

# **Creative Class, Human Capital and Urban Dynamism: Empirical Evidence for the Brazilian Cities**

Francisco de Lima Cavalcanti

University of Barcelona, [francisco.lima.cavalcanti@gmail.com.br](mailto:francisco.lima.cavalcanti@gmail.com.br)

Raul da Mota Silveira Neto

Federal University of Pernambuco – PIMES/UFPE, [rau.silveira@uol.com.br](mailto:rau.silveira@uol.com.br)

## **Abstract**

This article follows the debate initiated by Florida (2002) and Glaeser (2005) of which measures of human capital have better prediction on economic performance of cities (urban dynamism), Creative Class or more traditional education indicators. Using micro-level data extracted from Brazilians Census (1991, 2000 and 2010), we propose a Spatial Durbin Panel analysis for measuring the effect of Creative Class and of Schooling on urban dynamism, an approach that allow us to control for municipalities fixed effect, year effect and spatial spillover effect. In addition, following LeSage and Pace (2009), we measure the effects of these variables by calculating the direct, indirect and total effects. The results show that education or schooling indicators have higher association with urban dynamism than creativity indicators. This suggests that, for the Brazilian context, is better for policy makers support accumulation of high education per se, than to focus on policies that aim at attracting professionals in creative occupations.

**Keywords:** Creative Class, Human Capital, Spatial Panel.

## **Resumo**

Motivado pelo debate entre Florida (2002) e Gleaser (2005) a respeito da importância da Classe Criativa como medida de capital humano, o trabalho faz uso dos microdados dos Censos Demográficos brasileiros de 1991, 2000 e 2010 e especificações econométrica representadas por painéis espaciais (*Spatial Durbin Panel Models*) para investigar a importância deste tipo específico de ocupação vis à vis medidas tradicionais de capital humano na determinação da dinâmica de crescimento do emprego das cidades brasileiras. Os resultados obtidos a partir dos painéis espaciais, que permitem o controle para a influência dos efeitos fixos das cidades, efeitos específicos dos períodos e transbordamentos espaciais dos efeitos das variáveis, indicam que as medidas mais tradicionais de capital humano, como por exemplo, o percentual de pessoas com o ensino superior, apresentam associações mais significativas e robustas com o dinamismo do empregos das cidades brasileiras que as diferentes medidas de Classe Criativa disponíveis na literatura, o que é percebido a partir do calculo dos efeitos diretos e indiretos das variáveis sobre o crescimento do emprego.

**Palavras-chave:** Classe Criativa, Capital Humano, Painei Espacial.

**Código JEL:** R11, R15.

**Área Anpec:** 10 - Economia Regional e Urbana

# **Creative Class, Human Capital and Urban Dynamism: Empirical Evidence for the Brazilian Cities**

## **1. Introduction**

There is well-known literature showing that human capital plays an important role in economic growth both at the country level (Lucar Jr, 1988; Romer, 1990; Benhabid and Spiegel, 1994) and the regional level (Moretti, 2004; Marracu and Paci, 2012, 2013). Nevertheless, it is still debatable what measure of human capital best predicts economic development. Since the publication of Florida's seminal book (2002), many scholars have started to investigate the role of creative people as one driver of economic performance. The creative professions are those occupations which necessarily need innovative and creative behavior. Since this kind of behavior is very conducive to the production process, especially because it is closely linked to technological innovation and increased productivity, those occupations have characteristically been desired for enhancing economic performance. The hypothesis is that the presence of creative people improves the quality of the economic environment. Said differently, a region whose population is proportionally more employed in creative occupations has more conditions that stimulate economic growth. One possible explanation is that the method of this kind of individual is to identify problems, discover original solutions, generate new ideas, and create new technologies. This may have a positive effect on the attraction of new firms, which in turn attracts more skilled workers and then generates a virtuous cycle that improves the regional economy.

The first question that arose from Florida's contribution was what is the best way to measure creativity? It is not straightforward to define which occupations possess innovative and creative tasks. For many scholars, Florida's definition of a creative class was too vague and hardly convertible for distinct countries' contexts (Markusen, 2006; Wojan et al., 2007). So many proposals for measuring creativity were put forward by researchers. Each new definition was based mostly on the aim of that study and on the data available, instead of on achieving compatible measures for the creative class among countries. This was troublesome for empirical comparisons.

Additionally, the creative class definition was accused of overlapping with the standard measure of human capital based on educational attainment. Indeed, a close look shows that the occupations that Florida argued to be part of the creative class require a university degree. It is not easy to find an engineer without a bachelor's degree, for instance. Thus, some believed that creativity does not have an independent effect on the local economy. Once educational attainment is controlled for, the effect of creativity might disappear, as remarked in Glaeser (2005). From here, the debate shifted to be what is the best measure of human capital? Those that use only educational achievement, or those that measure what people actually do, rather than what they are trained to do? In other words, which feature of human capital, education or creativity, fosters better economic performance? This is an important question, since it can induce policy makers to formulate strategies for human capital accumulation.

Motivated by this debate, many articles were produced that tried to compare the measures of education and creative class to their associations with regional and urban dynamism. For studies showing that creativity outperforms the education indicator, Mellander and Florida (2011) used data from Sweden to implement a structural equations approach. Analyzing for all of the Nordic countries (Denmark, Finland, Norway and Sweden), Andersen et al. (2010) ran a simple partial correlation framework that showed that the creative class is positively associated with employment growth, but the sign was negative when using the education indicator. Analyzing for the U.S. context, Wojan et al. (2007) ran a cross-section regression showing that the creative class predicts employment growth better than education. Using employment growth as a proxy for urban dynamism, Marlet and Van Woerkens (2007) used data from the Netherlands to find similar results. In a case of German regions, Wedemeier (2010) found that labor productivity growth is positively affected by the creative class. In an article with the same objective, Marracu and Paci (2012, 2013) used 27 European regions and employed a spatial error model, showing that the creativity indicator fosters better economic performance than the education indicator.

However, there were other studies that did not reach any clear conclusion of what measures outperform the others, or that did not demonstrate that creativity is relevant to economic performance. For instance, Florida et al. (2008) used information from China to show that neither the education nor creativity indicator exerts a positive and significant effect on the spatial variation of technology and economic performance. Raush and Negrey (2006), using information for the U.S., ran a cross-section to show that the creative class has no positive association with gross product growth. Also running a cross-section for the U.S., Donegan et al. (2008) found no statistically significant association for either indicator with respect to employment growth. Additionally, few studies show that standard measures of human capital based on educational achievement outperform the creative class measures. To the best of our knowledge, only Bochma and Fritsh (2009) reached this conclusion, when analyzing the Netherlands and Germany.

These empirical analyses can be differentiated from each other in many ways, so it is hard to make comparisons between them. The first important difference comes from how they define regional and urban dynamism as a dependent variable. It is possible to find studies using per-capita wages, gross product growth, income growth, population growth or, the most widely used, employment growth. The second main difference comes from the methodology implemented. It is possible to find papers using cross-sectional analysis, structural equations and spatial cross-section models. The third difference comes from distinct definitions of the creativity indicator, as mentioned above. Additionally, few studies are implemented at the municipality level, and, to the best of our knowledge, none use panel data.

The aim of this study is to contribute to the debate about what matters most for economic performance—education or creativity? To do so we propose an empirical analysis of the developing country of Brazil. The analysis for this country should be interesting, since 85% of the population are settled in urban areas (Census 2010), there are notable regional disparities (Silveira Neto and Azzoni, 2012), the wage premium for educational attainment is high (Silveira Neto and Menezes, 2008) and there are few studies examining the relevance of the creative class in this country<sup>1</sup>. We extract data at the microlevel from three Brazilian censuses (1991, 2000 and 2010) and construct indicators of creativity and education for Brazilian municipalities and a proxy for urban dynamism. We attempt to determine which human capital measures have the highest association with municipal economic performance. The novel contribution of this paper is the implementation of the Spatial Durbin Panel model at the urban level. Thus we can accurately estimate of the coefficients, since we can introduce time effect, municipality effect and spatial spillover effect. Our results show that the education indicators have a higher association with urban dynamism than do the creativity indicators. This suggests that for the Brazilian context, it is better for policy makers to support the attainment of higher education per se, than to focus on policies that aim at attracting professionals in creative occupations.

The paper is organized as follows. In the next section we discuss the database; we also explain the spatial scope that we implement in the analysis; we discuss various measures used throughout the paper of the creativity and education indicators, explain the urban characteristics used as the control variables and present some descriptive analyses. In the third section we detail the methodology implemented in the econometric approach. The fourth section shows the results. The fifth section proposes a robustness check. The sixth section concludes the analysis. The Appendix reports the creative occupations used to construct the creativity indicators.

## **2. Data and initial descriptive analysis**

In this section we explain how we constructed the analysis. First we discuss how we delimited the spatial scope used in the investigation. Then we detail our construction of the creativity and education indicators, show the correlations with the variables in Table 1 and discuss some possible caveats. Finally, we propose some control variables that the literature suggests play an important role in the presence of

---

<sup>1</sup> Even papers that have dealt with the creative class in the Brazilian context, for instance Golgher (2011), have not analyzed the relative importance of education attainment and creativity as standard measures of human capital.

human capital and urban dynamism, and present a descriptive analysis in Table 2. All observations were extracted from microlevel data of Brazilians censuses (1991, 2000 and 2010).

## 2.1 Spatial definition

Bearing in mind that we intend to compare the associations of the creativity and education indicators as conditions of urban dynamism, while controlling the spatial spillover, it is important to define the most suitable spatial scope for our empirical investigation.

A concern that arises in spatial analysis is to ensure that the geographical boundary delimitations should be homogeneous over time. Historically, there have been some municipalities that received interventions in their space delimitation. Some cities were divided into two and eventually three entities, while others fused to become one. To account for changes in administrative boundaries during the period of analysis, we used information on municipality border changes provided by Reis et al. (2009), namely AMC (*Áreas Mínimas Comparáveis*). This municipality measure guarantees the homogeneity of the geographical boundary delimitations throughout the period of study. However, this source only reported until the year 2000, so we had to manually insert the AMC border changes which occurred from 2000 to 2010.

The numbers extracted from AMC correspond to 4267 urban areas in Brazil. Bearing in mind that Brazil is a big country, it is reasonable to expect heterogeneity among the characteristics of its municipalities. To account for this potential problem, we imposed a restriction on the spatial scope of the econometric analysis. We excluded municipalities from the sample that had fewer than fifty-thousand inhabitants in Census 1991. The argument for this is to dampen a bias from unobserved variables that emerge from heterogeneity of the populations<sup>2</sup>. This restriction resulted in shrinking our sample from 4267 administrative boundaries to only 293 each year. The hypothesis was that the 293 biggest municipalities played an agglomerating role with respect to their neighboring areas. The urban areas selected were located in all twenty-six states of Brazil, and included the federal district and all state capitals.

## 2.2 Creativity and education indicators

The very first attempt to measure some kind of creativity of economic agents came from the report Creative Industries Mapping Document of DCMS (1998). After that, many others institutions started their own research to map creative economic agents among several countries<sup>3</sup>. Unfortunately, each institution adopted its own classification of creative industries, precluding a cross-country comparison. Moreover, most of them are very conservative definitions, sometimes limited to sector activities with cultural traits.

A well-known definition of creative economic agents came from Florida (2002). His specification of the creative class is subdivided into categories of occupations which rely on innovative tasks. The two main subdivisions are: Core Creative Occupations and Professions Creative Occupations. The Core Creative Occupations are defined as those occupations that have the intrinsic necessity to directly employ creativeness in their everyday routine. This subdivision includes people whose economic function is to create new ideas, technologies and concepts. These occupations are represented by five categories:

- Computers and math;
- Architecture and engineering;
- Life, physical and social sciences;
- Education, training and library positions;
- Design work and entertainment, sports and media occupations.

---

<sup>2</sup> We also did the same exercise with no restriction on the sample and restricting for municipalities that had fewer than one hundred-thousand inhabitants in Census 1991. The results are available upon request.

<sup>3</sup> For instance, a newsletter is published on the U.S. named *Creative Industries: Business & Employment in the Arts*.

In many studies a fifth category of bohemian occupations is also treated<sup>4</sup>. The subdivision of Professions Creative Occupations is defined as those occupations that border the Core Creative Occupations. They are occupations in which arise a considerable number of complex problems demanding a high degree of discernment in making decisions independently, thus requiring a high level of education and/or professional experience. These occupations are represented by six categories:

- Management occupations;
- Business and financial operations;
- Legal positions;
- Healthcare practitioners;
- Technical occupations;
- High-end sales and sales management.

One important concern about the definition of creativity is how it overlaps with the measures of human capital based on educational attainment. Indeed, most of the proposals for a definition of creative class are based on occupations in which the individuals have a high likelihood of holding a university degree. Many studies fail to disentangle the overlapping problem because they don't have detailed microlevel information on the educational attainment and current occupation of each individual. Fortunately, we can solve this problem straightforwardly because we can extract that information from each Brazilian Demographic census.

This paper partially adopts the description of creativity suggested by Florida (2002). We assume only the Core Creative Occupations subdivision as the scope of this study for creativity. The first reason to do this is that people in these professions have to directly implement creativity in their everyday tasks. The second reason is that many scholars argue that Florida's definition is too vague (Markusen, 2006; Wojan et al., 2007). Thus, we choose the occupations which are more often addressed in the economic literature (Marrocu and Paci, 2012, 2013). The last reason but not the least is that if one takes a close look at the Professions Creative Occupations he/she straightway concludes that they overlap the standard measure of human capital based on educational attainment.

We used the *Classificação de Ocupações Para Pesquisas Domiciliares* (COD) 2010 from IBGE to determine which jobs illustrate the creative class in Brazil. For compatibility among the censuses of 1991, 2000 and 2010, we converted them to occupations defined in CIUO-88 and CIUO-08, which are two versions of a tool for the international comparison of job descriptions from the International Labor Organization (ILO)<sup>5</sup>.

The creativity and education indicators were constructed as proportions of each category with relation to the populations of the AMC. Following the previous contributions of Marrocu and Paci (2012, 2013), we developed creative class and education indicators defined by five categories:

- Graduates;
- Noncreative graduates;
- Creatives;
- Creative graduates;
- Bohemians;

where *Creatives* represents individuals that are in one of four Core Creative categories: computers and math; architecture and engineering; life, physical, and social sciences; and education, training, and library positions. The occupations selected for these categories can be seen in Tables 10, 11, 12 and 13 in the Appendix. *Creative graduates* represents only the individuals that are in one of the occupations above and additionally hold a bachelor's degree. *Graduates* are the individuals that hold a bachelor's degree

---

<sup>4</sup> See for instance Boschma and Fritsch (2009), Marlet and Van Woerkens (2007) and Marrocu and Paci (2012).

<sup>5</sup> A complete definition of the occupations defined as the creative class is presented in the Appendix.

regardless of profession. *Noncreative graduates* represents the individuals that hold a bachelor's degree but do not have a job in the creative class. Finally, *bohemians* represents the individuals that are in the Core Creative category of design work and entertainment, sports, and media occupations. The occupations selected for the bohemians can be seen in Table 14 in the Appendix.

In Table 1 we show the correlations between the five indicators of education and creativity for each census. We can see that with time, the proportion of individuals in creative occupations with a bachelor's degree increases. This suggests that in the Brazilian context it is more difficult nowadays to find an individual doing creative tasks without higher education. The same pattern can be seen in relation of graduates and non-creative graduates. On the other hand, the correlation between bohemians and creatives does not change too much over time.

The correlation coefficients depicted in Table 1 reveal an obstacle to econometric analysis. Since there is a huge parallel between the creativity and education indicators, because of strong multicollinearity problems, it is not appropriate to introduce all variables at the same time in a regression analysis. Thus, considering that there is robust literature showing that human capital plays an important role in economic growth<sup>6</sup>, and the creativity and education indicators are proxy for human capital, we decided to run separate regressions for these two variables and to control for potential bias associated with omitted variables by using additional covariates as regressors and spatial fixed-effect econometric specifications.

### 2.3 Urban characteristics

In this subsection we explain some control variables included in the empirical analysis that can affect the creativity and education indicators as well as urban dynamism. The first characteristic that might be relevant to the share of human capital in a municipality is population size. On the one hand, the larger the population the higher the probability of services and goods differentiation (Quigley, 1998). This might affect the presence of creative and educated people since such individuals have on average higher income and thus more ability to afford specific services and goods. On the other hand, population size can also suggest congestion, which may repel high productivity people (Tsekeris and Geroliminis, 2013; Su, 2011). Moreover, the larger the population, the higher the probability of the agglomeration effect occurring in neighboring urban areas. Therefore, municipalities that are closer to major centers have a higher likelihood to attract creative and educated people.

The second characteristic that might be relevant to the share of creative and educated people is the average income per capita. As higher productivity means higher wages, there must be a connection between the proportion of human capital and the average income in a municipality. To control for this argument, this variable was also included in the analyses<sup>7</sup>.

---

<sup>6</sup> For instance, Lucas, Jr (1988), Romer (1990) and Benhabib and Spiegel (1994).

<sup>7</sup> The average incomes were deflated by the *Índice do Preço ao Consumidor* (IPC) from IPEA for base year 2010.

**Table 1 - Correlations Between Variables of the Creative Class and Human Capital**

		Creative		Non-Creatives	
Year 1991	Creatives	Graduates	Graduates	Graduates	Bohemians
Creatives	1.00				
Creative Graduates	0.79	1.00			
Graduates	0.65	0.80	1.00		
Non-Creatives Graduates	0.63	0.78	0.99	1.00	
Bohemians	0.40	0.61	0.64	0.63	1.00
<b>Year 2000</b>					
Creatives	1.00				
Creative Graduates	0.96	1.00			
Graduates	0.76	0.77	1.00		
Non-Creatives Graduates	0.74	0.75	0.99	1.00	
Bohemians	0.52	0.52	0.52	0.52	1.00
<b>Year 2010</b>					
Creatives	1.00				
Creative Graduates	0.98	1.00			
Graduates	0.87	0.89	1.00		
Non-Creatives Graduates	0.85	0.87	0.99	1.00	
Bohemians	0.56	0.59	0.62	0.61	1.00

*Source:* micro-data of Census 1991, 2000 and 2010 from IBGE.

The third characteristic relies on Florida's hypotheses of the positive effect of tolerance environment on the presence of creative people. The more open the minds of the inhabitants of one municipality, the more fuel for creative and innovate practices. The argument for this relation depends on low entry barriers for creative capital. Regularly scholars address tolerance as a matter of diversity. Municipalities with more diverse individuals may exert better conditions for the generation of new ideas, and consequently employ influence on the presence of creative people (Inglehart and Norris, 2003; Welzel and Inglehart, 2013; Florida, 2002; Golgher, 2011). The technology and talent have been mostly seen as stock variables which accumulate in urban areas and have effect on regional economic growth. However, for some scholars both technology and talent are flow variables. The ability to capture these flows requires an understanding of tolerance, the open-minded environment and diversity. This suggests that there is a connection between diversity and productivity (Ottaviano and Peri, 2005; Page, 2008; Longhi, 2011). Several papers use the composition of different national origins of its inhabitants as a

proxy for urban tolerance <sup>8</sup>. Following this assumption, we construct our proxy for tolerance and diversity, which we assume to correspond with the share of foreign people. The control variable is calculated by the proportion of people originally from different countries instead Brazil in relation to the total population of each municipality.

**Table 2 - Summary of Statistics**

1991	Obs	Mean	Std. Dev.	Min	Max
Population	293	224727	678987	50328	9646185
Income	293	R\$ 445.57	R\$ 413.27	R\$ 10.52	R\$ 2904.56
Employers	293	88647	287861	14606	4159764
Foreign Share	293	0.17%	0.26%	0.00%	1.74%
College Share	293	1.09%	0.49%	0.00%	2.38%
Creatives	293	0.83%	0.60%	0.00%	3.62%
Creative Graduates	293	0.43%	0.47%	0.00%	3.15%
Graduates	293	6.06%	4.62%	0.03%	32.26%
Non-Creatives Graduates	293	5.62%	4.21%	0.03%	29.11%
Bohemians	293	1.03%	0.45%	0.04%	2.88%
2000	Obs	Mean	Std. Dev.	Min	Max
Population	293	264572	739632	51008	1.04e+07
Income	293	R\$ 979.26	R\$ 403.93	R\$ 152.11	R\$ 2639.29
Employers	293	103042	301829	13749	4308729
Foreign Share	293	0.21%	0.23%	0.00%	1.74%
College Share	293	1.57%	0.49%	0.04%	2.84%
Creatives	293	0.63%	0.60%	0.00%	3.45%
Creative Graduates	293	0.34%	0.40%	0.00%	2.28%
Graduates	293	8.17%	5.79%	0.06%	39.26%
Non-Creatives Graduates	293	7.83%	5.44%	0.06%	36.97%
Bohemians	293	1.42%	0.66%	0.23%	7.65%
2010	Obs	Mean	Std. Dev.	Min	Max
Population	293	298872	803025	52338	1.13e+07
Income	293	R\$ 1152.87	R\$ 412.93	R\$ 244.45	R\$ 2895.89
Employers	293	128804	352949	15733	4986043
Foreign Share	293	0.22%	0.42%	0.00%	6.17%
College Share	293	8.70%	3.11%	1.08%	19.90%
Creatives	293	1.51%	1.17%	0.06%	7.41%
Creative Graduates	293	1.12%	0.99%	0.00%	6.54%
Graduates	293	14.81%	7.56%	2.46%	48.44%
Non-Creatives Graduates	293	13.68%	6.65%	2.46%	42.10%
Bohemians	293	1.27%	0.54%	0.20%	3.89%

Source: micro-data of Census 1991, 2000 and 2010 from IBGE.

The last urban characteristic that may be relevant to the share of human capital in a municipality is the size of the university environment (Florida et al., 2006, 2008). First, since universities always stay in the vanguard of technological innovation, they can attract startup firms. Second, university environments act as a magnet both directly for students, teachers and researchers, and indirectly for highly skilled entrepreneurs who want to take advantage of the academic resources. The third reason relies on the assumption that academic environments enhance tolerance and diversity in a community, attracting students and faculty with a wide variety of racial, ethnic and national backgrounds. Finally, the fourth reason counts on a possible neighbor effect. Municipalities located near academic environments have a higher probability of taking advantage of their spillover effects. Thus, we construct a proxy for the university environment as the share of university students in the total population of each municipality.

<sup>8</sup> See for instance Marlet and Van Woerkens (2004), Ottaviano and Peri (2005) and Longhi (2011).



Table 2 presents a descriptive analysis of the database. It is possible to see that in the period analyzed an expansion occurred in the purchasing power of Brazilian citizens living in big cities. The average income growth was almost 59%. The foreign share was a really small part of the population and remained basically stagnant. The college share increased significantly over time. The initial levels of the creatives in 1991 and 2000 did not change much. Nor did those of the creative graduates or bohemians. However, the initial levels in 1991 and 2000 of the graduates and non-creative graduates increased slightly.

### 3. Empirical model specification

The main contribution of the model specifications is the simultaneous introduction of controls for time effect, municipality fixed effect and spatial spillover effect in the econometric analysis. As we have information about the growth of employment for each municipality over two periods, we can implement a Spatial Durbin Panel Model. Such an approach takes account of variabilities in time trends, municipalities and spaces. Specifically, we consider the following econometric specification:

$$y = \rho(I_t \otimes W)y + (I_t \otimes W)X\theta + X\beta + (\iota \otimes I_n)\mu + \varepsilon \quad (1)$$

where  $\varepsilon = \sigma(I_t \otimes W)\varepsilon + v$ .

Here  $y$  is a vector  $nt \times 1$  of observations of the employment growth rate of  $n$  cities ( $n = 1, 2, \dots, 293$ ) for  $t$  periods of time (1991-2000 and 2000-2010);  $X$  is a matrix of explanatory variables (which includes one of the five proxies for educated people and the creative class, as well as the control variables for population, average income per capita, share of foreign individuals and share of college students) of length  $nt \times K$ ;  $W$  is a matrix  $n \times n$  of spatial weights;  $\rho$  is the coefficient of the spatial correlation for the endogenous variable;  $I_t$  is an identity matrix  $t \times t$ ;  $I_n$  is an identity matrix  $n \times n$ ;  $\iota$  is a vector  $t \times 1$  of ones;  $\mu$  is a vector of unobserved, fixed, specific characteristics of each region of dimension  $n \times 1$ ;  $\sigma$  is the coefficient of the spatial correlation of the error term;  $\varepsilon$  is a vector of  $nt \times 1$  spatially correlated innovations with  $\varepsilon \sim N(0, \sigma_\varepsilon^2)$ ; and  $v$  is a vector  $nt \times 1$  of idiosyncratic errors with  $v \sim N(0, \sigma_v^2)$ . We will suppose that the vector  $\varepsilon$  is uncorrelated with the explanatory variables or with vector  $\mu$ . The symbol  $\otimes$  represents the Kronecker product.

Note that the model includes spatial lags for employment growth, the explanatory variable and the control variables; and it includes spatial dependence in the error term as well. These factors imply that different kinds of spatial interaction may be involved in the determination of urban dynamism. More specifically, the presence of the spatial lag of the endogenous variable represents a control for a potentially omitted, spatially correlated variable that affects the employment growth. The presence of the city's neighbors variable simply captures spatial spillovers of the effects of these variables. Finally, the spatial dependence of the error represents unexpected or irregular, spatially correlated shocks. In addition, by using a panel model, we allow for the existence of a heterogeneous process of employment generation across the cities. As argued by Baltagi (2005), panel data exhibit greater variability and a lower degree of collinearity among variables, and provide more efficient estimators. We estimate the parameters of equation (1) by the maximum likelihood approach suggested by Millo and Piras (2012). The estimation utilizes a concentrated likelihood function and an interactive process to obtain the values of parameters  $\rho$ ,  $\beta$ ,  $\theta$ ,  $\sigma_\varepsilon^2$  and  $\sigma_v^2$ .

Analysis of the parameters of the indicators of creativity and education in spatial models that include spatial lags of employment growth become complicated and require special interpretation, because a change in the measures of education or creativity for a single municipality can potentially affect the employment growth in all other municipalities (LeSage and Page, 2008). Thus, the impact of the creativity and education indicators includes the effects of *feedback loops* where municipality  $i$  affects municipality  $j$ , which in turn affects municipality  $i$ , as well as longer paths which might go from municipalities  $i$  and  $j$  to  $k$  and back to  $i$  again, with  $i \neq j$ ,  $j \neq k$  and  $i \neq k$ . This is a clear consequence in our suggested model, since we included  $Wy_{it}$  and  $WX_{it}$  in the right-hand side of equation (1).

More formally, if we rewrite equation (1) as

$$y = [I_{nt} - \rho(I_t \otimes W)]^{-1}[(I_t \otimes W)X\theta + X\beta + (I_t \otimes I_n)\mu + \varepsilon] \quad (2)$$

and take the partial derivative of  $y$  with respect to the explanatory variable of the indicator of creativity or education, let's say  $x_r$ , we get

$$\frac{\partial y}{\partial x_r} = [I_{nt} - \rho(I_t \otimes W)]^{-1}[(I_t \otimes W)\theta_r + I_{nt}\beta_r] \quad (3)$$

As is clear, the resulting expression is not equal to  $\beta_r$  as in the least-square. Instead, the resulting expression is matrix  $nt \times nt$ . The elements of the diagonal of this matrix represent the direct impact of the indicator of creativity or education of municipality  $i$  on the employment growth of municipality  $i$ . The elements of the matrix that are outside the diagonal represent the indirect impact on municipality  $j$  of variation in the employment growth of municipality  $i$  in response to changes in the indicators of creativity or education. As the indirect and direct impacts can be different among municipalities, Pace and LeSage (2008) proposed measures of direct and indirect impact as the average of the elements inside and outside of the diagonal of the matrix, respectively.

#### 4. Creativity and education indicators impacting on urban dynamism

The aim of this section is to provide an estimation of the association between the creativity and education indicators and urban dynamism in Brazil, measured by employment growth. The idea is to contribute to the debate about which proxy for human capital is the best predictor of Brazilian urban employment growth. The novel contribution of this paper is the introduction in the same regression analysis of controls for time effect, municipality fixed effect and spatial spillover effects. Two recent papers have already found some spatial dependence of income at the microregion and municipality levels in Brazil (Resende, 2011, and Cravo et al., 2014), but to the best of our knowledge, there is no paper analyzing the same issue using a spatial fixed-effect model.

In Table 3 we present the coefficients estimated using the Ordinary Least Square estimator for all of the observations (columns (1), (3) and (5)) and using the concentrated maximum likelihood and interactive approach for the Spatial Durbin Panel model represented in equation (1) (columns (2), (4) and (6)). Columns (1) and (2) present estimations using the creative class as the variable of interest. Columns (3) and (4) present estimations when restricting the creative class to only those individuals holding a bachelor's degree. Columns (5) and (6) present estimations considering a third indicator of creativity: in them only bohemian occupations are considered.

The set of evidence of Table 3 indicates significant differences between the OLS estimates and the spatial panel ones. Particularly, note that both estimates of the spatial parameters are positive and statistically significant, a result that is in line with Resende (2012) and Cravo et al. (2014), the most recent studies for Brazilian cities and microregions. We can thus identify different kinds of spatial dependence for the growth of employment in Brazilian cities and cannot rely on the traditional OLS estimator when analyzing employment dynamism for cities.

In fact, when we introduce the spatial spillover effect, municipality effect and year effect, the share of the creative occupations appears to have a positive and significant association with urban dynamism. This result is opposed to the coefficient obtained when using the standard Ordinary Least Square approach. The coefficient of the share of the creative individuals with a bachelor's degree is also positive, but with a smaller association than the share of the creatives, and with no significance. This result must be due to the very small variability in this category, since the creative graduates are a very small part of the graduates. For instance, the mean initial value of this category in 1991 is only 0.43% of the population with standard deviation 0.47%. However, this result differs from Marracu and Paci (2012, 2013), who found this category to be the highest predictor of regional dynamism. The last creativity indicator is the share of the bohemians, which is presented in columns (5) and (6).

Regarding the control variables, we note a negative coefficient for initial populations and a positive one for the share of college students in the populations of the cities. The first result suggests that, ever more equal, small cities present a higher employment growth rate than big cities in Brazil, a result that is consistent with the decreasing life quality in the big cities. The second result is similar to the one obtained by Da Matta et al. (2007) and suggests that the human capital in the urban environment presents benefits for urban dynamism.

**Table 3: Associations Between Creativity Indicators and the Urban Dynamism**

<b>Dependent Variable: Employment Growth</b>						
<i>Creativity Indicator:</i>	Creatives		Creatives Graduates		Bohemians	
	(1)	(2)	(3)	(4)	(5)	(6)
	-0.007 (0.021)	0.059*** (0.019)	0.001 (0.028)	0.026 (0.040)	0.078*** (0.028)	-0.037 (0.025)
<i>Controls</i>						
Population	0.012** (0.006)	-0.607*** (0.031)	0.012* (0.007)	-0.581*** (0.031)	0.008 (0.006)	-0.579*** (0.031)
Income	0.044*** (0.006)	-0.001 (0.007)	0.045*** (0.006)	-0.004 (0.008)	0.044*** (0.006)	0.002 (0.007)
Foreign Share	-0.052** (0.025)	-0.052 (0.037)	-0.054** (0.024)	-0.025 (0.037)	-0.063*** (0.024)	-0.024 (0.037)
College Share	-0.079*** (0.015)	0.035* (0.019)	-0.081*** (0.016)	0.032 (0.020)	-0.098*** (0.014)	0.032 (0.020)
<i>Spatial Lags</i>						
Creativity Indicator		0.113*** (0.040)		-0.106 (0.087)		-0.120* (0.063)
Population		0.352*** (0.070)		0.466*** (0.067)		0.457*** (0.067)
Income		0.003 (0.009)		-0.011 (0.009)		-0.006 (0.009)
Foreign Share		0.101 (0.062)		0.059 (0.063)		0.066 (0.062)
College Share		-0.132*** (0.038)		-0.108** (0.039)		-0.116*** (0.039)
Rho		0.257*** (0.067)		0.347*** (0.064)		0.321*** (0.065)
Sigma		0.002*** (0.000)		0.003*** (0.000)		0.003*** (0.000)
<i>Fixed Effect</i>	No	Yes	No	Yes	No	Yes
<i>Year Effect</i>	No	Yes	No	Yes	No	Yes
Obs	586	586	586	586	586	586

*Source:* micro-data of Census 1991, 2000 and 2010 from IBGE; author elaboration; spatial weight matrix is the inverse of the distance squared and their eigenvalues normalized; robust standard deviation in parentheses; variables transformed in log; \*  $p \leq 0.10$ , \*\*  $p \leq 0.05$ , \*\*\*  $p \leq 0.01$ .

In Table 4, we present the results using indicators of educational attainment instead of the creative class. Columns (1) and (2) show the results of the standard Ordinary Least Square approach and the Spatial Durbin Panel model, respectively, using indicators of the education of the graduates. Similarly, columns (3) and (4) show the results for the non-creative graduates. With respect to educational attainment, we can see that the share of the graduates has the highest statistically significant, positive coefficient among all of the indicators analyzed. This result suggests that for the Brazilian context,

Florida's creative class contribution is not as relevant as the widely used measure of human capital based on education level. For an additional comparative analysis between the creativity and education indicators as conditions of urban dynamism, we did the same exercise for the noncreative graduates. This examination helps to avoid the overlap problems between the education and creativity indicators. Again the coefficient is positive and significant and higher than that of the creative class. Overall, Tables 3 and 4 show that the indicators of education have a higher association with urban dynamism than do the indicators of creativity.

**Table 4: Associations Between Education Indicators and Urban Dynamism**

<b>Dependent Variable: Employment Growth</b>				
<i>Education</i>			Non-Creatives	
<i>Indicator:</i>	Graduates		Graduates	
	(1)	(2)	(3)	(4)
	-0.023 (0.018)	0.170*** ( 0.031)	-0.027 (0.019)	0.165** ( 0.030)
<i>Controls</i>				
Population	0.012** (0.006)	-0.568*** (0.030)	0.012** (0.006)	-0.567*** (0.030)
Income	0.044*** (0.006)	0.007 (0.007)	0.045*** (0.006)	0.006 (0.007)
Foreign Share	-0.047** (0.023)	-0.029 (0.036)	-0.047** (0.023)	-0.026 (0.036)
College Share	-0.054** (0.025)	0.007 (0.020)	-0.050*** (0.025)	0.005 (0.020)
<i>Spatial Lags</i>				
Education		0.061 (0.075)		0.090 (0.075)
Population		0.444*** (0.067)		0.436*** (0.067)
Income		-0.009 (0.009)		-0.007 (0.009)
Foreign Share		0.026 (0.061)		0.017 (0.061)
College Share		-0.124*** (0.038)		-0.127** (0.038)
Rho		0.306*** (0.066)		0.299*** (0.064)
Sigma		0.002*** (0.000)		0.002*** (0.000)
<i>Fixed Effect</i>	No	Yes	No	Yes
<i>Year Effect</i>	No	Yes	No	Yes
Obs	586	586	586	586

*Source:* micro-data of Census 1991, 2000 and 2010 from IBGE; author elaboration; spatial weight matrix is the inverse of the distance squared and their eigenvalues normalized; robust standard deviation in parentheses; variables transformed in log; \*  $p \leq 0.10$ , \*\*  $p \leq 0.05$ , \*\*\*  $p \leq 0.01$ .

It is important to note that the introduction of municipality fixed effect shrinks the power of explanation of the control variables income per capita, share of foreign individuals and share of college students. Nevertheless, the spatial coefficients remain imperative in the analysis. This suggests that the introduction of municipality fixed effect and spatial spillover effect are powerful. Moreover, municipality population size appears to have a negative effect on urban dynamism, perhaps owing to congestion

problems as discussed above, but it seems to have a positive indirect effect, suggesting spillover influence.

By calculating the total, direct, and indirect effects of neighbors we can measure the influence of spatial dependence more precisely, as pointed out by LeSage and Pace (2008). Table 5 shows the results for each indicator of creativity and education used in the spatial panel model. As we can see, the presence of creative individuals has a positive association with urban dynamism for both the direct and indirect effects. Consequently, the total effect of the creative class appears to be positive and significant. The creative graduates have different signs for the direct and indirect effects, but a negative total effect which is not statistically significant. The bohemian indicator has negative indirect and direct effects which are statistically significant. The indicators of education, represented by graduates and noncreative graduates, show positive direct and indirect effects, and both have higher total effects than any creativity indicator. These results strongly suggest that in the Brazilian context, education matters more than creativity to urban dynamism.

Our empirical analyses present different results from those found by Marlet and Van Woerkens (2007, 2004) and Mellander and Florida (2011) that identified a stronger correlation between regional growth and creative measures. Our results are also distinct from the findings of Marrocu and Paci (2012, 2013), who encountered a stronger correlation between regional growth and the subset of the creative class with higher education attainment.

**Table 5: Effects of human capital variables on urban dynamism: direct, indirect and total effects**

Effect:	Direct	Indirect	Total
Creatives	0.065*** (0.018)	0.169*** (0.053)	0.233*** (0.053)
Creatives Graduates	0.018 (0.041)	-0.145 (0.130)	-0.127 (0.146)
Bohemians	-0.045* (0.025)	-0.187** (0.087)	-0.232** (0.094)
Graduates	0.175*** (0.030)	0.159 (0.104)	0.334*** (0.113)
Non-Creatives Graduates	0.172*** (0.029)	0.194* (0.104)	0.365*** (0.112)

\*  $p \leq 0.10$ , \*\*  $p \leq 0.05$ , \*\*\*  $p \leq 0.01$ .

Standard deviations in parentheses.

## 5. Robustness Checks

In this section we check if the results above are robust with the inclusion of additional control variables and use of an alternative spatial weights matrix. More specifically, as we are dealing with the dependent variable that represents employment growth, we first examine if our results are explained by the productive structure of the cities. Secondly, we inspect the robustness of our results using a different matrix of spatial weights; this could be decisive if, for instance, the creative and education indicators presented different levels of spatial interaction.

The production structure of each municipality may play an important role in urban dynamism. It is plausible that the initial conditions of the labor market are correlated with the composition of the creative class occupations and other graduates within each municipality. In the case that our municipality fixed effect does not capture all of this impact, our coefficients may not be estimated with a high degree of accuracy. Therefore, we introduced in the Spatial Durbin Panel model variables to control for the municipal production structure. We measured the shares employed in industry sector, service sector, and public sector. Here we do not look at what is the routine task of each employed person. We just look at which sector he/she is working in to capture the production configuration of the municipality. This mechanism enables us to control for the initial conditions of the labor market and rule out potential coefficient bias associated to economic structure of the cities.

Table 6 shows the results for this robustness check. Again, among the creativity indicators, only the creatives measure has a positive and significant effect. However, the indicators of education still have a higher association with urban dynamism than creativity. Therefore, we can conclude that our results are robust for municipality production structure. It is worth noting that, as expected, the unemployed share is highly correlated with employment growth, since these are potentially employed in the long run. Moreover, the coefficient of the college share is always positive-significant, reinforcing the importance of educational attainment to urban dynamism. In relation to the production sector, the business and service sectors have a positive association with urban dynamism, while the public sector has a negative one.

For the spatial models in the previous section, we used a row-standardized spatial weights matrix which accounted for the inverse distance squared between all possible pairs of municipalities. However, Brazil is a huge country, and pairs are sometimes so distant that it does not make sense to consider spatial spillover between them. To account for this possible problem, we suggest an alternative spatial weights matrix as a robustness check, a row-standardized spatial weights matrix for the five nearest neighbors. The idea is to put all of the spatial weight in the very close municipalities. Thus, the spillover effect is limited to a few pairs of municipalities.

**Table 6 - Association Between the Creativity and Education Indicators and the Urban Dynamism****Dependent Variable: Employment Growth***Model: Spatial Durbin Panel*

<i>Indicators:</i>	Creatives (1)	Creatives Graduates (2)	Bohemians (3)	Graduates (4)	Non-Creatives Graduates (5)
	0.049** (0,019)	0,019 (0,042)	-0,032 (0,024)	0.162*** (0,031)	0.159*** (0,030)
<i>Controls</i>					
Population	-0.597*** (0,033)	-0.578*** (0,032)	-0.576*** (0,032)	-0.568*** (0,032)	-0.566*** (0,032)
Income	0,004 (0,007)	0,005 (0,007)	0,004 (0,007)	0,009 (0,007)	0,008 (0,007)
Foreign Share	-0,052 (0,036)	-0,044 (0,037)	-0,041 (0,036)	-0,041 (0,036)	-0,037 (0,035)
College Share	0.037* (0,019)	0.038* (0,020)	0.039* (0,020)	0,015 (0,020)	0,013 (0,020)
% Industry	-0,026 (0,018)	-0.032* (0,018)	-0.031* (0,018)	-0,022 (0,018)	-0,021 (0,018)
% Service	0,011 (0,040)	0,023 (0,041)	0,028 (0,040)	0,034 (0,039)	0,037 (0,039)
% Public	-0,022 (0,017)	-0.032* (0,017)	-0,028 (0,017)	-0.040** (0,017)	-0.038** (0,017)
<i>Spatial Lags</i>	Yes	Yes	Yes	Yes	Yes
<i>Fixed Effect</i>	Yes	Yes	Yes	Yes	Yes
<i>Year Effect</i>	Yes	Yes	Yes	Yes	Yes
Obs	586	586	586	586	586

*Source:* micro-data of Census 1991, 2000 and 2010 from IBGE; author elaboration; spatial weight matrix is the inverse of the distance squared and their eigenvalues normalized; robust standard deviation in parentheses; variables transformed in log; \* p < 0.10, \*\* p < 0.05, \*\*\* p < 0.01.

Using this spatial weights matrix we ran the spatial panel model for each creativity and education indicator again. For a sense of brevity, we suppressed the coefficients of the control variables from the results table. Table 7 shows the results of the spatial panel model for creatives, creative graduates, graduates, noncreative graduates and bohemians in columns (1), (2), (3), (4) and (5), respectively. As we can see, the sign and significance of the results remain the same. However, the distance dampened between the coefficients of the education and creativity indicators. Furthermore, the magnitude of the creatives coefficient increased, while those of the graduates and noncreative graduates decreased slightly.

**Table 7 - Associations between creativity and education indicators and urban dynamism**

<b>Dependent Variable: Employment Growth</b>					
<i>Model: Spatial Durbin Panel</i>					
<i>Indicators:</i>	Creatives			Non-Creatives	
	Creatives (1)	Graduates (2)	Bohemians (3)	Graduates (4)	Graduates (5)
	0.096*** (0.018)	0.019 (0.041)	-0.033 (0.025)	0.151*** (0.031)	0.149*** (0.031)
<i>Controls</i>	Yes	Yes	Yes	Yes	Yes
<i>Spatial Lags</i>	Yes	Yes	Yes	Yes	Yes
<i>Fixed Effect</i>	Yes	Yes	Yes	Yes	Yes
<i>Year Effect</i>	Yes	Yes	Yes	Yes	Yes
<i>Obs</i>	586	586	586	586	586

*Source:* micro-data of Census 1991, 2000 and 2010 from IBGE; author elaboration; spatial weight matrix is the row-standardized five nearest neighbor; robust standard deviation in parentheses; variables transformed in log; \*  $p \leq 0.10$ , \*\*  $p \leq 0.05$ , \*\*\*  $p \leq 0.01$ .

To be sure that the education indicators remain presenting higher impacts on urban dynamism than the creativity indicators, we calculate the total, direct, and indirect effects of neighborhood for both models. Columns (1), (2) and (3) of Table 8 show the results for direct, indirect and total effects with additional controls for production structure for each municipality. Here, the direct effect of graduates and noncreative graduates on municipality employment growth is still higher than the measures of creativity. However, the introduction of many controls increases the noise of the indirect effect, which cancels out the significance of the total effect of the graduate indicator. Nevertheless, the total effect of the noncreative graduates remains the only positive and significant result. Columns (4), (5) and (6) of Table 8 show the results for the direct, indirect and total effects of the model using the five nearest neighbors spatial weights matrix. The gap between the total effects of the creativity and education indicators actually widens, reinforcing the conclusion that for Brazil it is better for policy makers to support the accumulation of higher education per se, than focus on policies that aim at attracting professionals in a specific field, such as the creative class.



**Table 8- Direct, Indirect and Total Effect of the Creativity and Education Indicators on Urban Dynamism**

Alternative Model:						
Effect:	Additional controls			Five nearest neighbor		
	Direct (1)	Indirect (2)	Total (3)	Direct (4)	Indirect (5)	Total (6)
Creatives	0.050*** (0,019)	0,061 (0,054)	0.111** (0,055)	0.096*** (0,018)	0,012 (0,043)	0.108** (0,046)
Creatives Graduates	0,012 (0,042)	-0,179 (0,119)	-0,167 (0,134)	0,010 (0,041)	-0.209* (0,118)	-0,199 (0,133)
Bohemians	-0,035 (0,024)	-0,08 (0,074)	-0,116 (0,079)	-0,039 (0,025)	-0.157** (0,069)	-0.196** (0,077)
Graduates	0.163*** (0,030)	0,067 (0,088)	0.231** (0,094)	0.159*** (0,031)	0.275*** (0,091)	0.434*** (0,098)
Non-Creatives Graduates	0.161*** (0,029)	0,108 (0,086)	0.269*** (0,091)	0.157*** (0,030)	0.280*** (0,086)	0.437*** (0,093)

\* p < 0.10, \*\* p < 0.05, \*\*\* p < 0.01. Standartized desviation in parenthesis.

## 6. Conclusion

This study follows the debate initiated by Florida (2002) and Glaeser (2005) about what measures of human capital are better predictors of economic performance. Our intent is to contribute an empirical analysis of how urban dynamism in Brazil is correlated with worker abilities based on creativity and/or educational levels. This analysis should help policy makers decide what is the best strategy to support the accumulation of human capital.

Using microlevel data extracted from Brazilian censuses (1991, 2000 and 2010), we selected the 293 biggest municipalities and computed the urban characteristics that might simultaneously affect the presence of human capital and urban dynamism. Following the definition of creative class from Florida (2002) and adding the contribution of Marrocu and Paci (2012), we constructed five indicators for creativity and education: creatives, creative graduates, graduates, noncreative graduates and bohemians. Aware of the trade-off between omitted variable bias and multicollinearity problems, our analysis relies on the previous literature that shows the role of human capital in economic performance, and proposes to compare the coefficients of the creativity and education indicators as mere conditions of urban dynamism, instead of interpreting them as causes.

Besides cross-section regression and spatial cross-section analysis, which have been widely implemented in the literature, our paper goes further and proposes a Spatial Durbin Panel analysis. Thus, we control for time effect, municipality fixed effect and spatial spillover effect. We also measure the influence of spatial dependence more precisely by calculating the total, direct, and indirect effects of neighbor-city characteristics on the presence of the creative class and educated workers. As a robustness check, we include more independent variables to control for the production structure of each municipality. Additionally, we propose an alternative spatial weights matrix that increases the influence of the nearest municipalities.

The results prove that human capital plays an important role in employment growth at the municipality level in Brazil. Moreover, the comparison between the creativity and education indicator coefficients suggests that for the Brazilian context it is better for policy makers to support the

accumulation of higher education per se, than to focus on policies that aim at attracting professionals in a specific field such as the creative class. This result contradicts the hypothesis of Florida (2002) and clashes with other empirical findings in Marlet and Van Woerkens (2004, 2007), Mellander and Florida (2011) and Marrocu and Paci (2012, 2013), for instance. Thus, It appears that, in Brazilian case, before the idea of attracting creative professionals, local governments must to try to attract more educated migrants and to improve local schooling.

## References

- Andersen, K. V., Hansen, H. K., Isaksen, A., and Raunio, M. (2010). Nordic city regions in the creative class debate putting the creative class thesis to a test. *Industry and Innovation*, 17(2):215-240.
- Baltagi, B. (2008). *Econometric analysis of panel data*, volume 1. John Wiley & Sons.
- Benhabib, J. and Spiegel, M. M. (1994). The role of human capital in economic development evidence from aggregate cross-country data. *Journal of Monetary economics*, 34(2):143-173.
- Boschma, R. A. and Fritsch, M. (2009). Creative class and regional growth: empirical evidence from seven European countries. *Economic Geography*, 85(4):391-423.
- Cravo, T., Becker, B., Gourlay, A. (2014) Regional Growth and SMEs in Brazil: A Spatial Panel Approach. *Regional Studies* 48. 1–22.
- Da Mata, D., Deichmann, U., Henderson, J. V., Lall, S. V., and Wang, H. G. (2007). Determinants of city growth in brazil. *Journal of Urban Economics*, 62(2):252-272.
- DCMS (1998). Creative industries mapping documents.
- Donegan, M., Drucker, J., Goldstein, H., Lowe, N., and Malizia, E. (2008). Which indicators explain metropolitan economic performance best? traditional or creative class. *Journal of the American Planning Association*, 74(2):180-195.
- Elhorst, P. (2003) Specification and Estimation of Spatial Panel Data Models. *International Regional Sciences Review* 26, 244-268.
- Florida, R. (2002). The rise of creative class. *Basic Books*.
- Florida, R., Gates, G., Knudsen, B., and Stolarick, K. (2006). The university and the creative economy. *Journal of Urban Economics*.
- Florida, R., Mellander, C., and Qian, H. (2008). Creative china? the university, tolerance and talent in Chinese regional development. Technical report, Royal Institute of Technology, CESIS-Centre of Excellence for Science and Innovation Studies.
- Glaeser, E. (2005). Edward L. Glaeser, Review of Richard Florida's The Rise of the Creative Class. *Regional Science and Urban Economics*, 35(5):593-596.
- Golgher, A. B. (2011). A distribuição de indivíduos qualificados nas regiões metropolitanas brasileiras: a influência do entretenimento e da diversidade populacional. *Nova Economia*, 21(1).
- Inglehart, R. and Norris, P. (2003). Rising tide: Gender equality and cultural change around the world. *Cambridge University Press*.
- LeSage, J. and Pace, R. K. (2008). Introduction to spatial econometrics. *CRC press*.
- Longhi, S. (2011). Impact of cultural diversity on wages and job satisfaction in England. *Technical report, ISEI working paper series*.
- Lucas Jr, R. E. (1988). On the mechanics of economic development. *Journal of monetary economics*, 22(1):3-42.
- Markusen, A. (2006). Urban development and the politics of a creative class: evidence from a study of artists. *Environment and planning A*, 38(10):1921.
- Marlet, G. and Van Woerkens, C. (2004). Skills and creativity in a cross-section of dutch cities. *Technical report, Utrecht School of Economics*.
- Marlet, G. and Van Woerkens, C. (2007). The Dutch creative class and how it fosters urban employment growth. *Urban Studies*, 44(13):2605-2626.
- Marrocu, E. and Paci, R. (2012). Education or creativity: what matters most for economic performance? *Economic Geography*, 88(4):369-401.
- Marrocu, E. and Paci, R. (2013). Regional development and creativity. *International Regional Science Review*, 36(3):354-391.

- Mellander, C. and Florida, R. (2011). Creativity, talent, and regional wages in Sweden. *The Annals of Regional Science*, 46(3):637-660.
- Millo, G., Piras, G. (2012) splm: Spatial Panel Data Models in R. *Journal of Statistical Software* 47, 1–38.
- Moran, P. A. (1950). Notes on continuous stochastic phenomena. *Biometrika*, 37(1-2):17-23.
- Moretti, E. (2004). Workers education, spillovers, and productivity: Evidence from plant-level production functions. *The American Economic Review*, 94(3):656-690.
- Ottaviano, G. I. and Peri, G. (2005). Cities and cultures. *Journal of Urban Economics*, 58(2):304-337.
- Page, S. E. (2008). The Difference: how the power of diversity creates better groups, firms, schools, and societies (New Edition). *Princeton University Press*.
- Quigley, J. M. (1998). Urban diversity and economic growth. *Journal of economic perspectives*, 12:127-138.
- Rausch, S. and Negrey, C. (2006). Does the creative engine run? a consideration of the effect of creative class on economic strength and growth. *Journal of Urban Affairs*, 28(5):473-489.
- Reis, E., Pimentel, M., and Alvarenga, A. I. (2009). Áreas mínimas comparáveis para os períodos intercensitários de 1872 a 2000. Rio de Janeiro, *IPEA-DIMAC*.
- Resende, G. (2011) Multiple dimensions of regional economic growth: The Brazilian case, 1991-2000. *Papers in Regional Science* 90, 629-662.
- Romer, P. M. (1990). Endogenous technological change.
- Su, Q. (2011). The effect of population density, road network density, and congestion on household gasoline consumption in us urban areas. *Energy Economics*, 33(3):445-452.
- Silveira-Neto, R. M. and Azzoni, C. R. (2012). Social politycy as regional policy: Market and nonmarket factors determining regional inequality. *Journal of Regional Science*, 52(3):433 {450.
- Silveira-Neto, R. M. and Menezes, T. A. (2008). Disparidades regionais de renda no brasil: Analisando a importância do capital humano. In: Fundao Konrad-Adeneur.
- Tsekeris, T. and Geroliminis, N. (2013). City size, network structure and traffic congestion. *Journal of Urban Economics*, 76:1-14
- Wedemeier, J. (2010). The impact of the creative sector on growth in german regions. *European Planning Studies*, 18(4):505-520.
- Welzel, C. and Inglehart, R. (2013). Modernization, cultural change and democracy. *Foresight*.
- Wojan, T. R., Lambert, D. M., and McGranahan, D. A. (2007). Emoting with their feet: bohemian attraction to creative milieu. *Journal of Economic Geography*, 7(6):711-736.

## Appendix

**Table 8 - Computer and Math Category**

mathematical and statistical
systems analysts
developers of programs and applications (software)
developers of pages of internet (web) and multimedia
applications programmers
designers and management of databases

**Table 9 - Architeture and Engineering Category**

---

---

industrial engineers
production engineers
civil engineers
environmental engineers
mechanical engineers
chemical engineers
mine engineers
architects building
landscape architects
transit engineers
cartographers
electricians engineers
electronic engineers
telecom engineers

---

---

**Table 10 - Life, Physical, and Social Science Category**

---

---

physicists
astronomers
chemical
geologists and geophysicists
biologists
agronomists
economists
sociologists
philosopher
historians
psychologists

---