# Economic growth of Minas Gerais: a quantile regression approach between 1980 and 2000

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**Guilherme Mendes Resende**
PhD candidate pela London School of Economics (LSE)
Mestre em economia pelo CEDEPLAR/UFMG
Pesquisador do Instituto de Pesquisa Econômica Aplicada (IPEA)
Email: g.resende@lse.ac.uk

**Lízia de Figueiredo**
PhD em economia
Professora de economia do CEDEPLAR/UFMG
Email: lizia@cedeplar.ufmg.br

ABSTRACT

We run quantile regressions to verify if the fast-growing municipalities in Minas Gerais state react differently to the slow-growing ones with respect to the initial level of income and to other variables between 1980 and 2000. Our results show that higher human capital, higher urbanization rates, better social infra-structure and lower infant mortality rates are related to higher economic growth rates. All results show evidence that the quantile coefficients are not significantly different from the OLS results. These results imply that conditional convergence cannot be denied in the case of municipalities of the Minas Gerais state.

Keywords: Economic growth, Income Convergence, Quantile regression, Minas Gerais.

RESUMO

Este artigo estima regressões quantílicas para verificar se os municípios mineiros que apresentaram um maior crescimento econômico entre 1980-2000 reagem de forma diferente daqueles com baixo crescimento em relação ao nível inicial de renda e outras variáveis explicativas. Os resultados mostram que maiores níveis de capital humano, taxas de urbanização, infra-estrutura social e menor mortalidade infantil estão relacionados com um maior crescimento econômico. Todos os resultados evidenciam que os coeficientes das regressões quantílicas não são estatisticamente diferentes daqueles gerados pelo método de mínimos quadrados ordinários. Assim, os resultados demonstram que a hipótese de convergência condicional não pode ser rejeitada para o caso dos municípios mineiros.

Palavras-chave: Crescimento econômico, Convergência de renda, Regressão quantílica, Minas Gerais.

JEL classification: C30, O40.

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## 1. Introduction

In recent years, there has been an increasing empirical literature that seeks to understand the main determinants of economic growth on the Minas Gerais state[1] (Fontes et al., 2005; Figueirêdo et al, 2006; Silva & Resende, 2007; and Resende, 2005). This literature is based on the conditional convergence hypothesis: in other words, it does not consider that worse initial conditions can negatively affect long-run income levels. On the other hand, some studies for all Brazilian municipalities (Gondim et al., 2004 and Coelho, 2006) have showed the existence of club convergence, when collecting evidence that show that initial conditions are critical to determine regional income (and dynamic) differences. In particular, we are interested in examine the findings of Coelho (2007), who suggested that some municipalities of Minas Gerais are trapped in lower levels of income, for which we will use a quantile regression approach. The selection of a geographical area (Minas Gerais) that shares relevant characteristics also avoids biases in our estimations due to omission of variables.

As can be inferred in Durlauf & Johnson (1995), if different "basin of attraction" exists, differences in growth rates would be driven not by differences in the level of its determinants, but by differences in their marginal impacts, which by its turn would be due to differences in initial conditions. As a consequence, if the estimated coefficients of a traditional growth equation are different among groups of regions (selected by the relevant initial conditions), this is evidence in favour of the club convergence hypothesis. If the coefficients are significant, but similar among groups, this is evidence in favour of the conditional convergence hypothesis. Durlauf et al. (2004) highlights the importance of testing for parameter heterogeneity. Thus, our question is: Do the fast-growing municipalities in Minas Gerais react differently to the slow-growing ones with respect to the initial level of income and to other variables? Quantile regression approach is an interesting way to deal with this question.

We want to contribute to the problem of identification between the club x conditional hypothesis, running a regression for municipalities of Minas Gerais not only with the initial income per capita, but also including other regressors, besides regional dummies. The initial level of income is correlated with several other relevant economic aspects as the initial level of human capital or the initial level of urbanization. In this case, omitted variables problems could be biasing the coefficients of the initial level of income. Thus, if the coefficients of the other regressors come to be significant, we could also add to the understanding of what initial conditions are important to the case of Minas Gerais.

The paper is organized as follows. Section 2 examines the literature about economic growth. First, we discuss some background papers about economic growth in Brazil. Next, we show the related debate about economic growth in Minas Gerais. Section 3 explains procedures and properties of quantile regression that we will apply to study economic growth of municipalities of Minas Gerais. Section 4 presents the dataset. Section 5 provides the empirical model. In Section 6, we discuss the results by using traditional and quantile approaches. Finally, Section 7 reports conclusions.

[1] Minas Gerais is the second most populous (18 million) state, in Brazil, and the third richest state, accordingly to the GDP level, in 2000.

## 2. Literature Review

### 2.1 Empirical Background

Since the beginning of the nineties, there has been a growing empirical literature trying to understand the determinants of per capita income of the Brazilian sub-units, having Solow's model of growth as a theoretical background.

Solow's model basic reminds us that the production per worker is a function of capital per worker and of technology. Therefore, higher rates of investment, lower depreciation and lower population growth rate should be associated with higher per capita income. If this is not true, the main determinant of per capita income should be technology. The interesting question raised by the model is though how is the relative importance of factor accumulation or technology in explaining well-being (not surprisingly, Solow's 1957 paper was developed to show a method to isolate both components).

The incorporation of human capital in the basic growth model has added another interesting line of investigation: how is the relative importance of the "broad concept" of capital, relative to technology, and how is the relative importance of the human capital, relative to the physical one. Recent developments in growth theory have also encouraged us to think about the level of the production function in a richer way: institutions, geography, openness, and also technology.

One of the ways the related empirical literature tries to answer these questions is estimating Barro-type growth equations. For the sub-units of Brazil – states, micro-regions and municipalities, it was reached a consensus that human capital is an important determinant of per capita income. We have also a good deal of evidence that the following variables are relevant in determining per capita income: participation rates, social infra-structure, demographical factors (population growth) and geography (Ferreira, 1995, 2000; Azzoni, 1994, 2001; Azzoni et al., 2000; Bleaney & Figueirêdo, 2002; Ferreira & Ellery Jr., 1996; Resende, 2005; Coelho, 2007, Souza, 2007).

Another consensus is that, accordingly to the level of disaggregation, the shape and the evolution of the distribution of per capita income changes: in the case of the Brazilian states, the literature has found an evolution in the direction of one unique peak (Gondim et al., 2004), what is not true for the municipalities (Gondim et al., 2004; Coelho, 2007) and for the micro-regions. Recently, Coelho (2007) has shown that the shape and the evolution of the human capital distribution among municipalities are quite similar to the shape and the evolution of the per capita income distribution. This finding confirms the one from Gondim et al. (2004), using another methodology.

What is not a consensus is what process does a twin-peaked distribution represent, since it can reflect both differences in preferences and technology (conditional convergence) or in initial conditions (club convergence). While Andrade et al (2002), comparing the results of a growth equation using OLS and quantile regression, came to the conclusion that initial conditions did not matter, in the case of the Brazilian municipalities, Laurini et al (2003) found that at intermediate levels of income there was no beta convergence, an evidence that favours the club convergence hypothesis. Coelho (2007) also favours the club convergence hypothesis, since he has found that different groups of municipalities were reacting differently to the initial level of income.

This paper wishes to contribute to this attempt to identify if differences in initial conditions matter for the inequality of per capita income. Similarly to Andrade et al.(2002), we will use quantile regression to estimate a growth equation. Differently to them, we introduce not only the initial level of per capita income as the independent variable, due to the evidence that other variables, especially human capital, also matter in the Brazilian case. Resende & Figueirêdo (2007) studied this issue for the whole sample of the Brazilian municipalities.

Similarly to the empirical literature on convergence (Sala-i-Martin, 1996), we found it interesting to select some geographical area that shares relevant characteristics, to avoid biases in our estimations due to omission of variables, which is one of the reasons why we will study the case of Minas Gerais. Another reason that justifies this sample selection is the finding of Coelho (2007) that some municipalities of Minas Gerais are trapped in lower levels of income.

## 2.2. Economic growth in the municipalities of Minas Gerais

We should not expect that differences in per capita income among the sub-units of a state would be mainly related to technology or physical capital accumulation, due to technological spillovers and to capital migration. It has been also difficult to discuss this issue, since data for physical capital was only recent available.

What we know for the sub-units of Minas Gerais is that human capital is an important determinant of their per capita income (Fontes et al., 2005, for the micro-regions in the period 1980-1996, Figueirêdo et al., 2006, for the micro-regions in the period 1970-2000; Silva & Resende, 2007; and Resende, 2005, for the municipalities in the nineties)[2]. All these studies found a negative and significant coefficient for the initial level of per capita income, what does not deny the hypothesis of beta convergence. We also have evidence that spatial externalities play an important role in the region, as discussed in Silva & Resende (2007), and particularly, in Resende (2005), who also shows that there are spatial correlations among several variables: per capita income (positive), mortality rates (negative), years of education (negative), population density (negative), and social infra-structure (positive).

These findings suggest that different areas of the state of Minas Gerais do not have a different production function from the rest of Brazil, since these results are in accordance with the overall results for the states, micro-regions and for the municipalities of Brazil.

As it is well known (Sala-i-Martin,1996), the above results do not imply that there will be a decrease in the dispersion of per capita income (in other words, beta convergence is a necessary condition but not a sufficient one for the existence of sigma convergence), what seems to be the case of the sub-units of Minas Gerais: Figueirêdo et al. (2006) observed that the dispersion of relative per capita income was quite stable (the standard deviation was around 0,3 in all censuses years).

The shape of the relative per capita income distribution of the micro-regions of Minas Gerais has also been investigated: the distribution has been shifting to the right, which is consistent with the process of economic growth, and the regions were clustering around the mean (which was of 0.8 of Minas Gerais' per capita income) (Figueirêdo et al., 2006). The transition probability matrix (estimated using kernel) showed the existence of three peaks in 2000, while its ergodic estimation showed a two-peaked distribution. The ergodic distribution is consistent with a high standard deviation, since almost 77% of the micro-regions were located in a wide interval that goes from half to 1.56 % of the average income of Minas

[2] Silva & Resende (2007) show the importance of inequality, schooling and social infra-structure (electrical energy) for the determination of the per capita income growth. Resende (2005) shows evidence that population growth, schooling and the fertility rate also impact on per capita income growth.

Gerais. The results using non-parametric techniques confirm the ones from Salvato et al. (2006) and from Fontes et al. (2005) that found two peaks in the ergodic distribution.

Once more we have the same doubt: is the twin-peaked distribution due to differences in taste and technology or are they due to differences in initial conditions? That is exactly the topic for which we would like to contribute: we would like to use quantile regression to observe if the fast-growing municipalities in Minas Gerais react differently to the slow-growing ones with respect to the initial level of income and to other variables.

## 3. A quantile regression approach

In this section we discuss some procedures and properties of quantile regression that we will apply next to study economic growth of Brazilian municipalities. First of all, it is important to note what Mosteller and Tukey (1977, p.266) point out about linear regression model in their seminal book:

> *What the regression curve does is give a grand summary for the averages of the distributions corresponding to the set of x's. We could go further and compute several different regression curves corresponding to the various percentages points of the distributions and thus get a more complete picture of the set. Ordinarily this is not done, and so regression often gives a rather incomplete picture. Just as the mean gives an incomplete picture of a single distribution, so the regression curve gives a correspondingly incomplete picture for a set of distribution.*

Koenker (2005) argues that the quantile regression approach "go further" and intends to offer a comprehensive strategy for completing the regression picture. So, next we discuss the problems with OLS regressions and quantile regression methodology introduced by Koenker & Basset (1978), which is one possible solution to the problems with OLS approach.

There are at least three problems when OLS regressions are used to study economic growth: parameter homogeneity assumption, "Galton's Fallacy", and existence of outliers (and heterocedasticity). The first assumption that Temple (1999) questions is parameter homogeneity, which implies that the marginal effect of a change in any of the independent variables will be the same for all countries (or regions). There is nothing on the theory of growth saying that the effect of an increase in human capital, for example, should be the same across countries or regions. In fact, we expect it to depend on the specifics of each economy such as its level of development or its growth rate (Mello & Perreli, 2003). The quantile regression estimator gives, potentially, one solution to each quantile. So, this methodology is an interesting way of capturing regions' heterogeneity.

Second, OLS growth regressions ignore the problem known in the literature as "Galton's Fallacy". A negative coefficient in the traditional OLS regression may not indicate that economies are converging to the same long-run steady-state, but it can only signal regression to the mean. Friedman (1992) and Quah (1993) point out that sub-sample of countries or regions has a different mean growth rate and average initial income, which ultimately determines whether the economy is converging or not. So, the analysis of convergence based on a regression of growth rates on levels depends explicitly on the sample selection. However, using quantile regression it is possible to obtain different coefficient estimates for each chosen quantile, as well as allows the estimates to indicate convergence or not for each quantile.

Third, the existence of outliers is one of the problems in estimating and interpreting classical growth regressions that have been well documented [see Temple (1999)]. Outliers can bias the coefficient estimated from the OLS regression. Quantile regression is robust to outliers with the added benefit that it allows us to better understand the behavior of the unusual observations.

Thus, we can see the problems with the OLS estimation and the advantages of using the quantile regression approach to study economic growth. In the rest of this section we discuss the quantile regression estimation procedure[3].

Quantile regression is a method for estimating functional relations between variables for all portions of a probability distribution. Koenker & Hallock (2001, p.145) observe that we can define the quantiles through a simple alternative expedient as an optimization problem:

> *Just as we can define the sample mean as the solution to the problem of minimizing a sum of squared residuals, we can define the median as the solution to the problem of minimizing a sum of absolute residuals. The symmetry of the piecewise linear absolute value function implies that the minimization of the sum of absolute residuals must equate the number of positive and negative residuals, thus assuring that there are the same number of observations above and below the median.*

Since the symmetry of the absolute value yields the median, minimizing a sum of asymmetrically weighted absolute residuals yields the quantiles. Solving

$$\min_{\xi \in \Re} \sum \rho_\tau (y_i - \xi), \qquad (1a)$$

where the function $\rho_\tau(\cdot)$ is the tilted absolute value function that yields the $\tau$ th sample quantile as its solution.

After we define the unconditional quantiles as an optimization problem, it is easy to define conditional quantiles in an analogous way. Least squares regression offers a model for how to proceed. Koenker & Hallock (2001) show in their paper that if we solve $\min_{\xi \in \Re} \sum_{i=1}^{n} (y_i - \mu)^2$ we obtain the sample mean, which is an estimate of the unconditional population mean, EY. If we now replace the scalar $\mu$ by a parametric function $\mu(x, \beta)$ and solve $\min_{\xi \in \Re p} \sum_{i=1}^{n} (y_i - \mu(x_i, \beta))^2$, we obtain an estimate of the conditional expectation function E(Y|$x$).

We proceed in the same way in the case of quantile regression. To obtain an estimate of the conditional median function, we replace the scalar $\xi$ in the Equation (1a) by the parametric function $\xi(x_i, \beta)$ and set $\tau$ to $1/2$. The estimates of the other conditional quantile functions are obtained replacing absolute values by $\rho_\tau(\cdot)$ and solving:

$$\min_{\xi \in \Re p} \sum_{i=1}^{n} \rho_\tau (y_i - \xi(x_i, \beta)), \qquad (1b)$$

[3] See Koenker & Bassett (1978) for the seminal article, and Koenker & Hallock (2001) and Koenker (2005) for recent surveys on quantile regression.

The resulting minimization problem, when $\xi(x,\beta)$ is formulated as a linear function of parameters, can be solved very efficiently by linear programming methods[4]. Next we discuss the dataset that we employ in our empirical analysis.

## 4. Data

In this paper, we examined patterns of economic growth of municipalities of Minas Gerais between 1980 and 2000 and sub periods (1980-1991 and 1991-2000). It was necessary to make some adjustments in the data because the number of municipalities increased from 722 municipalities in 1980 to 853 municipalities in 2000. To address this problem, we merged municipalities into 720 Minimum Comparable Areas (MCAs) – consisting of sets of municipalities whose borders were constant over 1980 to 2000. All data have then been aggregated to match these MCAs.

The data used in this paper comes from the Brazilian Population Censuses of 1980, 1991 and 2000. We used censuses information for household per capita income, urbanization rate, education (years of schooling), percentage of houses with piped water provision, and health (infant mortality rate). Per capita (household) income information are monthly data, deflated to 2000 Real (R$).

## 5. Empirical Model

We wish to construct an empirical model in order to help us to interpret our results. Our model is based in Mankiw, Romer & Weil (1992), Jones (1999), and also sharing features with McDonald & Roberts (2002).

Let us assume the augmented neoclassical production function, as proposed by Mankiw, Romer & Weil (1992), which includes human capital as one of the economy's input. Instead of only consider the education aspect of human capital (S), let us also consider its health aspect (H), as in McDonald & Roberts (2002).

$$Y_{it} = K_{it}^{\alpha}(A_{it}H_{it})^{\beta}(AS_{it})^{1-\alpha-\beta} \quad (1)$$

Production (Y) is a function of capital (K), technology (A), health (H) and education (S). The index (i) stands for region and (t) for time.

$$H_{it} = \varepsilon^{\delta m_i} L_{it} \quad (2)$$

$$h_i = \varepsilon^{\delta m_i} \quad (3)$$

$$S_{it} = \varepsilon^{\phi u_i} L_{it} \quad (4)$$

$$s_i = \varepsilon^{\phi u_i} \quad (5)$$

Equations (2)-(5) follow the simple specification proposed by Jones (1999), where the accumulation of human capital follows the rate of population (L) growth (n).

The population level, on the other hand, will be higher if people have better health (higher $m_i$) and a higher education, higher $u_{i..}$

[4] In this paper, we use Stata software. Buchinsky (1998) presents and discusses several alternative estimators for the covariance matrix of the quantile regression estimates. Our estimates are via *bootstrap*.

Expressing (1) efficient units of labour - the hat variables, (dividing (1) by AL):

$$\hat{y}_{it} = \hat{k}_{it}^{\alpha} h_i^{\beta} s_i^{1-\alpha-\beta} \qquad (6)$$

Following the usual Solow hypothesis – constant saving rate (sr), constant effective depreciation rate (n+g+δ)),

$$\hat{k}_i^* = \left( \frac{sr_i h_i^{\beta} s_i^{1-\alpha-\beta}}{n_i + g + \delta} \right)^{\frac{1}{1-\alpha}} \text{ (7a) and } \hat{y}_i^* = \left( \frac{sr_i h_i^{\beta} s_i^{1-\alpha-\beta}}{n_i + g + \delta} \right)^{\frac{\alpha}{1-\alpha}} \quad \text{(7b)}$$

The equilibrium per capita income will be:

$$y_{it}^* = A_{it} \left( \frac{sr_i h_i^{\beta} s_i^{1-\alpha-\beta}}{n_i + g + \delta} \right)^{\frac{\alpha}{1-\alpha}} h_i^{\beta} s_i^{1-\alpha-\beta}$$

$$y_{it}^* = A_{it} \left( \frac{sr_i}{n_i + g + \delta} \right)^{\frac{\alpha}{1-\alpha}} h_i^{\frac{\beta}{1-\alpha}} s_i^{\frac{1-\alpha-\beta}{1-\alpha}} \qquad (8)$$

Taking logs:

$$\ln y_{it}^* = \ln A_{it} + \frac{\alpha}{1-\alpha} \ln sr_i - \frac{\alpha}{1-\alpha} \ln(n_i + g + \delta) + \frac{\beta}{1-\alpha} \ln h_i + \frac{1-\alpha-\beta}{1-\alpha} \ln s_i \qquad (9)$$

Let us assume that technology has three determinants: external economies of scale due to the original level of urbanization (urb) and due to the regions' social infra-structure (social) determine the region initial technological level; a common constant and exogenous growth rate explains its growth (g), while it is also subject to a stochastic error.

$$\ln A_{it} = \ln A_{i0} + gt + \mu_{it} \qquad (10)$$

$$\ln A_{i0} = \kappa_1 urb_{i0} + \kappa_2 social_{i0}$$

From (9) and (10) we have our empirical model (11a):

$$\ln y_{it}^* = \kappa_1 urb_{i0} + \kappa_2 social_{i0} + gt + \frac{\alpha}{1-\alpha} \ln sr_{it} - \frac{\alpha}{1-\alpha} \ln(n_i + g + \delta)_t + \frac{\beta}{1-\alpha} \ln h_{it} + \frac{1-\alpha-\beta}{1-\alpha} \ln s_{it} + \mu_{it}$$

or, using (3) and (5):

$$\ln y_{it}^* = \kappa_1 urb_{i0} + \kappa_2 social_{i0} + gt + \frac{\alpha}{1-\alpha} \ln sr_{it} - \frac{\alpha}{1-\alpha} \ln(n_i + g + \delta)_t + \frac{\beta}{1-\alpha} \delta m_{it} + \frac{1-\alpha-\beta}{1-\alpha} \phi u_{it} + \mu_{it}$$

(11b)

But we should consider Durlauf & Johnson (1995) warning that, accordingly to their level of development, regions could have different responses to the economic impulses. It is possible that regions that did not reach some threshold levels of the human capital variables – h and s, could have different income elasticities with respect to these variables.

Log-linearizing the above equation around the steady state value:

$$\gamma_{\hat{k}} \cong (\alpha - 1)(\delta + g + n) \left[ \log \hat{k} - \log \hat{k}^* \right] \qquad (12),$$

where the right-hand side variable is the growth rate of capital per efficient units, which will be, in a Cobb-Douglas specification, the growth rate of income per efficient units.

Following Durlauf et al. (2004) in developing the expression for per capita income growth rate, this can be expressed by

$$\log y(t) - \ln y(0) = (1-\varepsilon^{-\lambda t})\kappa_1 urb_{i0} + (1-\varepsilon^{-\lambda t})\kappa_2 social_{i0} + (1-\varepsilon^{-\lambda t})gt + (1-\varepsilon^{-\lambda t})\frac{\alpha}{1-\alpha}\ln sr_{it}$$
$$-(1-\varepsilon^{-\lambda t})\frac{\alpha}{1-\alpha}\ln(ni+g+\delta)_t + (1-\varepsilon^{-\lambda t})\frac{\beta}{1-\alpha}\delta m_{it} + (1-\varepsilon^{-\lambda t})\frac{1-\alpha-\beta}{1-\alpha}\phi u_{it} + \mu_{it} \qquad (13),$$

where λ=(α-1)(δ+g+n).

Our null hypothesis will be that there is club convergence, in which case a region dynamics is influenced by its initial conditions and/or is subject to different regimes (Durlauf & Johnson, 2005 and Johnson & Takeyama, 2001).

If our null hypothesis is correct, we should expect that regions with the same fundamentals – technology, sr, n, g, δ, m and u, could have different per capita income growth rates, what can happen if they respond differently to these variables, in which case the estimated coefficients of equation (13) will differ among regions.

We will consider that the alternative hypothesis of conditional convergence is the correct one if the coefficients are different from zero, but not different among regions. "Regions", in our case, will be municipalities. We will use dummy variable to proxy for regional differences in the saving behaviour and in the depreciation rate.

## 6. Results

First in this section, we present some statistics concerning the per capita income growth from 1980 to 2000. After we show the results of quantile regression for municipalities of Minas Gerais and we compare the quantile and OLS estimations.

### 6.1. Basic statistics

Our main objective in this paper is to understand the main determinants of economic growth in Minas Gerais state. It is useful to know how income growth was distributed across space between 1980 and 2000. In 2000, Minas Gerais state was composed of 853 municipalities grouped in 10 macro-regions for regional policy implementation and planning[5].

Table 1 highlights the distribution of the per capita income growth among the ten macro-regions of Minas Gerais state. We can observe that income per capita in the Noroeste de Minas region grew 3.81% per year during 1980 and 2000. It is the highest rate of economic growth between 1980 and 2000 and subperiods (1980-1991 and 1991-2000) among Minas Gerais regions. On the other hand, Triângulo Mineiro region showed the lowest rate of economic growth between 1980-2000 and 1980-1991, respectively, 1.85% and 0.77% per year. Concerning the 1991-2000 period, Norte de Minas region showed the lowest rate of per capita income growth (2.56% per year).

[5] The macro-regional division was defined by the government of Minas Gerais that establishes the 10 following regions: Alto Paranaíba, Central, Centro-Oeste de Minas, Jequitinhonha/Mucuri, Zona da Mata, Noroeste de Minas, Norte de Minas, Rio Doce, Sul de Minas e Triângulo.

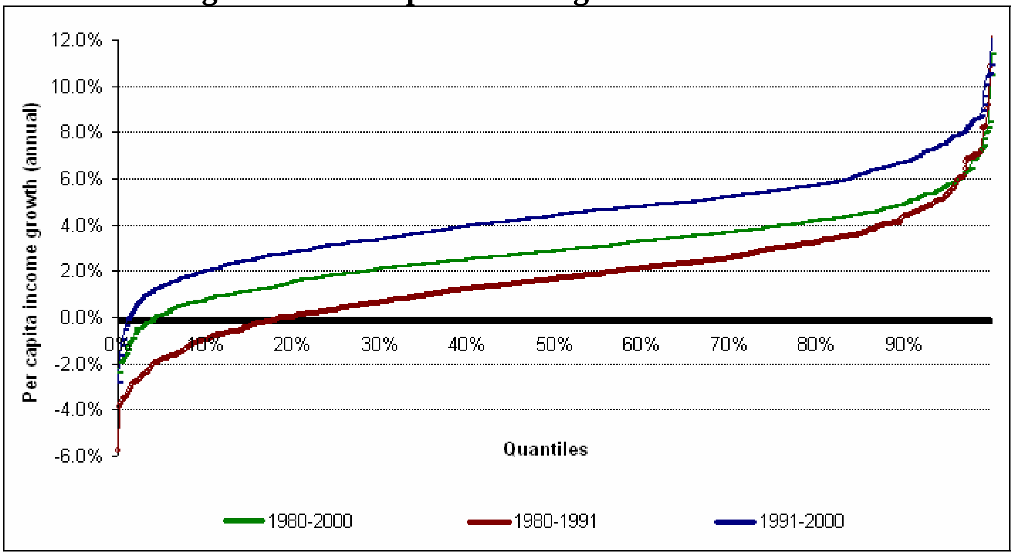
**Table 1 – Per capita income growth (annual)**

| Macro-regions | Obs | 1980-2000 | 1980-1991 | 1991-2000 |
|---|---|---|---|---|
| Alto Paranaíba | 31 | 2.41% | 0.92% | 4.24% |
| Central | 149 | 2.39% | 1.52% | 3.47% |
| Centro-Oeste de Minas | 55 | 2.90% | 1.12% | 5.07% |
| Jequitinhonha/Mucuri | 49 | 2.39% | 1.48% | 3.50% |
| Noroeste de Minas | 12 | 3.81% | 2.50% | 5.41% |
| Norte de Minas | 42 | 2.28% | 2.04% | 2.56% |
| Rio Doce | 75 | 2.94% | 1.81% | 4.33% |
| Sul de Minas | 151 | 2.65% | 1.24% | 4.36% |
| Triângulo Mineiro | 30 | 1.85% | 0.77% | 3.17% |
| Zona da Mata | 126 | 2.97% | 1.70% | 4.53% |
| **Minas Gerais** | **720** | **2.55%** | **1.49%** | **3.83%** |

Source: Own elaboration from data of Demographic Censuses 1980, 1991 and 2000 – IBGE.

The quantile regression approach gives, potentially, one solution to each quantile. So, it is useful to observe the distribution of per capita income growth across quantiles. Figure 1 shows the rate of economic growth of each municipality in ascending order for the three periods of study (1980-2000, 1980-1991 and 1991-2000). This figure confirms what Table 1 shows: per capita income growth for the period 1991-2000 is higher than for the period 1980-1991, for all municipalities of Minas Gerais. The quantile regression results in the next section will show the determinants of economic growth for each quantile described here. Finally, in the appendix we have the statistics for all exploratory variables for Minas Gerais macro-regions.

**Figure 1 – Per capita income growth distribution**




Source: Own elaboration from data of Demographic Censuses 1980, 1991 and 2000 – IBGE.

### 6.2. Quantile regressions for the state of Minas Gerias

The OLS and quantile results for the test of absolute convergence among municipalities of Minas Gerais are displayed in Table 2. The coefficients of OLS for (ln of) per capita income are always significant and negative for all the periods analyzed.

**Table 2 – Unconditional Convergence – OLS and Quantile Regressions**

Dependent variable: average growth rate in real (household) income per capita

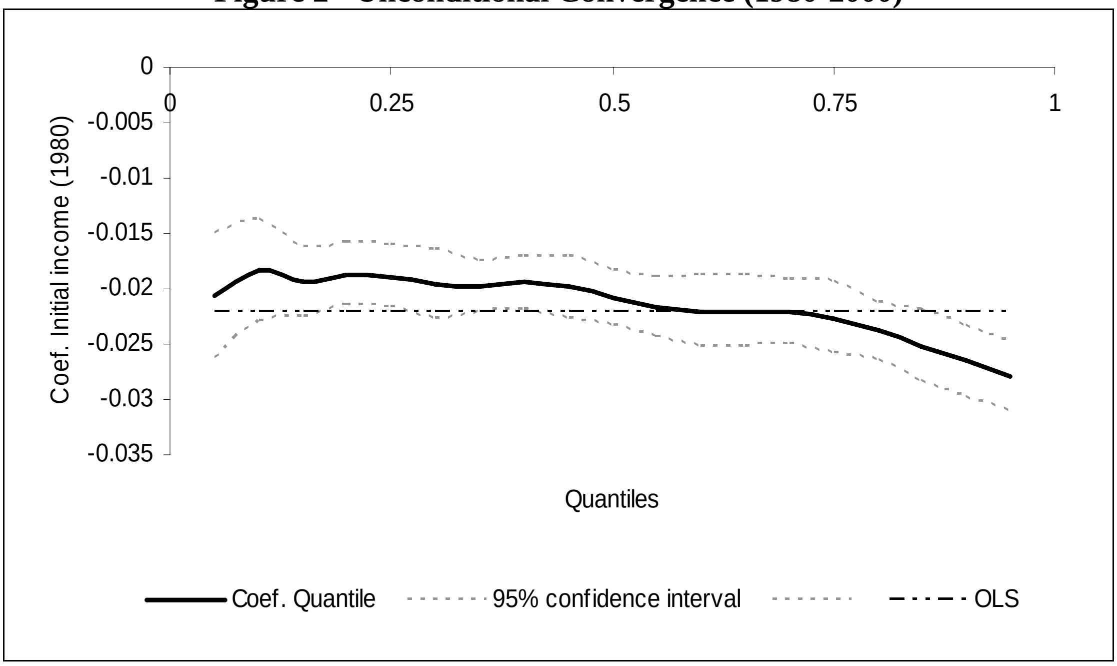
| Variable | tau | Eq. 1:1980-2000 Coefficient | Std. Err. | Eq. 2:1980-1991 Coefficient | Std. Err. | Eq. 3: 1991-2000 Coefficient | Std. Err. |
|---|---|---|---|---|---|---|---|
| constant | 0.25 | 0.1071 | 0.0064 | 0.1337 | 0.0063 | 0.0639 | 0.0135 |
| | 0.50 | 0.1257 | 0.0062 | 0.1342 | 0.0090 | 0.0965 | 0.0107 |
| | 0.75 | 0.1413 | 0.0076 | 0.1572 | 0.0087 | 0.1327 | 0.0137 |
| | OLS | 0.1304 | 0.0044 | 0.1508 | 0.0055 | 0.0986 | 0.0085 |
| Initial income per capita | 0.25 | -0.0189 | 0.0013 | -0.0279 | 0.0014 | -0.0066 | 0.0027 |
| | 0.50 | -0.0208 | 0.0013 | -0.0256 | 0.0020 | -0.0109 | 0.0023 |
| | 0.75 | -0.0226 | 0.0016 | -0.0282 | 0.0018 | -0.0163 | 0.0027 |
| | OLS | -0.0221 | 0.0010 | -0.0292 | 0.0012 | -0.0115 | 0.0018 |

Own elaboration. Note: The table reports estimates of the slope coefficient of the following equation $(1/T)*\ln(y_{T,i}/y_{0,i}) = \alpha + \beta \ln(y_0) + \varepsilon_i$, where $y_{T,i}$ and $y_{0,i}$ are, respectively, the final period and the initial period household income per capita, $T$ is the time period in years, and $\varepsilon_i$ error term. All coefficients are significant at 5% level.

Table 2 shows up that all the coefficients of the initial per capita income variables are negative and significant, for all quantiles, reflecting the faster growth of the poorest municipalities of Minas Gerais state within any percentile. On the other hand, the magnitudes are different across percentiles, showing faster convergence for the fast-growing ones. In other words, inside each range of the distribution, the poorer the municipality, the faster its growth in the direction of the percentile's mean. This evidence shows that results could vary according to the quantiles. However, this pattern can be observed only for the 1991-2000 period. In the other two periods (1980-2000 and 1980-1991) we reject the hypothesis that quantile coefficients are different from the OLS coefficients. Figures 2-4 highlights these results.

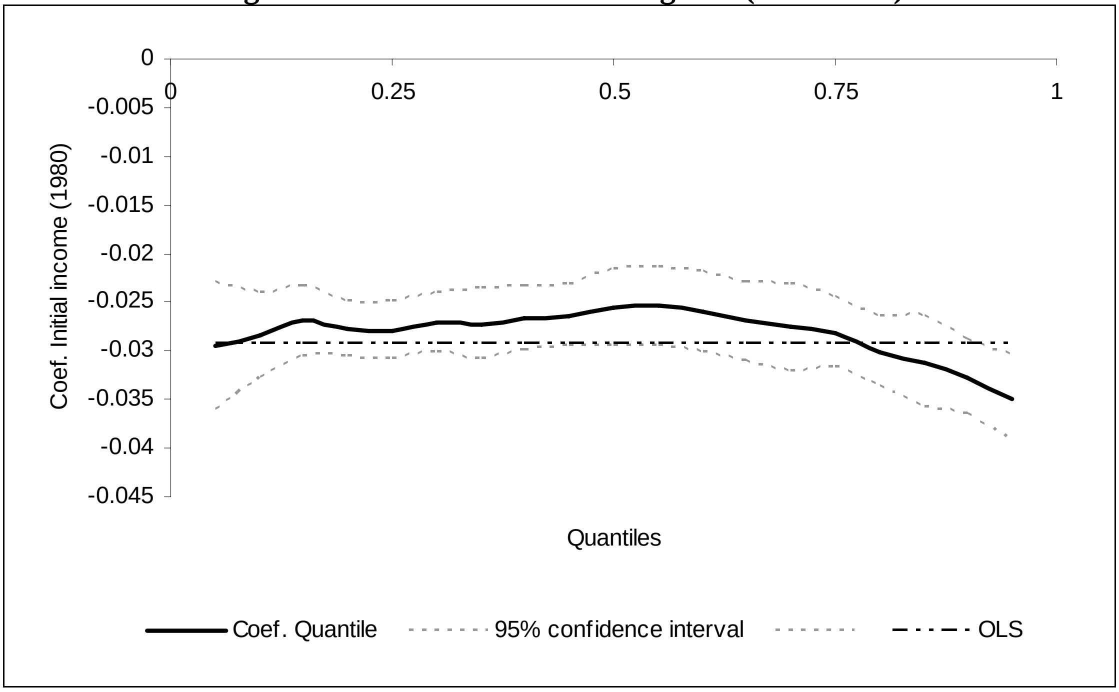
Figures 2, 3 and 4 display the regression quantile processes for the unconditional growth equation for 1980-2000, 1980-1991 and 1991-2000, respectively. Each figure exhibits the entire quantile regression process on the initial income variable, the 95% confidence interval for the quantile regression estimate, and the OLS estimate on the initial income (dashed line).

**Figure 2 - Unconditional Convergence (1980-2000)**



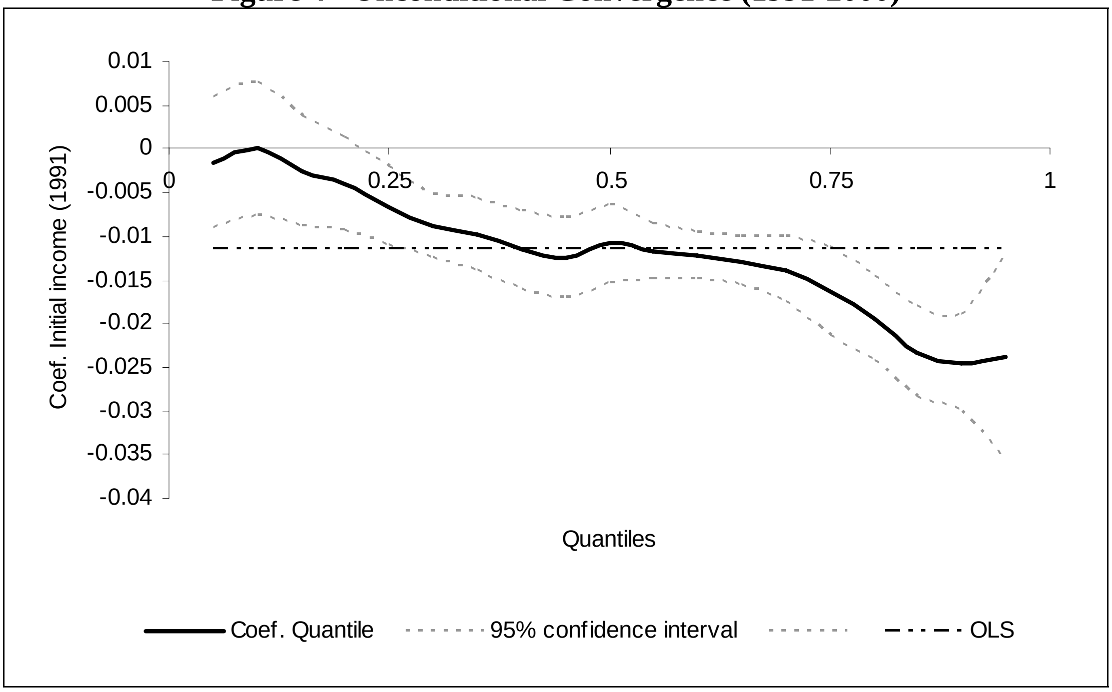

Own elaboration.

**Figure 3 - Unconditional Convergence (1980-1991)**




Own elaboration.

**Figure 4 - Unconditional Convergence (1991-2000)**




Note: Quantiles between 0.05 and 0.20 are not significant.

Table 3 shows the OLS and quantile results for the conditional convergence test for the periods 1980-2000, 1980-1991 and 1991-2000. Conditional convergence cannot be denied (using OLS), since the per capita income variables always show negative and significant coefficients (-0.04, for 1980-2000, -0.05, for 1980-1991 and -0.06, for the period 1991-2000), with higher absolute values than in the unconditional convergence case, as it is usual to find in the literature. Controlling for other independent variables, the highest speed of convergence is found in the 90's decade, differently to the results in Table 2.

The OLS coefficients of the other independent variables were significant for almost all periods. Higher urbanization rates are related to higher growth rates, except in the period 1991-2000, where the coefficient is not significant. Higher human capital – higher average years of schooling and lower infant mortality rates - is good for growth, while a better social infra-structure, proxied by access to piped water, also fosters economic growth. The OLS coefficient of schooling for all periods is statistically significant while the infant mortality one is significant for the periods 1980-1991 and 1991-2000 and the piped water one is significant for the period 1991-2000. Concerning the regional dummies, only the Noroeste de Minas one is not significant for all periods. It means that regional fixed effect for this region is not statically different of the Alto Paranaíba region (the excluded regional dummy).

Table 3 also shows the results for the quantile regressions for the conditional case. Similar to the unconditional case, the coefficients of the initial per capita income are quite stable among quantiles. The coefficients of the other independent variables are also stable among quantiles. Figures 5-7 show the quantile coefficients, the standard deviations and the OLS results, from which we can observe that the quantile coefficients are not significantly different from the OLS results.

Mello & Perrelli (2003) using a sample of countries found that fast-growing countries would converge quicker to their steady state value, when testing for unconditional convergence. When controlling for other determinants, the coefficients were much more similar to the OLS ones resembling our findings in this case.

## Table 3 – Conditional Convergence – OLS and Quantile Regressions

Dependent variable: average growth rate in real (household) income per capita

| | | Eq. 1:1980-2000 | | Eq. 2:1980-1991 | | Eq. 3: 1991-2000 | |
|---|---|---|---|---|---|---|---|
| Variable | $\tau$ | Coefficient | Std. Err. | Coefficient | Std. Err. | Coefficient | Std. Err. |
| constant | 0.25 | **0.18770** | **0.00620** | **0.21984** | **0.00571** | **0.28977** | **0.02031** |
| | 0.50 | **0.20049** | **0.00657** | **0.22291** | **0.00752** | **0.28181** | **0.02292** |
| | 0.75 | **0.20339** | **0.00730** | **0.22976** | **0.00887** | **0.31083** | **0.02308** |
| | OLS | **0.19930** | **0.00423** | **0.23190** | **0.00509** | **0.29899** | **0.01431** |
| Initial income per capita | 0.25 | **-0.04006** | **0.00104** | **-0.05232** | **0.00121** | **-0.06198** | **0.00479** |
| | 0.50 | **-0.04108** | **0.00136** | **-0.05169** | **0.00153** | **-0.05649** | **0.00516** |
| | 0.75 | **-0.04012** | **0.00149** | **-0.05153** | **0.00155** | **-0.05992** | **0.00505** |
| | OLS | **-0.04045** | **0.00078** | **-0.05261** | **0.00094** | **-0.06152** | **0.00333** |
| Mortality rate | 0.25 | -0.00002 | 0.00005 | -0.00006 | 0.00004 | **-0.00028** | **0.00009** |
| | 0.50 | -0.00003 | 0.00004 | -0.00007 | 0.00005 | **-0.00020** | **0.00009** |
| | 0.75 | -0.00003 | 0.00004 | -0.00004 | 0.00006 | -0.00023 | 0.00012 |
| | OLS | -0.00004 | 0.00003 | **-0.00007** | **0.00004** | **-0.00019** | **0.00007** |
| Years of schooling | 0.25 | **0.01000** | **0.00114** | **0.01370** | **0.00097** | **0.01289** | **0.00167** |
| | 0.50 | **0.00947** | **0.00096** | **0.01344** | **0.00150** | **0.01159** | **0.00183** |
| | 0.75 | **0.00824** | **0.00109** | **0.01332** | **0.00125** | **0.01204** | **0.00209** |
| | OLS | **0.00943** | **0.00076** | **0.01262** | **0.00091** | **0.01208** | **0.00137** |
| Piped water | 0.25 | 0.00503 | 0.00336 | 0.00461 | 0.00436 | 0.00027 | 0.00008 |
| | 0.50 | 0.00453 | 0.00379 | 0.00209 | 0.00670 | 0.00019 | 0.00009 |
| | 0.75 | -0.00132 | 0.00435 | 0.00259 | 0.00406 | **0.00019** | **0.00011** |
| | OLS | 0.00343 | 0.00300 | 0.00626 | 0.00362 | **0.00026** | **0.00006** |
| Urbanization rate | 0.25 | **0.00009** | **0.00003** | **0.00021** | **0.00004** | -0.00001 | 0.00006 |
| | 0.50 | **0.00007** | **0.00004** | **0.00020** | **0.00005** | -0.00007 | 0.00007 |
| | 0.75 | **0.00009** | **0.00004** | **0.00016** | **0.00004** | -0.00013 | 0.00007 |
| | OLS | **0.00008** | **0.00003** | **0.00019** | **0.00003** | -0.00005 | 0.00004 |
| Dummy Central | 0.25 | **-0.01245** | **0.00191** | **-0.01217** | **0.00173** | **-0.01935** | **0.00439** |
| | 0.50 | **-0.01335** | **0.00218** | **-0.01106** | **0.00231** | **-0.01585** | **0.00334** |
| | 0.75 | **-0.01127** | **0.00256** | **-0.01231** | **0.00439** | **-0.01710** | **0.00394** |
| | OLS | **-0.01374** | **0.00166** | **-0.01358** | **0.00200** | **-0.01828** | **0.00305** |
| Dummy Centro-Oeste de Minas | 0.25 | -0.00375 | 0.00176 | **-0.00903** | **0.00170** | -0.00146 | 0.00468 |
| | 0.50 | -0.00279 | 0.00193 | **-0.00724** | **0.00250** | 0.00066 | 0.00322 |
| | 0.75 | -0.00145 | 0.00280 | **-0.00865** | **0.00447** | 0.00098 | 0.00472 |
| | OLS | -0.00327 | 0.00175 | **-0.00935** | **0.00211** | -0.00059 | 0.00327 |
| Dummy Jequitinhonha/ Mucuri | 0.25 | **-0.01537** | **0.00294** | **-0.01400** | **0.00308** | **-0.00146** | **0.00468** |
| | 0.50 | **-0.01742** | **0.00278** | **-0.00886** | **0.00317** | **0.00066** | **0.00322** |
| | 0.75 | **-0.01713** | **0.00328** | **-0.01320** | **0.00500** | **0.00098** | **0.00472** |
| | OLS | **-0.01796** | **0.00217** | **-0.01418** | **0.00261** | **-0.02169** | **0.00390** |
| Dummy Noroeste de Minas | 0.25 | 0.00498 | 0.00323 | 0.00646 | 0.00516 | 0.00032 | 0.00565 |
| | 0.50 | 0.00190 | 0.00333 | 0.00614 | 0.00384 | 0.00088 | 0.00689 |
| | 0.75 | -0.00041 | 0.00662 | 0.00132 | 0.00847 | 0.00000 | 0.01858 |
| | OLS | 0.00235 | 0.00266 | 0.00498 | 0.00320 | 0.00345 | 0.00492 |
| Dummy Norte de Minas | 0.25 | **-0.02021** | **0.00253** | **-0.01196** | **0.00308** | **-0.03171** | **0.00565** |
| | 0.50 | **-0.02114** | **0.00269** | **-0.00917** | **0.00316** | **-0.03364** | **0.00461** |
| | 0.75 | **-0.02100** | **0.00293** | -0.00943 | 0.00510 | **-0.03696** | **0.00563** |
| | OLS | **-0.02259** | **0.00204** | **-0.01196** | **0.00246** | **-0.03518** | **0.00389** |
| Dummy Rio Doce | 0.25 | **-0.01104** | **0.00259** | **-0.01227** | **0.00240** | **-0.01044** | **0.00467** |
| | 0.50 | **-0.01130** | **0.00239** | **-0.00904** | **0.00271** | **-0.01424** | **0.00374** |
| | 0.75 | **-0.01064** | **0.00274** | **-0.01170** | **0.00461** | **-0.01332** | **0.00478** |
| | OLS | **-0.01228** | **0.00190** | **-0.01353** | **0.00229** | **-0.01399** | **0.00338** |
| Dummy Sul de Minas | 0.25 | -0.00215 | 0.00181 | **-0.00471** | **0.00156** | -0.00502 | 0.00400 |
| | 0.50 | -0.00152 | 0.00184 | -0.00126 | 0.00237 | -0.00296 | 0.00267 |
| | 0.75 | 0.00004 | 0.00253 | -0.00199 | 0.00455 | -0.00322 | 0.00377 |
| | OLS | -0.00242 | 0.00158 | **-0.00372** | **0.00190** | -0.00426 | 0.00292 |
| Dummy Triângulo Mineiro | 0.25 | 0.00000 | 0.00243 | 0.00487 | 0.00353 | -0.00506 | 0.00581 |
| | 0.50 | 0.00244 | 0.00256 | **0.00672** | **0.00284** | -0.00072 | 0.00306 |
| | 0.75 | 0.00314 | 0.00305 | 0.00990 | 0.00551 | -0.00498 | 0.00404 |
| | OLS | 0.00067 | 0.00197 | **0.00664** | **0.00237** | -0.00320 | 0.00365 |
| Dummy Zona da Mata | 0.25 | **-0.00747** | **0.00194** | **-0.01193** | **0.00166** | **-0.01066** | **0.00448** |
| | 0.50 | **-0.00800** | **0.00186** | **-0.01081** | **0.00229** | **-0.00949** | **0.00369** |
| | 0.75 | **-0.00642** | **0.00234** | **-0.01257** | **0.00427** | **-0.01054** | **0.00423** |
| | OLS | **-0.00906** | **0.00167** | **-0.01323** | **0.00202** | **-0.01077** | **0.00317** |

Own elaboration. Note: Coefficients in bold are significant at 5% level.

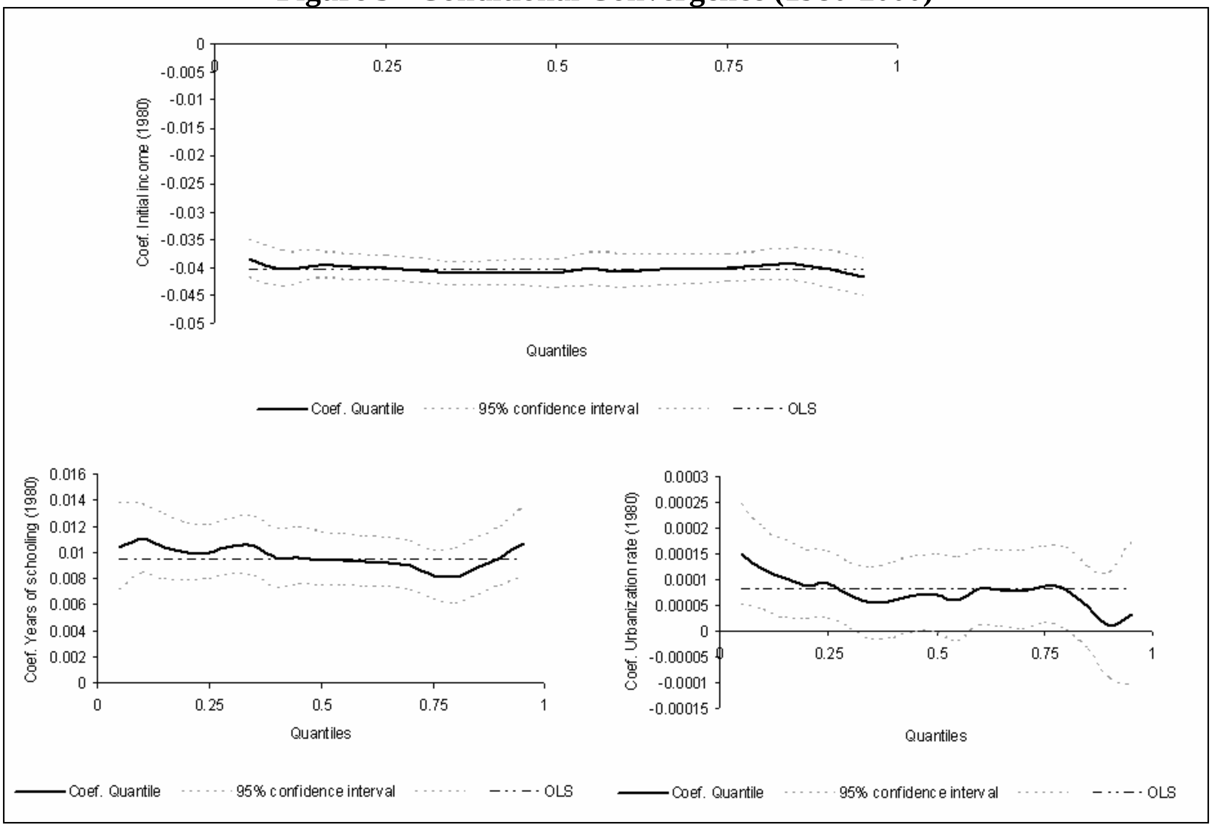
The results in Table 3 for the period 1991-2000 confirm the findings of Resende (1995) and Silva & Resende (2007) that shows up the importance of schooling and social infra-structure on the economic growth process in Minas Gerais. Our results also imply, similarly to the Brazilian literature, that several determinants are playing a role in the determination of per capita income growth between 1980-2000, such as human capital and urbanization rate, since the results of the conditional case (OLS and quantile) are better than the unconditional case ones.

Also Table 3 shows the results for the dummies variables. First, it is important to note that the quantile coefficients for the regional dummies are not statistically different from the OLS ones. This fact means that there are not different dynamics for per capita income among the municipalities within a specific macro-region.

Dummies coefficients (OLS and quantile ones) for all regions (except the Noroeste de Minas region) are negative and significant (for at list one period), implying a worse behavior of all regions with respect to Alto Paranaíba region (the excluded dummy). It is useful to note that for five regions the dummy coefficient is negative and significant for all periods: Central, Jequitinhonha/Mucuri, Norte de Minas, Rio Doce and Zona da Mata.

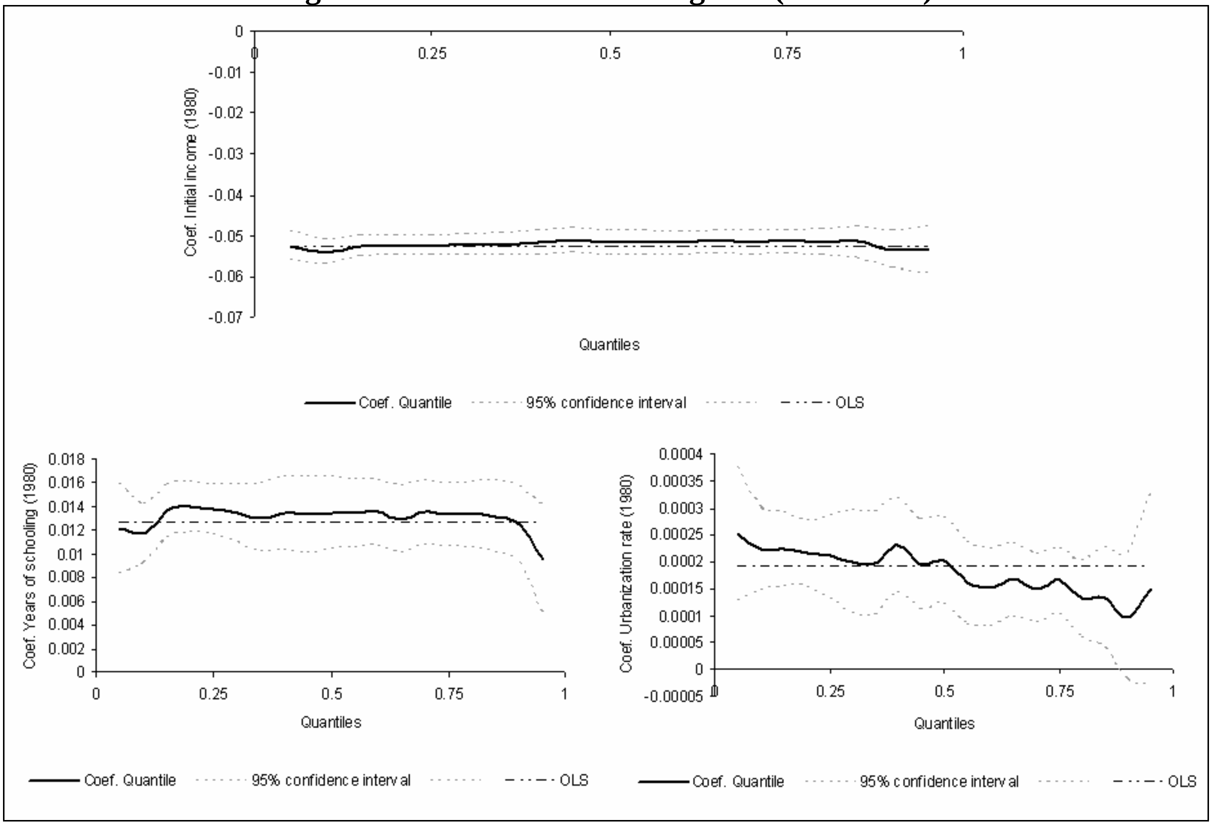
Our results imply that conditional convergence cannot be denied in the case of municipalities of Minas Gerais state. Decreasing returns are operating elsewhere, as Resende (2005) and also Silva & Resende (2007) found. The twin-peaks found by Figueirêdo et al (2006), Salvato et al (2006) and Fontes et al (2005) should not be interpreted as an evidence that favour the club convergence hypothesis, but only the result of the conditional convergence process.

**Figure 5 - Conditional Convergence (1980-2000)**



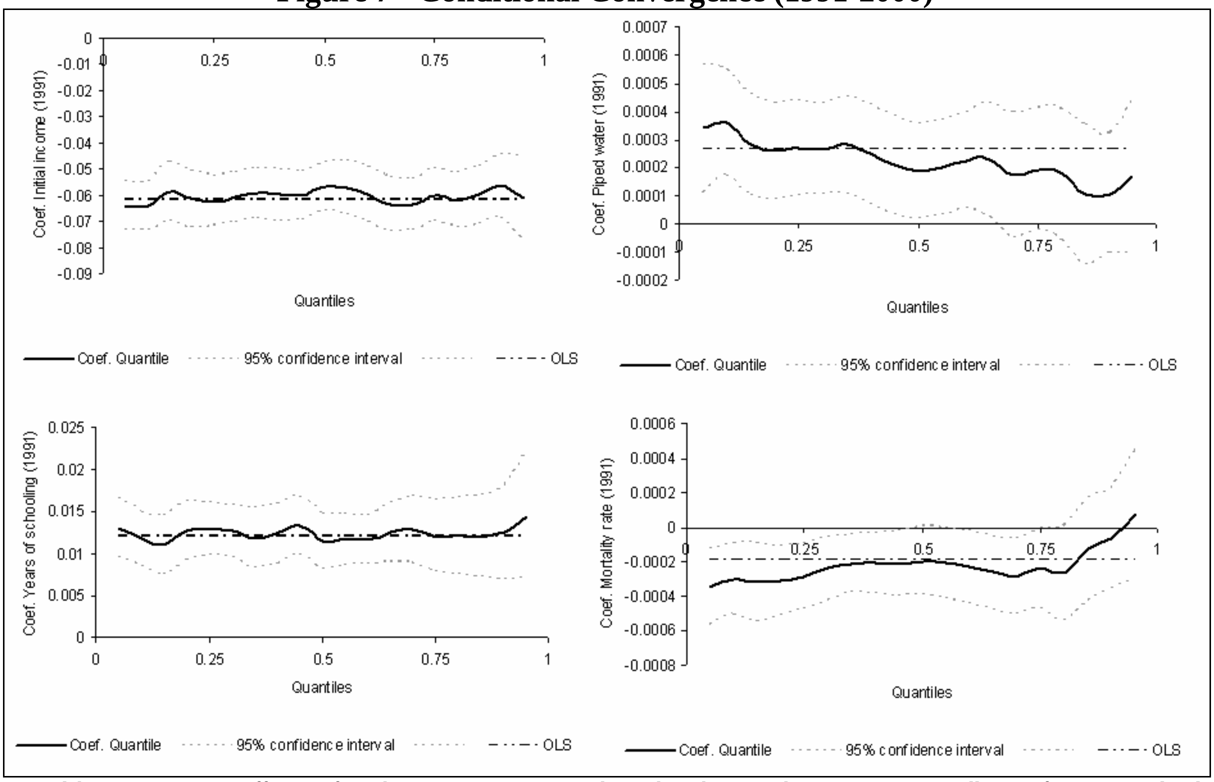

Own elaboration. Note: Coefficients for infant mortality rate and piped water provision for quantile regression are not shown here because they are not statistically significant at 5% level.

## Figure 6 - Conditional Convergence (1980-1991)




Own elaboration. Note: Coefficients for infant mortality rate and piped water provision for quantile regression are not shown here because they are not statistically significant at 5% level.

## Figure 7 - Conditional Convergence (1991-2000)




Own elaboration. Note: Coefficients for urbanization rate are not shown here because they are not statistically significant at 5% level. Quantiles between 0.70 and 0.95 are not statistically significant at 5% level for piped water provision. Quantiles between 0.80 and 0.95 are not statistically significant at 5% level for infant mortality rate.

## 7. Conclusion

This paper examines the convergence growth process using quantile and OLS regression methods for the sample of municipalities of Minas Gerais state between 1980-2000 (and sub-periods). The quantile regression estimator gives, potentially, one solution to each quantile. Thus, it is possible to obtain different coefficient estimates for each chosen quantile. This methodology allows us to observe if the fast-growing municipalities in Minas Gerais react differently to the slow-growing ones with respect to the initial level of income and to other variables.

Our conclusions are threefold. Firstly, the test of absolute convergence among municipalities of Minas Gerais shows a faster convergence for the fast-growing ones in the period 1991-2000. In the other two periods (1980-2000 and 1980-1991) we reject the hypothesis that the quantile coefficients are different from the OLS coefficients. On the other hand, results for the conditional equation shows that the coefficients of the initial per capita income are quite stable among quantiles for all periods. This result means that the quantile coefficients are not significantly different from the OLS results.

Secondly, our results show that higher human capital, urbanization rates and social infra-structure are related to higher economic growth rates and that lower infant mortality rates also foster economic growth. These results imply the existence of different steady states levels.

Finally, per capita income growth rates react similarly to chocks in the controlling variables among the municipalities of Minas Gerais. This conclusion is based on the fact that the quantile coefficients are not significantly different from the OLS results. Thus, fast-growing municipalities in Minas Gerais react similarly to the slow-growing ones with respect to the exploratory variables, such as human capital, urbanization rates, social infra-structure and infant mortality rates. Moreover, quantile coefficients for regional dummies are not statistically different from the OLS ones. Our results imply that conditional convergence cannot be denied in the case of municipalities of Minas Gerais state.

Altogether these results corroborate the evidences found by Resende (2005) and Silva & Resende (2007). It means that each municipality of Minas Gerais should be converging towards its own steady state level of per capita income. Moreover, future research could investigate if grouping municipalities by initial income rather than by growth performance will change our results. The idea is to apply the regression tree method for the municipalities of Minas Gerais. Coelho (2007) suggests the dominance of the club convergence hypothesis over the conditional one for all Brazilian municipalities in the period 1970-2000.

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## Appendix:

**Socioeconomic variables in 1980**

| Macro-regions | Statistics | Urbanization rate | Income per capita (in R$ of 2000) | Average years of schooling | Infant mortality rate (per 1,000) | Piped water provision (proportion) |
|---|---|---|---|---|---|---|
| Alto Paranaíba | N | 31 | 31 | 31 | 31 | 31 |
| Alto Paranaíba | MIN | 29.32 | 77.62 | 1.70 | 33.49 | 0.00 |
| Alto Paranaíba | MAX | 96.08 | 278.15 | 4.00 | 66.33 | 0.71 |
| Alto Paranaíba | MEAN | 66.37 | 179.28 | 3.15 | 52.15 | 0.42 |
| Alto Paranaíba | STD | 2145.67 | 5138.19 | 61.50 | 862.52 | 19.23 |
| Central | N | 149 | 149 | 149 | 149 | 149 |
| Central | MIN | 11.35 | 14.13 | 0.90 | 42.25 | 0.00 |
| Central | MAX | 99.68 | 386.84 | 5.80 | 91.09 | 0.85 |
| Central | MEAN | 84.31 | 238.22 | 4.34 | 69.41 | 0.56 |
| Central | STD | 3780.55 | 22256.98 | 237.46 | 1039.22 | 33.03 |
| Centro-Oeste de Minas | N | 55 | 55 | 55 | 55 | 55 |
| Centro-Oeste de Minas | MIN | 13.98 | 46.13 | 1.70 | 38.23 | 0.00 |
| Centro-Oeste de Minas | MAX | 93.41 | 343.22 | 4.20 | 84.03 | 0.73 |
| Centro-Oeste de Minas | MEAN | 71.58 | 153.11 | 3.18 | 56.28 | 0.49 |
| Centro-Oeste de Minas | STD | 2181.82 | 6290.93 | 76.49 | 877.06 | 21.00 |
| Jequitinhonha/Mucuri | N | 49 | 49 | 49 | 49 | 49 |
| Jequitinhonha/Mucuri | MIN | 7.33 | 21.17 | 0.50 | 45.07 | 0.00 |
| Jequitinhonha/Mucuri | MAX | 84.80 | 137.68 | 2.70 | 99.14 | 0.38 |
| Jequitinhonha/Mucuri | MEAN | 42.36 | 79.84 | 1.40 | 78.75 | 0.17 |
| Jequitinhonha/Mucuri | STD | 2938.78 | 4850.18 | 92.90 | 1788.33 | 16.43 |
| Noroeste de Minas | N | 12 | 12 | 12 | 12 | 12 |
| Noroeste de Minas | MIN | 14.55 | 54.77 | 1.30 | 53.28 | 0.04 |
| Noroeste de Minas | MAX | 60.96 | 166.81 | 2.90 | 70.94 | 0.32 |
| Noroeste de Minas | MEAN | 41.37 | 106.18 | 2.16 | 61.88 | 0.20 |
| Noroeste de Minas | STD | 1883.50 | 4769.09 | 67.19 | 886.95 | 12.74 |
| Norte de Minas | N | 42 | 42 | 42 | 42 | 42 |
| Norte de Minas | MIN | 5.13 | 26.98 | 0.30 | 45.12 | 0.00 |
| Norte de Minas | MAX | 96.40 | 139.62 | 3.90 | 83.95 | 0.54 |
| Norte de Minas | MEAN | 43.34 | 80.03 | 1.74 | 70.03 | 0.18 |
| Norte de Minas | STD | 4149.17 | 5266.72 | 177.91 | 1576.49 | 23.33 |
| Rio Doce | N | 75 | 75 | 75 | 75 | 75 |
| Rio Doce | MIN | 10.77 | 33.09 | 0.80 | 44.62 | 0.00 |
| Rio Doce | MAX | 99.21 | 189.75 | 4.70 | 98.35 | 0.74 |
| Rio Doce | MEAN | 58.25 | 112.40 | 2.48 | 76.50 | 0.31 |
| Rio Doce | STD | 3920.83 | 6335.21 | 154.13 | 1098.49 | 26.86 |
| Sul de Minas | N | 151 | 151 | 151 | 151 | 151 |
| Sul de Minas | MIN | 20.00 | 40.43 | 1.20 | 33.21 | 0.09 |
| Sul de Minas | MAX | 95.96 | 437.06 | 4.60 | 87.32 | 0.81 |
| Sul de Minas | MEAN | 63.05 | 170.11 | 3.22 | 60.86 | 0.50 |
| Sul de Minas | STD | 2196.30 | 6879.63 | 89.75 | 1047.66 | 19.13 |
| Triângulo Mineiro | N | 30 | 30 | 30 | 30 | 30 |
| Triângulo Mineiro | MIN | 20.23 | 53.97 | 2.00 | 30.79 | 0.00 |
| Triângulo Mineiro | MAX | 96.11 | 299.37 | 4.50 | 73.52 | 0.77 |
| Triângulo Mineiro | MEAN | 80.78 | 230.16 | 3.74 | 49.99 | 0.55 |
| Triângulo Mineiro | STD | 3318.30 | 10459.18 | 148.91 | 1222.32 | 37.22 |
| Zona da Mata | N | 126 | 126 | 126 | 126 | 126 |
| Zona da Mata | MIN | 12.27 | 23.16 | 0.90 | 36.20 | 0.00 |
| Zona da Mata | MAX | 98.10 | 298.24 | 5.20 | 82.31 | 0.74 |
| Zona da Mata | MEAN | 60.80 | 143.41 | 3.20 | 64.38 | 0.45 |
| Zona da Mata | STD | 3092.27 | 9539.42 | 134.63 | 1036.16 | 24.11 |
| Minas Gerais | N | 720 | 720 | 720 | 720 | 720 |
| Minas Gerais | MIN | 5.13 | 14.13 | 0.30 | 30.79 | 0.00 |
| Minas Gerais | MAX | 99.68 | 437.06 | 5.80 | 99.14 | 0.85 |
| Minas Gerais | MEAN | 67.13 | 170.32 | 3.25 | 66.35 | 0.44 |
| Minas Gerais | STD | 3739.66 | 14437.23 | 199.13 | 1550.52 | 31.67 |

Source: Own elaboration from data of Demographic Census 1980 – IBGE.

**Socioeconomic variables in 1991**

| Macro-regions | Statistics | Urbanization rate | Income per capita (in R$ of 2000) | Average years of schooling | Infant mortality rate (per 1,000) | Piped water provision (proportion) |
|---|---|---|---|---|---|---|
| Alto Paranaíba | N | 31 | 31 | 31 | 31 | 31 |
| Alto Paranaíba | MIN | 42.46 | 106.37 | 3.33 | 20.70 | 53.74 |
| Alto Paranaíba | MAX | 97.23 | 253.31 | 5.47 | 35.71 | 94.58 |
| Alto Paranaíba | MEAN | 76.37 | 198.05 | 4.55 | 28.87 | 83.33 |
| Alto Paranaíba | STD | 1961.35 | 3910.11 | 80.22 | 358.96 | 1092.30 |
| Central | N | 149 | 149 | 149 | 149 | 149 |
| Central | MIN | 16.37 | 46.62 | 1.54 | 21.74 | 17.14 |
| Central | MAX | 99.66 | 414.94 | 7.19 | 72.52 | 98.16 |
| Central | MEAN | 87.33 | 257.69 | 5.54 | 33.38 | 87.01 |
| Central | STD | 3423.84 | 24261.19 | 281.78 | 1105.65 | 2408.25 |
| Centro-Oeste de Minas | N | 55 | 55 | 55 | 55 | 55 |
| Centro-Oeste de Minas | MIN | 21.53 | 78.32 | 2.30 | 22.12 | 57.58 |
| Centro-Oeste de Minas | MAX | 95.36 | 253.49 | 5.55 | 49.42 | 94.70 |
| Centro-Oeste de Minas | MEAN | 79.39 | 170.39 | 4.47 | 30.05 | 86.00 |
| Centro-Oeste de Minas | STD | 1956.01 | 4866.48 | 95.12 | 747.71 | 1041.28 |
| Jequitinhonha/Mucuri | N | 49 | 49 | 49 | 49 | 49 |
| Jequitinhonha/Mucuri | MIN | 9.84 | 46.94 | 1.25 | 32.72 | 13.49 |
| Jequitinhonha/Mucuri | MAX | 89.55 | 152.26 | 4.19 | 76.00 | 69.60 |
| Jequitinhonha/Mucuri | MEAN | 50.67 | 92.11 | 2.48 | 47.78 | 40.10 |
| Jequitinhonha/Mucuri | STD | 3081.00 | 4802.03 | 123.30 | 1252.41 | 2273.40 |
| Noroeste de Minas | N | 12 | 12 | 12 | 12 | 12 |
| Noroeste de Minas | MIN | 31.74 | 88.73 | 2.31 | 32.79 | 30.28 |
| Noroeste de Minas | MAX | 79.19 | 184.29 | 4.53 | 49.69 | 72.19 |
| Noroeste de Minas | MEAN | 61.14 | 138.22 | 3.60 | 37.35 | 60.85 |
| Noroeste de Minas | STD | 1940.58 | 3962.06 | 100.82 | 666.02 | 1798.73 |
| Norte de Minas | N | 42 | 42 | 42 | 42 | 42 |
| Norte de Minas | MIN | 6.61 | 47.73 | 0.89 | 25.68 | 11.01 |
| Norte de Minas | MAX | 98.15 | 168.40 | 5.29 | 71.21 | 83.62 |
| Norte de Minas | MEAN | 54.74 | 101.74 | 3.07 | 41.89 | 45.00 |
| Norte de Minas | STD | 4416.24 | 6945.78 | 227.59 | 2265.03 | 3543.10 |
| Rio Doce | N | 75 | 75 | 75 | 75 | 75 |
| Rio Doce | MIN | 13.91 | 57.38 | 1.72 | 20.70 | 12.67 |
| Rio Doce | MAX | 99.31 | 221.46 | 6.01 | 75.51 | 96.15 |
| Rio Doce | MEAN | 66.92 | 141.30 | 3.80 | 39.19 | 67.45 |
| Rio Doce | STD | 3688.16 | 8220.72 | 178.32 | 1377.49 | 2945.63 |
| Sul de Minas | N | 151 | 151 | 151 | 151 | 151 |
| Sul de Minas | MIN | 23.88 | 89.14 | 2.27 | 20.70 | 66.16 |
| Sul de Minas | MAX | 98.75 | 303.09 | 6.18 | 42.75 | 97.73 |
| Sul de Minas | MEAN | 71.64 | 194.43 | 4.49 | 29.29 | 89.70 |
| Sul de Minas | STD | 2158.66 | 6513.27 | 113.33 | 671.68 | 831.94 |
| Triângulo Mineiro | N | 30 | 30 | 30 | 30 | 30 |
| Triângulo Mineiro | MIN | 28.91 | 132.63 | 3.01 | 21.90 | 67.21 |
| Triângulo Mineiro | MAX | 97.58 | 306.29 | 6.10 | 36.74 | 98.65 |
| Triângulo Mineiro | MEAN | 87.46 | 255.53 | 5.29 | 25.27 | 91.01 |
| Triângulo Mineiro | STD | 2689.87 | 9644.51 | 183.12 | 604.68 | 1265.34 |
| Zona da Mata | N | 126 | 126 | 126 | 126 | 126 |
| Zona da Mata | MIN | 15.47 | 53.59 | 2.01 | 24.59 | 44.24 |
| Zona da Mata | MAX | 98.51 | 311.64 | 6.56 | 77.01 | 98.03 |
| Zona da Mata | MEAN | 69.21 | 171.44 | 4.47 | 35.35 | 82.76 |
| Zona da Mata | STD | 2988.91 | 9934.70 | 162.47 | 1029.78 | 1735.13 |
| Minas Gerais | N | 720 | 720 | 720 | 720 | 720 |
| Minas Gerais | MIN | 6.61 | 46.62 | 0.89 | 20.70 | 11.01 |
| Minas Gerais | MAX | 99.66 | 414.94 | 7.19 | 77.01 | 98.65 |
| Minas Gerais | MEAN | 74.87 | 195.54 | 4.57 | 34.42 | 78.12 |
| Minas Gerais | STD | 3487.28 | 15466.85 | 229.89 | 1358.43 | 3132.20 |

Source: Own elaboration from data of Demographic Census 1991 – IBGE.

**Socioeconomic variables in 2000**

| Macro-regions of Minas Gerias state | Statistics | Urbanization rate | Income per capita (in R$ of 2000) | Average years of schooling | Infant mortality rate (per 1,000) | Piped water provision (proportion) |
|---|---|---|---|---|---|---|
| Alto Paranaíba | N | 31 | 31 | 31 | 31 | 31 |
| Alto Paranaíba | MIN | 53.75 | 172.55 | 4.24 | 16.01 | 86.87 |
| Alto Paranaíba | MAX | 98.41 | 487.48 | 6.53 | 28.42 | 99.19 |
| Alto Paranaíba | MEAN | 83.88 | 293.90 | 5.49 | 20.68 | 95.41 |
| Alto Paranaíba | STD | 1534.60 | 8357.05 | 93.07 | 593.16 | 367.15 |
| Central | N | 149 | 149 | 149 | 149 | 149 |
| Central | MIN | 21.17 | 78.95 | 2.56 | 14.97 | 34.36 |
| Central | MAX | 100.00 | 557.44 | 8.13 | 71.09 | 99.80 |
| Central | MEAN | 92.35 | 340.40 | 6.43 | 27.43 | 94.54 |
| Central | STD | 2926.62 | 34624.77 | 299.04 | 1019.39 | 1420.53 |
| Centro-Oeste de Minas | N | 55 | 55 | 55 | 55 | 55 |
| Centro-Oeste de Minas | MIN | 34.94 | 121.62 | 3.47 | 14.24 | 84.93 |
| Centro-Oeste de Minas | MAX | 97.81 | 371.11 | 6.62 | 36.62 | 98.88 |
| Centro-Oeste de Minas | MEAN | 85.60 | 269.77 | 5.43 | 20.32 | 96.55 |
| Centro-Oeste de Minas | STD | 1695.65 | 7474.76 | 105.71 | 802.47 | 321.72 |
| Jequitinhonha/Mucuri | N | 49 | 49 | 49 | 49 | 49 |
| Jequitinhonha/Mucuri | MIN | 21.58 | 61.54 | 2.17 | 27.04 | 33.12 |
| Jequitinhonha/Mucuri | MAX | 90.78 | 226.23 | 5.02 | 67.09 | 82.69 |
| Jequitinhonha/Mucuri | MEAN | 58.49 | 125.31 | 3.35 | 41.43 | 58.19 |
| Jequitinhonha/Mucuri | STD | 2786.91 | 6340.71 | 125.20 | 1220.96 | 1810.30 |
| Noroeste de Minas | N | 12 | 12 | 12 | 12 | 12 |
| Noroeste de Minas | MIN | 52.27 | 122.71 | 3.03 | 17.26 | 59.52 |
| Noroeste de Minas | MAX | 83.78 | 320.94 | 5.35 | 38.19 | 91.35 |
| Noroeste de Minas | MEAN | 74.66 | 230.10 | 4.61 | 26.49 | 81.72 |
| Noroeste de Minas | STD | 1558.66 | 10188.26 | 92.84 | 1124.19 | 1245.11 |
| Norte de Minas | N | 42 | 42 | 42 | 42 | 42 |
| Norte de Minas | MIN | 14.39 | 69.13 | 1.78 | 22.27 | 30.63 |
| Norte de Minas | MAX | 98.17 | 245.43 | 6.44 | 59.34 | 91.41 |
| Norte de Minas | MEAN | 64.53 | 133.59 | 4.00 | 34.53 | 62.31 |
| Norte de Minas | STD | 4023.15 | 11724.44 | 270.50 | 1955.46 | 3277.94 |
| Rio Doce | N | 75 | 75 | 75 | 75 | 75 |
| Rio Doce | MIN | 21.14 | 80.29 | 2.61 | 13.86 | 40.26 |
| Rio Doce | MAX | 99.76 | 309.18 | 6.86 | 71.09 | 96.65 |
| Rio Doce | MEAN | 75.85 | 211.55 | 4.81 | 31.79 | 85.58 |
| Rio Doce | STD | 3188.96 | 11440.95 | 189.53 | 1349.23 | 1841.30 |
| Sul de Minas | N | 151 | 151 | 151 | 151 | 151 |
| Sul de Minas | MIN | 25.64 | 129.95 | 3.26 | 11.34 | 84.81 |
| Sul de Minas | MAX | 100.00 | 435.56 | 7.13 | 37.05 | 99.43 |
| Sul de Minas | MEAN | 77.84 | 289.35 | 5.44 | 21.11 | 96.98 |
| Sul de Minas | STD | 2040.52 | 9304.34 | 122.87 | 659.25 | 317.81 |
| Triângulo Mineiro | N | 30 | 30 | 30 | 30 | 30 |
| Triângulo Mineiro | MIN | 41.17 | 199.65 | 4.05 | 13.44 | 79.39 |
| Triângulo Mineiro | MAX | 97.56 | 396.67 | 7.13 | 30.20 | 99.20 |
| Triângulo Mineiro | MEAN | 91.47 | 347.20 | 6.31 | 19.32 | 96.72 |
| Triângulo Mineiro | STD | 2151.92 | 12194.66 | 203.80 | 598.76 | 515.96 |
| Zona da Mata | N | 126 | 126 | 126 | 126 | 126 |
| Zona da Mata | MIN | 23.35 | 88.79 | 2.77 | 14.97 | 70.05 |
| Zona da Mata | MAX | 99.17 | 419.40 | 7.39 | 53.63 | 99.64 |
| Zona da Mata | MEAN | 76.68 | 256.12 | 5.37 | 27.57 | 94.90 |
| Zona da Mata | STD | 2692.46 | 12833.79 | 173.24 | 921.52 | 668.60 |
| Minas Gerais | N | 720 | 720 | 720 | 720 | 720 |
| Minas Gerais | MIN | 14.39 | 61.54 | 1.78 | 11.34 | 30.63 |
| Minas Gerais | MAX | 100.00 | 557.44 | 8.13 | 71.09 | 99.80 |
| Minas Gerais | MEAN | 82.00 | 276.96 | 5.54 | 27.12 | 89.52 |
| Minas Gerais | STD | 3108.49 | 21499.65 | 244.66 | 1349.17 | 2313.30 |

Source: Own elaboration from data of Demographic Census 2000 – IBGE.