the distribution dynamics directly. One alternative proposed by him is to work with a sequence of distributions and, after discretizing the space of values, to count the observed transitions into and out of the distinct cell values and construct a transition probability matrix (Quah, 1993a,b).

Quah (1997) warns, however, that a discretization could distort dynamics if the underlying observations are indeed continuous variables. He therefore suggests not to discretize at all, and rather to think of the distinct cells as tending to infinity and to the continuum, with the transition probability matrix tending to a matrix with a continuum of rows and columns, i.e., becoming a stochastic kernel.[8] In particular, the proposed methodology is based upon tracking the evolution of the entire cross-section distributions across regions over time through the estimation of kernel densities for '*relative*' variables. By relative variables, we mean that the variables of interest are expressed as relative to the national average, which allows abstraction from changes in the mean when we look at how the distribution changes.

Empirically, in a graph showing how the cross-sectional distribution of the relative variable of interest changes between two periods, if most of the mass of the estimated bivariate kernel density is concentrated along the 45-degree diagonal, then regions basically remain where they started. We will refer to this situation as *persistence* in the distribution of the relative variable of interest.

4 Data and Empirical Estimation

The convergence analysis in our paper is done at the department level. Using two cross-sections per variable, we treat each department as an observation and do not use population weights. We are interested in investigating whether departments that were lagging behind were able to catch up, and consider this to be a pertinent question in the Colombian case where, as mentioned in section 2, departments are important political entities.

[8] For a technical derivation of a stochastic kernel, see Quah (1997, section 4).

In this section, we deal briefly with the selection of variables, the transformation of the variables needed in some cases, and the particular choices we apply for the empirical estimation.

4.1 Data

As discussed by Micklewright and Stewart (1999), many quality-of-life variables have a complement (e.g., the infant survival rate is 1,000 minus the infant mortality rate). They warn that sigma-convergence results may depend upon whether one uses a variable or its complement. Kenny (2004) argues for measuring convergence towards a maximum and not towards zero, claiming that the latter approach favors small absolute changes, close to zero, above large absolute changes, further from zero. Additionally, he claims that convergence towards the maximum (i.e., a positive value) is what the majority of the literature on global trends does. We follow these arguments and use in this study '*positive*' variables. By this we mean that we transform the variables so that they are, in theory, positively correlated with living standards.

We have tried to obtain data at the department level for years close to 1975 and 2000, as we additionally want to compare our regional convergence results with those found for two income measures in Branisa and Cardozo (2009) for the period from 1975 to 2000. Evaluating a period of 25 years to investigate convergence seems reasonable as the time span roughly represents a generation. Our main source of data at the department level is DANE.[9] It kindly provided illiteracy rate data that were computed from information obtained in censuses for the years 1973 and 2005. For health data, we obtained infant mortality rates and life expectancy at birth. Data for the year 1975 are from DANE (1990) and for 2000, from DANE (2007). As explained before, we transform two of the variables so that they are 'positive' - we work with literacy rates instead of illiteracy rates, and with infant survival rates instead of infant mortality rates.

[9] Departamento Administrativo Nacional de Estadística. DANE is the official statistical agency in Colombia (http://www.dane.gov.co/).

The literacy rate (LIT) is the percentage of literate population above age 5. Being illiterate can be considered a deprivation of a very basic capability. As argued by Sen (1999), basic education can additionally be considered a semi-public good, as it is not only the literate person who benefits from it, but society in general, for example through the reduction in fertility and mortality.

The infant survival rate (ISR) is the number of babies that survive until their first birthday out of every 1,000 live-born babies during a particular year. It is a measure of nutrition and hygiene in the first months of life, and also reflects the degree of the existence of contagious diseases (Mazumdar, 2003). There are many empirical studies that show that women's education and literacy tend to increase the survival rates of children (Sen, 1999).

Life expectancy at birth (LEX) is the average number of years that a newborn is expected to live if current mortality rates continue to apply. This variable reflects the level of health care, nutrition, and income. However, at least at the cross-country level, some studies show that the connection between income and life expectancy works mainly through two channels, public expenditure on health care and the success of poverty eradication efforts (Sen, 1999).

In addition to the data provided by DANE, we use data from Demographic and Health Surveys for Colombia for the years 1995 and 2005 containing information about child nutrition at the department level. As this variable covers a shorter time period than the other three variables and is based upon data that are not always representative at the department level, we will treat the results based on the 'positive' variable, well-nourished rate, carefully.

Our well-nourished rate (WR) is defined as 100 minus the percentage of children which are underweight. Underweight means insufficient weight for age and is commonly used as a summary indicator of undernutrition (UNICEF, 1998). Undernutrition depends upon both food intake and the ability to make nutritive use of it, which ability is influenced by general health conditions that depend on health care and public health provisions (Drèze and Sen, 1989; Sen, 1999).

4.2 Empirical estimation

As the mean of the variables of interest has changed in the period considered, to test for sigma-convergence, we use the coefficient of variation, defined here as 100 times the ratio of the standard deviation to the mean.

For testing for beta-convergence, we follow one of the estimations used by Bloom and Canning (2007). We run regressions as

$$y_i = \alpha + \beta x_i + \epsilon_i, \tag{1}$$

where x_i is the initial value of the variable of interest for department i, and y_i is the change in the variable of interest in the period considered. [10] We assume that $\epsilon_i \sim N(0, \sigma^2)$ and estimate the regressions with ordinary least squares (OLS). We use HC3 robust standard errors, as proposed by Davidson and MacKinnon (1993), to account for possible heteroscedasticity, considering that the number of observations is relatively small (Long and Ervin, 2000). We are interested in checking whether the estimated coefficient β is negative and statistically different from 0 at the 5% level, meaning that lower initial levels of the variable of interest are associated with larger improvements in the periods considered. To check whether the results are robust, after the regression, we compute Cook's distance to detect observations that have an unusual influence or leverage, and re-run the regressions on the restricted sample, excluding those observations.

For the distributional approach, all variables are expressed relative to the Colombian value, as was explained in section 3. We additionally take the logarithm of the relative variable, as it facilitates the comparison to the national level. Expressed in logs, a relative value that is equal to 0 means that the department has the same value as the country, while a value that is, for example, equal to -0.05 means that the value of that department is 5% lower than the national value.

Before we define how we proceed to test for convergence using the distributional

[10] We have also tried a specification proposed by Barro and Sala-i-Martin (1992a) that uses the average growth rate as the dependent variable and a function of the logarithm of the initial value as a regressor, obtaining similar results.

approach, we briefly present some concepts needed for our estimation.[11]

A univariate kernel density estimate can be regarded as a generalization of a histogram. It has the form

$$\hat{f}_h(q) = \frac{1}{nh}\sum_{i=1}^{n} \kappa\left(\frac{q - Q_i}{h}\right), \tag{2}$$

where κ is a kernel[12], $h > 0$ is the bandwidth, also called the smoothing parameter, and n is the number of observations.

In the context of convergence, we are interested in checking whether we find unimodality or multimodality in the estimated univariate densities of the relative variable of interest in both periods, and in determining how the estimated densities changed.

Bivariate kernel density estimation requires two-dimensional data and a two-dimensional kernel. Here, $Q = (Q_1, Q_2)^T$, and the kernel K maps $\mathbb{R}^2$ into $\mathbb{R}_+$. The estimate has the form

$$\hat{f}_H(q) = \frac{1}{n}\sum_{i=1}^{n} \frac{1}{det(H)} K\{H^{-1}(q - Q_i)\}, \tag{3}$$

where K is a bivariate kernel function, H is a symmetric bandwidth matrix, and n is the number of observations.

For the analysis of convergence, we estimate the bivariate kernel density for the relative variable in two periods and check whether a large portion of the probability mass remains clustered around the 45-degree diagonal, which would indicate persistence in the distribution. We present the 3D representation of the estimated bivariate density and a contour plot showing the highest density regions.

All the results for kernel density estimation presented in section 5 were computed with the statistical software R (R Development Core Team, 2008) and the package

[11] A review of the statistical principles of univariate and multivariate kernel density estimation can be found in Härdle, Müller, Sperlich, and Werwaltz (2004), for example.

[12] Kernel refers to any smooth function satisfying the conditions $\kappa(q) > 0$, $\int \kappa(q)dq = 1$, $\int q\kappa(q)dq = 0$, and $\sigma_\kappa^2 \equiv \int q^2\kappa(q)dq > 0$ (Wasserman, 2006). In kernel density estimation, the choice of the kernel does not have a large impact on the estimation, but the choice of the bandwidth does.

ks.[13] For both univariate and bivariate kernel density estimation, we use gaussian kernels and smoothed cross validation (SCV) bandwidth selectors[14] (Jones, Marron, and Park, 1991; Duong and Hazelton, 2005). In the bivariate case, the smoothed cross validation in unconstrained, i.e., we do not impose the requirement that the (nonsingular) bandwidth matrix H has to be diagonal. Hence, we are able to handle correlation between components, as we allow kernels to have an arbitrary orientation (Wand and Jones, 1995). As we are especially interested in checking whether a large portion of the probability mass remains clustered around the 45-degree diagonal, this flexibility is relevant for us. If we were to impose a diagonal matrix H, only kernels which are oriented to the coordinate axes would be allowed.

5 Results

We address in this paper the question of regional "positive convergence" in Colombia (Micklewright and Stewart, 1999); that is, we investigate whether departments which were lagging behind at the beginning of the period in certain variables of interest proxying for health care and education have been able to catch up in a period that has been one of improvement in average.[15] As can be observed in the descriptive statistics of the variables (Table 1), there has been a general improvement in all the variables chosen as proxies for living standards.

5.1 Literacy Rate

We find strong evidence of convergence in literacy rates. Both sigma-convergence (Table 2) and beta-convergence are observed (Tables 3 and 4). In the OLS regression with all available observations, Bogotá and La Guajira are identified as having an unusual influence on regression results; the coefficient of the initial level remains negative and statistically significant, however, if one excludes these two departments.

[13] *ks* is currently the most comprehensive kernel density estimation package in R (Duong, 2008). All the estimations were done with the function *kde*.

[14] We also tried direct plug-in methods for bandwidth selection suggested by Sheather and Jones (1991) and obtained results that are not very different.

[15] "Negative convergence," (European Commission, 1996) a situation of general deterioration towards the standard of the worst, is not relevant for Colombia in the period considered.

In Bogotá literacy rates were already high in 1974 (90%), making it more difficult to achieve further improvements. La Guajira is in the opposite position, a department with very low literacy rates in 1973 and with a minor improvement in the 32 years of analysis. As suggested by Meisel (2007) in a study of this department, illiteracy is widespread in the indigenous population, consisting of the Wayúu group, which predominantly lives in rural areas. Estimations of this author suggest that around 80% of the Wayúu's had not even finished primary school in 2005.

The univariate kernel in Figure 3 shows that the distribution has narrowed between 1973 and 2005. In 1973 one can observe three modes that are no longer visible in 2005. However, one small group lags behind in 2005. In Figure 5, one can observe a clear pattern of convergence, as most of the mass of the estimated bivariate density is concentrated in an axis that is flatter than the 45-degree line. Nevertheless, the case of La Guajira raises attention; it was among the worst relative performers in 1973, and in 2005, it was the worst relative performer. La Guajira had literacy rates that were 28% lower than the national average in 1973 and 33% in 2005.

Although one can praise improvements for the other departments that were lagging behind in 1973, it is important to note that the literacy rate only indicates the existence of a basic education level, which is definitely important, but probably not adequate. [16] Even considering this very basic indicator, it is worrisome that in many departments (La Guajira, Chocó, Sucre, Córdoba, Magdalena, Caquetá, Cesar, Nariño, and Bolívar), more than 15% of the population is still illiterate. Unfortunately, we have not been able to access data at the department level that proxies higher levels of education.

5.2 Infant Survival Rate

Between 1975 and 2000, the average departmental infant survival rate per thousand live births improved, increasing from 936 to 962 (Table 1). Results show that the coefficient of variation of this indicator decreased slightly, suggesting mild sigma-

[16] Additionally, as discussed in Velez et al. (2003), there is some evidence that despite large and increasing public expenditures on public education, particularly after decentralization, the quality of education is decreasing.

convergence (Table 2). However, this result tells us little about how exactly the distribution of departments changed.

When looking at beta-convergence, we find a negative coefficient for infant survival rate in 1975, but it is not statistically significant unless we exclude the department of Chocó from the regression (Tables 5 and 6). This exclusion is based on unusual influence or leverage and indicates that this department has an important influence on the lack of convergence. Chocó had the lowest performance in 1975 and even though infant survival rate improved there, by 2000, it was the furthest from the departmental average. Notice that the infant survival rate in Chocó in 2000 was lower than the departmental average in 1975 (Table 1).

Figure 6 shows that after Chocó, departments with the lowest starting infant survival rates were Nariño, Caldas, Risaralda, and Quindío. Of these, Caldas, Risaralda, and Quindío achieved the largest improvements during the period of analysis. Changes in departments that were close to the average in 1975 vary considerably. Antioquia, Norte de Santander, and Valle experienced important improvements, while Cauca, Córdoba, Guajira, and Bolívar stagnated.

Kernel density estimators allow a closer look at changes in the distribution in relative terms. In Figure 7 we observe that the density was slightly narrower in 2000 than in 1975. Both years had a bimodal distribution. The bivariate kernel in Figure 8 and the corresponding contour plot in Figure 9 suggest persistence in the infant survival rate, as most of the estimated density is concentrated along the 45-degree diagonal. Thus, in relative terms, departments basically remained where they were in 1975. The departments of Chocó, Nariño, and Cauca are outside of the 90% contour.

To summarize, coastal regions have the lowest infant survival rates, although the rates have improved over time. The infant survival rate is particularly low in 2000 in the Pacific region (e.g., 912 children per 1,000 births in Chocó) where population density is low and a large share of the population lives in rural areas with precarious sanitation infrastructure. This department is also prone to a higher prevalence of tropical diseases, given that it is one of the rainiest and humid regions in the world.

Transport between small rural villages along the river shores, which are prone to floods, is possible only within the extensive network of rivers. This also explains why the the scope and reach of health programs are limited.[17]

In contrast, an important increase in infant survival rates has been observed in central regions located along the main transport corridors of the country. Increased vaccination was achieved in large cities and in departments where agglomeration around urban centers allows easier access to the population.

5.3 Life Expectancy at Birth

In Colombia, the average departmental life expectancy at birth was 62 years in 1975 and increased to 70 years in 2000 (Table 1). The coefficient of variation decreased from 5.7 to 3.7, suggesting sigma-convergence (Table 2). Beta-convergence analysis shows a negative relationship between the starting value in 1975 and its change up to 2000 (10). The regression coefficient is negative and statistically significant when including all observations, but it is insignificant once we exclude influential observations, in this case Chocó and Nariño, which experienced large improvements. In Nariño, people born in 2000 were expected to live 14 years longer than those born in 1975, and in Chocó the gain was 13 years. Once again the coffee-growing region (Caldas, Quindío, and Risaralda) had outstanding improvements. Sucre, located in the Atlantic coast, had the longest life expectancy at birth by 2000, even exceeding that of the capital district of Bogotà, which ranks frequently in first place for economic and well-being indicators. On the contrary, the set of departments that we group as Nuevos Departamentos in the eastern and southern parts of the country experienced modest improvements, taking into account their low starting position.

The univariate kernel density estimators of life expectancy at birth for 1975 and 2000 show that the distribution has become narrower, as was expected from the sigma-convergence result. Even if both distributions seem bimodal, the mode on

[17] According to the Demographic and Health Survey from 2005, 20% of women in La Guajira did not have any kind of prenatal care before delivery. These rates are also very high for Caquetá (20%), Cauca (15%), Chocó (15%), and CŮórdoba(14%). In Chocó, 40% of births were attended at home (usually by a midwife). The corresponding figures for Caquetá and Cauca are 32% and 31%, respectively (Profamilia, 2005).

the left of the distributions is much closer to the main mode in 2000 than in 1975.

In Figures 12 and 13, we observe the bivariate kernel density estimator, which is computed using life expectancy at birth relative to the national average for both years. Once again the results suggest persistence, rather than convergence, as most of mass of the estimated bivariate density is concentrated along the 45-degree diagonal. In relative terms, departments basically remained where they were in 1975. Chocó, Nariño, and Nuevos are the three departments outside of the 90% contour. As mentioned before, Chocó and Nariño improved dramatically in their relative positions, while Chocò remained the worst performer both years.

5.4 Nourishment

As was mentioned before, we must treat the results concerning nourishment with care, as we only have data for 1995 and 2005, a period which is shorter than that used for other variables, and as we are using data for 23 departments[18] from Demographic and Health Surveys which are not always representative at the department level. Nevertheless, we consider that some insight can be gained investigating convergence in the rate of well-nourished children.

Table 1 shows that between 1995 and 2005, the departmental average of the well-nourished rate (WR) improved from 93% to 95%. Both sigma-convergence (Table 2) and beta-convergence are observed. Figure 14 plots the value of WR in 1995 against the change in WR between 1995 and 2005. There is a clear negative relationship between them which is confirmed with the regressions presented in Tables 9 and 10.

Figure 15 shows the estimated univariate kernel density estimators of the log of relative WR and confirms that the distribution is less skewed in 2005, but the bimodality observed in 1995 remains in 2005. Bivariate kernel density estimators shown in Figures 16 and 17 suggest mild convergence in this indicator. Most of the mass of the estimated bivariate density is concentrated in an axis that is flatter than the 45-degree line.

[18] No information is available for Caquetá and Nuevos Departamentos.

6 Conclusions

Several points are important for the discussion. First, unlike in the case when one is dealing with income indicators, social indicators have natural upper bounds (Neumayer, 2003; Kenny, 2004). In the case of the three rates we use (infant survival rate, literacy rate, and well-nourished rate), the upper bound is evident and constant (e.g., no department can have a more than 100% literacy rate). In the case of life expectancy at birth, the upper bound can be thought of as variable, but a slow moving one.[19] As discussed by Neumayer (2003) and Kenny (2004), among others, convergence is more likely to be observed in variables with an upper bound when some departments are close to that bound in the initial year. Our results show that this is the case for the classical approach to convergence, where sigma-convergence is found in all cases, and beta-convergence also in all, with the exception of the infant survival rate. Working with relative values and using the distributional approach, it is possible to make a more precise evaluation if one uses bivariate kernel estimators. For example, the distributional approach yields persistence in the distribution of life expectancy at birth, while the beta-convergence analysis shows convergence. Obviously, regression results can be driven by outliers, as is the case for this variable. If one excludes outliers, no evidence of beta-convergence is observed.

Second, it has been argued that at least at the cross-country level, one can observe convergence in social indicators even in the absence of convergence in income. Two reasons advanced for this are high returns to small marginal increases in income at low income levels and causal relationships between the social indicators, themselves (Kenny, 2004), for example between literacy and mortality. Additionally, the dispersion of best practices in health care can lead to improvement in health outcomes, even without income convergence. This is relevant for us, as results in Branisa

[19] There is no consensus among scientists concerning the upper bound of life expectancy at birth and values between 85 years (which is the value currently used in the Human Development Reports) and 100 years have been mentioned. Olshansky, Carnes, and Cassel (1990), for example, claim that it seems unlikely that life expectancy at birth will exceed the age of 85, while other studies, based on extrapolations from historical trends, predict that it could attain 100 years in developed countries by 2060 (Oeppen and Vaupel, 2002) or by 2300 (United Nations, 2004).

and Cardozo (2009) suggest that there has been persistence in the distribution of departmental per capita GDP between 1975 and 2000.[20]

Third, the role of urbanization should also be highlighted, as it is relevant in our case. The percentage of total population in Colombia that lived in urban areas increased from 59% in 1973 to 75% in 2005. Urbanization facilitates convergence in social indicators, as it is easier to provide social services to urban residents than to rural (Kenny, 2004). As shown by Bettencourt, Lobo, Helbing, Kühnert, and West (2007), cities make economies of scale in infrastructure possible. Nevertheless, we stress that living in an urban area does not guarantee access to services.

Fourth, departments in Colombia differ according to climatic and geographic conditions, which conditions have been historically determinant for agglomeration and the availability of infrastructure, particularly roads. Two important consequences are that some diseases only affect departments that are located in the tropics and that access to sanitation services is more limited in isolated areas.

Fifth, and related to the last point, the internal conflict in Colombia is not of the same intensity across all departments.[21] Although it is a widespread problem affecting the whole country, sparsely populated departments, with predominantly rural areas having limited access due to geographic conditions and in which state presence has been historically low or weak, are more prone to the presence of illegal groups.

With these issues in mind, we begin the discussion of the results concerning convergence in education. In the final quarter of the last century, we find clear evidence of regional convergence in literacy rates in Colombia. As discussed by Barrera and Domínguez (2006), since the seventies, there have been policies in place having the

[20] PDB is the abbreviation used by Branisa and Cardozo (2009) for departmental GDP, based on the Spanish denomination "Producto Departamental Bruto" (CEGA, 2006).

[21] The current internal conflict began almost 50 years ago with the emergence of leftist guerrilla groups, the root motivations of which were mainly ideological. Up until 1980, the military capacity of these groups was limited and Was concentrated in marginal areas of the country. Parallel to those, paramilitary groups developed slowly in the eighties to defend isolated areas from guerrilla attacks. During the coca bonanza ("bonanza coquera") and the consolidation of drug trafficking in the eighties, illegal armed groups found new ways of financing operations and expanding through the control of areas where illegal crops where grown, as well as in territories that are rich in natural resources, particularly oil (Díaz and Sánchez, 2004).

objective of reducing illiteracy and increasing the coverage of primary education, which policies are partially responsible for our result. Urbanization probably also played a role here. While some of the departments with the best indicators in 1973 had a population that was primarily urban, many of the worst performers in that year had a population that was mainly rural and urbanization increased relatively more in the worst performers.[22] Another possible reason for the convergence result is that our indicator considers the population above five years of age in both periods. The elder population in 1973, which was no longer alive in 2005, likely had relatively high illiteracy rates, particularly in the departments which were lagging behind in 1973. Thus, there is a generational effect; the older cohorts included in 1973 are no longer visible in the statistics in 2005, while younger cohorts, who benefited from improved educational resources and literacy campaigns, are included.

Even if regional convergence in literacy rates seems to be a robust result, one should keep in mind that it only reflects very basic education and we do not know whether convergence was observed in education at higher levels. The department of La Guajira deserves special attention as it still lags far behind in literacy rates.[23]

Considering indicators of the health status of the population and using infant survival rates (ISR) as a proxy, we find no evidence of beta-convergence. Following the distributional approach and values expressed relative to the national levels, we find evidence of persistence in the distribution. In 2005 departments are basically where they were in 1973, in relative terms. These results can also be explained by a low prevalence of prenatal care in departments of the Pacific and Atlantic coasts (Profamilia, 2005).

Using life expectancy at birth as a proxy for health yields similar results (persistence) according to the distributional approach. In relative terms, in the year 2005,

[22] As examples for well performing departments in terms of literacy rates in 1973, consider Antioquia, which had an urban percent of population of 62% in 1973 and 78% in 2005, and Valle, which had 76% in 1973 and 87% in 2005. Examples for poorly performing departments in 1973 are Chocó, which had an urban percentage of population of 26% in 1973 and 54% in 2005, and Sucre, which had an urban percentage of population of 47% in 1973 and 64% in 2005.

[23] As mentioned before, this department has a large indigenous population (44%) of which population 80% has not attained any educational degree (Meisel, 2007).

departments are basically where they started in 1973. However, the two departments that had the lowest values at the beginning of the period improved substantially in relative terms. Beta-convergence is driven by these two departments.

Results regarding nourishment show regional convergence in the 10 years studied (1995 through 2005). (As previously mentioned, estimates have to be considered cautiously because the sample of 1995 is not representative for all departments.) Two interesting issues emerge. First, the well-nourished rate deteriorated slightly for some departments that were close to the upper bound in the initial year. Second, the three poorest departments in the Pacific coast improved considerably in relative terms, as pointed by Profamilia (2005). Interestingly, in the Atlantic coast, nourishment relative to the national average stagnated.

Our results differ from those in the scarce literature on convergence among departments in Colombia which used health and education indicators. Some of our results contradict those obtained by Aguirre (2005), who finds convergence in life expectancy at birth, but not in education. The difference concerning life expectancy can be explained as follows. We find that beta-convergence is driven by two influential observations, and once we use bivariate kernel estimators with the variable expressed as a ratio to the the national value, we find persistence in the distribution of life expectancy rather than convergence. The difference concerning education could be due to the fact that Aguirre uses *illiteracy* rate for the analysis, while we use literacy rates. Note that while Aguirre also computes univariate kernel density estimators for the variables in both periods, they are based on absolute values (i.e., not relative to the national average), making judgements as to distributional changes more difficult given that the means vary.

Finally, the study of Meisel and Vega (2007) considers a much longer period (1870 through 2003) for investigating regional convergence in Colombia, using the evolution of adult height over time as an alternative perspective on the standard of living. They find both sigma and beta-convergence among departments and highlight that nutritional improvements are among the main explanations of this result. Even if our results concerning nourishment cover a much shorter period (1995 through 2005), they point to the same conclusion. It could be interesting to test for convergence among departments with the distributional approach using the sample of Meisel and Vega (2007).

Lack of convergence among Colombian departments in the two variables proxying for health raises some doubts as to the effectiveness of current policies, as convergence is what one would expect, for the reasons explained above. Understanding why some departments still lag behind is relevant, as it is not clear whether the reasons are due mainly to the differences in per capita income, climatic and geographic conditions, infrastructure, or behavior, or to still other factors. It is crucial to understand the main causes of infant and adult morbidity and mortality in the departments lagging behind to assess which specific policies could improve living conditions in each case.

Summary of Results

	Social indicator used			
	Literacy rate	Infant survival rate	Life expectancy at birth	Well-nourished rate
Classical Approach: Convergence?				
Sigma	Yes	Yes	Yes	Yes
Absolute Beta (all obs.)	Yes	No	Yes	Yes
Absolute Beta (excl. outliers)	Yes	Yes	No	Yes
Distributional Approach				
Univariate Kernel Estimators	Dispersion decreases	Dispersion decreases	Dispersion decreases	Dispersion decreases
Bivariate Kernel Estimators	Convergence	Persistence in the distribution	Persistence in the distribution	Suggests slow convergence

Note: Results for the distributional approach based on relative values, i.e. ratios to the national level.

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Tables

Table 1: Descriptive Statistics of the Variables Used

Variable	**Literacy rate**		**Infant survival rate**		**Life expectancy at birth**		**Well-nourished rate**	
Year	**1973**	**2005**	**1975**	**2000**	**1975**	**2000**	**1995**	**2005**
mean	70.3	85.8	935.9	962.3	61.7	69.9	93.0	95.3
median	69.0	87.4	940. 1	967.8	62.5	69.9	93.8	95.7
stand. deviation	9.38	6.8	16.6	14.4	3.6	2.6	4.2	2.3
skewness	-0.0	-1.8	-2.0	-2.0	-1.6	-1.0	-1.4	-0.9
kurtosis	2.5	6.5	7.8	7.6	6.6	4.4	4.8	3.9
range	37.3	30.2	81.3	64.8	17.6	11.5	17.8	9.8
minimum	52.2	63.1	876.7	911.5	49.7	62.4	80.9	88.9
maximum	89.6	93.4	958.1	976.3	67.3	73.8	98.7	98.7
Number of obs.	25	25	24	24	24	24	23	23

Source: Own calculations based on data at the department level from DANE and DHS.

Literacy rate measured as the percentage of literate population above age 5.

Infant survival rate measured as per thousand live births.

Life expectancy at birth measured in years.

Well-nourished rate measured as the percentage of population under age 5 not underweight.

Table 2: Evolution of Point Estimates and 95% Confidence Intervals of the Coefficients of Variation (CV)

Literacy rate		
Year	1973	2005
CV	13.3	7.9
95% conf. int. of CV	10.6 - 17.5	4.9 - 13.3
Infant survival rate		
Year	1975	2000
CV	1.8	1.5
95% conf. int. of CV	1.0 - 2.7	0.9 - 2.6
Life expectancy at birth		
Year	1975	2000
CV	5.8	3.7
95% conf. int. of CV	3.7 - 9.8	2.6 - 5.6
Well-nourished rate		
Year	1995	2005
CV	4.6	2.4
95% conf. int. of CV	2.8 - 6.8	1.8 - 3.6

Source: Own calculations based on data from DANE.
Note: The coefficient of variation is defined as 100 times the ratio of the standard deviation to the mean. The confidence intervals were calculated using the adjusted bootstrap percentile (BCa) method.
(Davison and Hinkley, 1997; R Development Core Team, 2008)

Table 3: Beta Convergence (OLS) using all available Observations. Dependent Variable: Change in Literacy Rate (LIT) between 1973 and 2005

Variable	**Coefficient**	**Robust Std. error**	**p-value**
Intercept	43.42	9.56	0.000
LIT in 1973	-0.40	0.13	0.005
Number of observations	25		
R-squared	0.50		

Source: Own calculations based on data from DANE.

Note: HC3 robust standard errors calculated following Davidson and MacKinnon (1993).

Table 4: Beta convergence (OLS) excluding Outliers. Dependent Variable: Change in Literacy Rate (LIT) between 1973 and 2005

Variable	**Coefficient**	**Robust Std. error**	**p-value**
Intercept	49.36	5.93	0.000
LIT in 1973	-0.47	0.08	0.000
Number of observations	23		
R-squared	0.81		

Source: Own calculations based on data from DANE.

Notes: Two departments (Bogotá and La Guajira) were excluded using Cook's distance to detect for unusual influence or leverage after the regression with all observations. HC3 robust standard errors calculated following Davidson and MacKinnon (1993).

Table 5: Beta Convergence (OLS) using all available Observations. Dependent Variable: Change in Infant Survival Rate (ISR) between 1975 and 2000

Variable	**Coefficient**	**Robust Std. error**	**p-value**
Intercept	370.75	297.25	0.257
ISR in 1975	-0.37	0.32	0.225
Number of observations	24		
R-squared	0.28		

Source: Own calculations based on data from DANE.

Note: HC3 robust standard errors calculated following Davidson and MacKinnon (1993).

Table 6: Beta Convergence (OLS) excluding Outliers. Dependent Variable: Change in Infant Survival Rate (ISR) between 1975 and 2000

Variable	**Coefficient**	**Robust Std. error**	**p-value**
Intercept	660.00	195.01	0.003
ISR in 1975	-0.68	0.21	0.004
Number of observations	23		
R-squared	0.41		

Source: Own calculations based on data from DANE.

Notes: One department (Chocó) was excluded using Cook's distance to detect for unusual influence or leverage after the regression with all observations. HC3 robust standard errors calculated following Davidson and MacKinnon (1993).

Table 7: Beta Convergence (OLS) using all available Observations. Dependent Variable: Change in Life Expectancy at Birth (LEX) between 1975 and 2000

Variable	**Coefficient**	**Robust Std. error**	**p-value**
Intercept	34.69	6.67	0.000
LEX in 1975	-0.43	0.11	0.001
Number of observations	24		
R-squared	0.48		

Source: Own calculations based on data from DANE.

Note: HC3 robust standard errors calculated following Davidson and MacKinnon (1993).

Table 8: Beta Convergence (OLS) excluding Outliers. Dependent Variable: Change in Life Expectancy at Birth (LEX) between 1975 and 2000

Variable	**Coefficient**	**Robust Std. error**	**p-value**
Intercept	27.48	10.46	0.016
LEX in 1975	-0.32	0.17	0.070
Number of observations	22		
R-squared	0.19		

Source: Own calculations based on data from DANE.

Notes: Two departments (Chocó and Nariño) were excluded using Cook's distance after the regression with all observations to detect for unusual influence or leverage.

HC3 robust standard errors calculated following Davidson and MacKinnon (1993).

Table 9: Beta Convergence (OLS) using all available Observations. Dependent Variable: Change in Well-nourished Rate (WR) between 1995 and 2005

Variable	**Coefficient**	**Robust Std. error**	**p-value**
Intercept	0.86	0.23	0.001
WR in 1995	-0.90	0.24	0.001
Number of observations	23		
R-squared	0.74		

Source: Own calculations based on data from DHS.

Note: HC3 robust standard errors calculated following Davidson and MacKinnon (1993).

Table 10: Beta Convergence (OLS) excluding Outliers. Dependent Variable: Change in Well-nourished Rate (WR) between 1995 and 2005

Variable	**Coefficient**	**Robust Std. error**	**p-value**
Intercept	0.99	0.16	0.000
WR in 1975	-1.04	0.17	0.000
Number of observations	21		
R-squared	0.68		

Source: Own calculations based on data from DHS.

Notes: Two departments (Chocó and La Guajira) were excluded using Cook's distance after the regression with all observations to detect for unusual influence or leverage.

HC3 robust standard errors calculated following Davidson and MacKinnon (1993).

Table 11: Poverty Headcount Index (% of Households below the Poverty Line) by Department. 1996 to 2005

Department	**1996**	**1999**	**2002**	**2003**	**2004**
Antioquia	54.1	57.8	58.9	55.6	54.1
Atlántico	49.5	57.9	53.2	52.1	48.2
Bogotá	37.8	46.3	36.1	34.2	29.5
Bolivar	60.3	59.9	67.8	51.5	54.6
Boyacá	65.0	62.6	72.3	70.3	71.5
Caldas	54.3	54.0	59.6	58.8	57.7
Caquetá	58.0	59.9	53.5	54.5	56.8
Cauca	61.4	73.3	64.5	69.0	63.0
Cesar	49.7	53.7	67.2	61.6	59.3
Chocó	70.9	78.0	62.6	70.3	71.6
Córdoba	74.3	72.6	68.5	66.5	70.8
Cundinamarca	44.5	50.9	58.4	51.9	53.6
Huila	62.9	62.7	74.4	69.7	66.3
Guajira	49.3	50.2	68.4	54.6	52.8
Magdalena	62.6	62.7	66.4	55.4	55.0
Meta	50.9	52.4	47.9	44.3	42.5
Nariño	68.1	71.7	70.7	71.2	67.3
N.Santander	61.3	58.2	57.3	57.3	57.9
Quindío	45.4	51.4	49.3	41.3	47.3
Risaralda	52.1	51.5	47.9	45.3	44.7
Santander	48.9	55.4	50.2	48.6	48.6
Sucre	47.9	64.0	69.4	56.5	65.7
Tolima	59.3	58.4	60.6	58.8	60.1
Valle	47.4	47.6	44.1	37.4	38.9

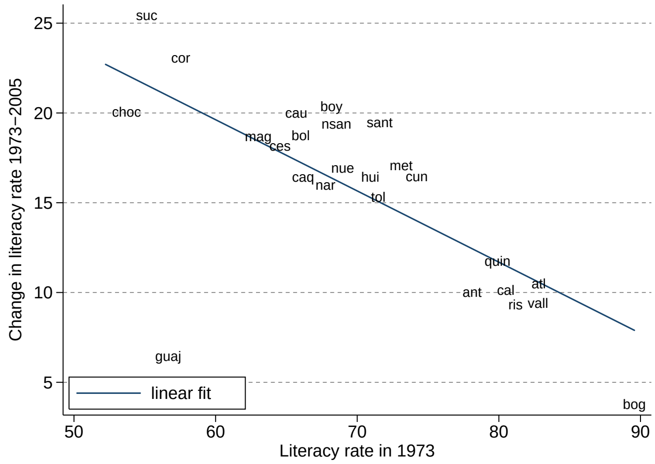
Source: Own calculations based on Household Surveys from DANE.

Figures

Figure 1: Official Map of Colombia.

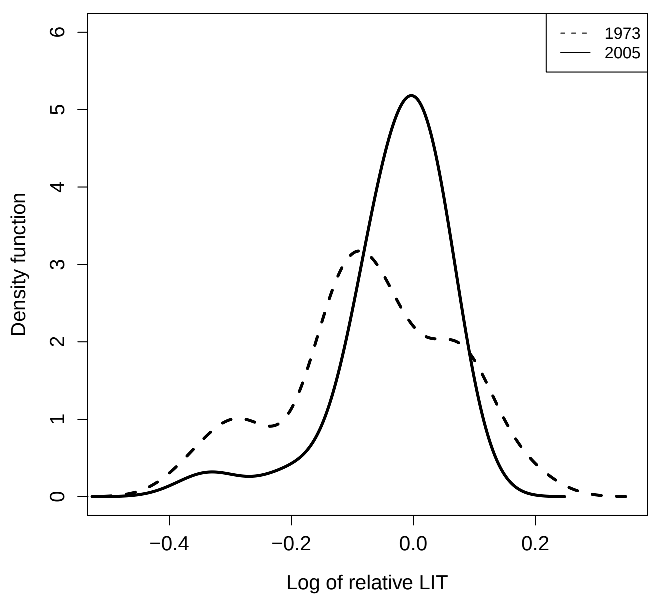
Source: Instituto Geográfico Agustín Codazzi.

Figure 2: Evolution of Literacy Rate. 1973-2005



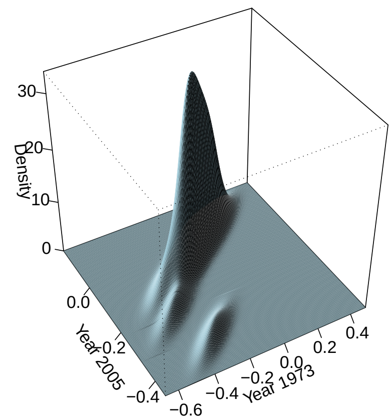
Source: Own calculations based on data from DANE.

Figure 3: Univariate Kernel Density Estimators of Relative Literacy Rate. 1973 and 2005.



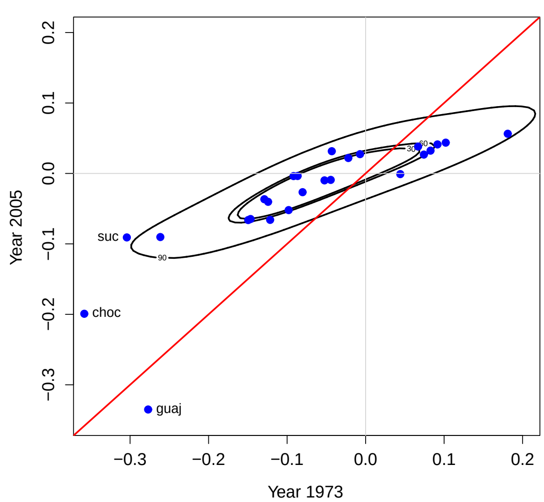
Source: Own calculations based on data from DANE.
Note: Variables relative to the national average and in logs.

Figure 4: Bivariate Kernel Density Estimators of Relative Literacy Rate. 3D Representation. 1973 and 2005.



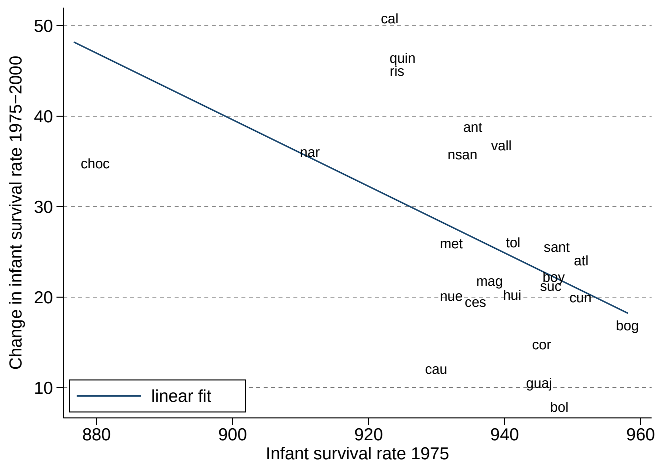
Source: Own calculations based on data from DANE.
Note: Variables relative to the national average and in logs.

Figure 5: Bivariate Kernel Density Estimators of Relative Literacy Rate. Contour Plot. 1973 and 2005.



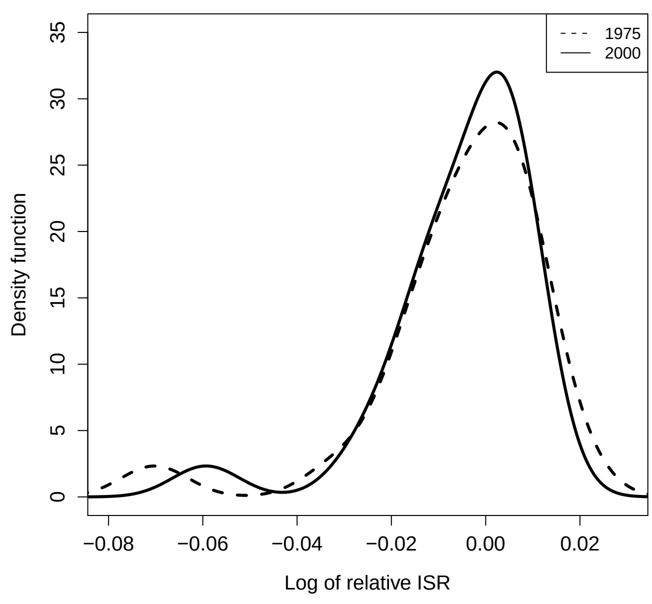
Source: Own calculations based on data from DANE. Variables in logs.
Note: Contours at drawn at the 30%, 60%, and 90% which are upper percentages of highest density regions. The points represent the 25 observations. Points outside the 90% contour are identified. A 45 degree line is added to the plot.

Figure 6: Evolution of Infant Survival Rate. 1975-2000



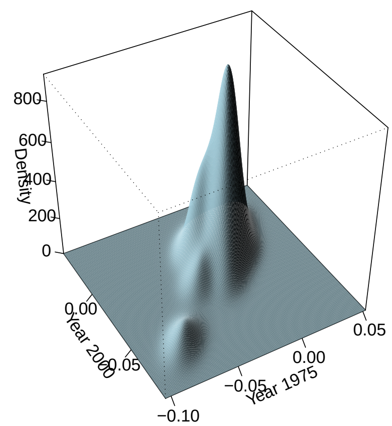
Source: Own calculations based on data from DANE.

Figure 7: Univariate Kernel Density Estimators of Relative Infant Survival Rate. 1975 and 2000.



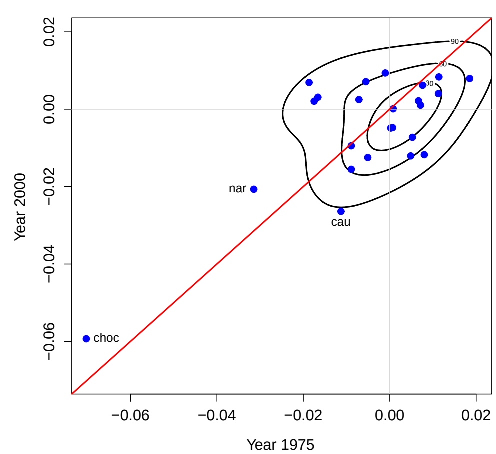
Source: Own calculations based on data from DANE.
Note: Variables relative to the national average and in logs.

Figure 8: Bivariate Kernel Density Estimators of Relative Infant Survival Rate. 3D Representation. 1975 and 2000.



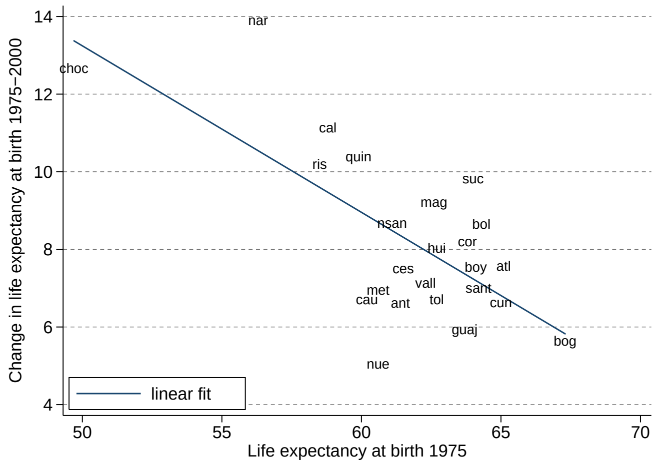
Source: Own calculations based on data from DANE.
*Note:*Variables relative to the national average and in logs.

Figure 9: Bivariate Kernel Density Estimators of Relative Infant Survival Rate. Contour Plot. 1975 and 2000.



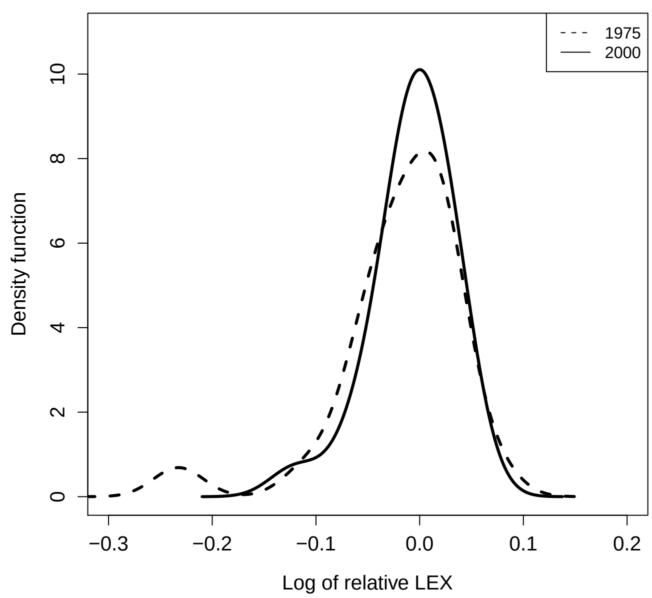
Source: Own calculations based on data from DANE. Variables in logs.
Note: Contours at drawn at the 30%, 60%, and 90% which are upper percentages of highest density regions. The points represent the 25 observations. Points outside the 90% contour are identified. A 45 degree line is added to the plot.

Figure 10: Evolution of Life Expectancy at Birth. 1975-2000



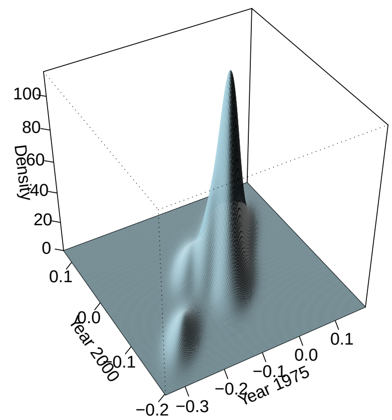
Source: Own calculations based on data from DANE.

Figure 11: Univariate Kernel Density Estimators of Relative Life Expectancy at Birth. 1975 and 2000.



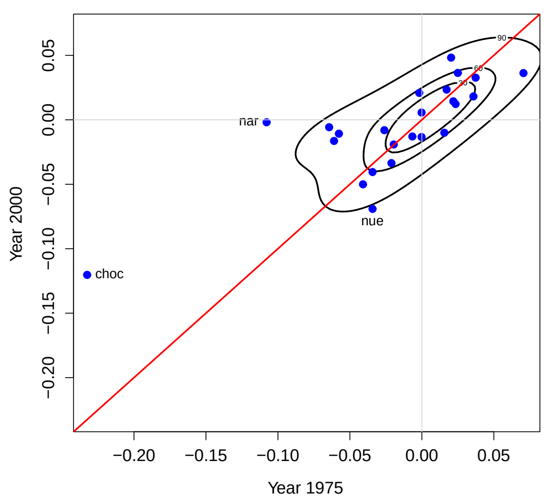
Source: Own calculations based on data from DANE.
*Note:*Variables relative to the national average and in logs.

Figure 12: Bivariate Kernel Density Estimators of Relative Life Expectancy at Birth. 3D Representation. 1975 and 2000.



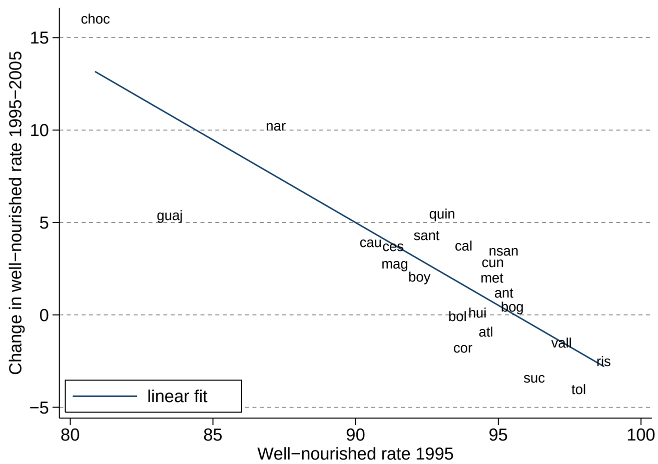
Source: Own calculations based on data from DANE.
Note: Variables relative to the national average and in logs.

Figure 13: Bivariate Kernel Density Estimators of Relative Life Expectancy at Birth. Contour Plot. 1975 and 2000.



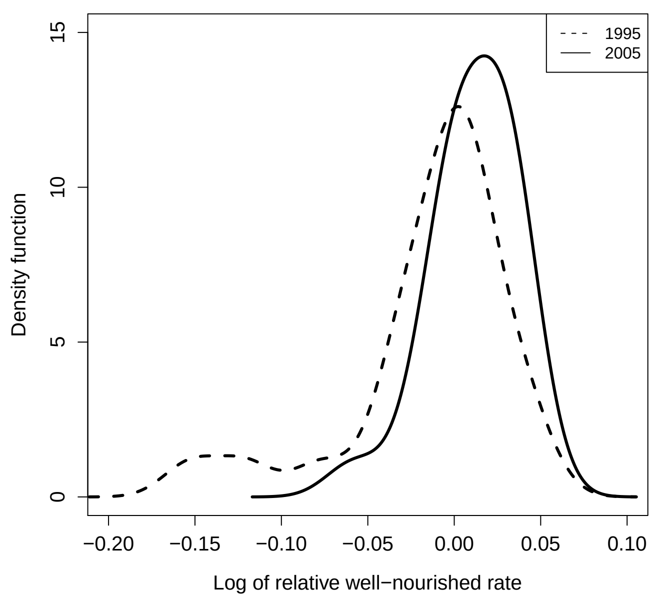
Source: Own calculations based on data from DANE. Variables in logs.
Note: Contours at drawn at the 30%, 60%, and 90% which are upper percentages of highest density regions. The points represent the 25 observations. Points outside the 90% contour are identified. A 45 degree line is added to the plot.

Figure 14: Evolution of Well-Nourished Rate. 1995-2005



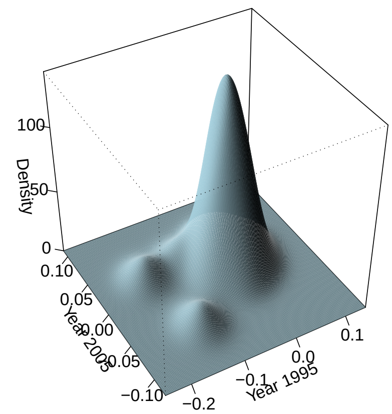
Source: Own calculations based on data from DHS

Figure 15: Univariate Kernel Density Estimators of Relative Well-nourished Rate. 1995 and 2005.



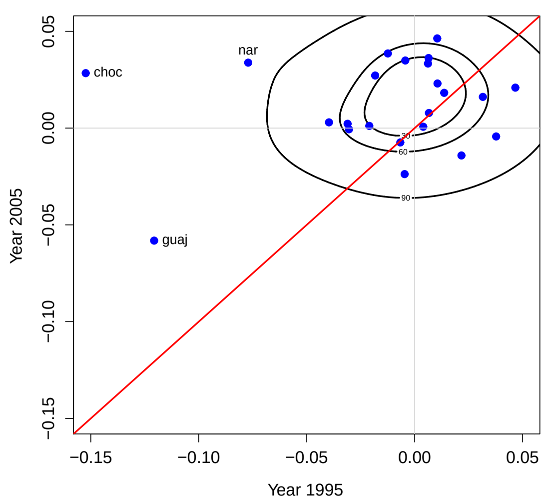
Source: Own calculations based on data from DHS.
Note: Variables relative to the national average and in logs.

Figure 16: Bivariate Kernel Density Estimators of Relative Well-nourished Rate. 3D Representation. 1995 and 2005.



Source: Own calculations based on data from DHS.
Note: Variables relative to the national average and in logs.

Figure 17: Bivariate Kernel Density Estimators of Relative Well-nourished Rate. Contour Plot. 1973 and 2005.



Source: Own calculations based on data from DHS *Note:* Contours at drawn at the 30%, 60%, and 90% which are upper percentages of highest density regions. The points represent the 25 observations. Points outside the 90% contour are identified. A 45 degree line is added to the plot.