Education and Development

A spatial-econometric approach on spatial change and permanence in southern Brazil

Vinícius Floriani Martins

June 2016
Supervisor: Bo Malmberg
Department of Human Geography
Stockholm University
SE-106 91 Stockholm / Sweden

Images of urban duality in Paraná: Vinícius Floriani Martins
Abstract

Floriani Martins, Vinícius (2016). **Education and Development**  
A spatial-econometric approach on spatial change and permanence in southern Brazil

Urban and Regional Planning, advanced level, master thesis for master exam in Urban and Regional Planning, 30 ECTS  
Supervisor: Bo Malmberg  
Language English

Keywords: education, development, exploratory spatial data analysis, spatial econometrics, path dependence, Brazil, Paraná.

The Brazilian state of Paraná exhibits a violent geography of inequality and duality, hosting both the most developed city in the country, internationally recognized by its urban and environmental innovations, and southern Brazil’s most concentrated cluster of poverty and underdevelopment. Over the course of the past decades, the state underwent a major economic transformation, modernizing and increasing its industrial structure and shifting to the service sector with a larger participation of the knowledge economy. This study is concerned on the interplay between formal education and socioeconomic development during this process, and above all its spatial character. It attempts make sense of the rich literature on education and growth and/or development, discussing it through the lenses of human geography and planning. In order for the analysis to be possible, this study created a consistent database of municipal scores of education over the course of 40 years, dealing with changing census methodologies and municipal boundaries. Making use of modern exploratory spatial data analysis combined with spatial regressions, the study identifies a clustered, time-persistent interplay between education and development that is stronger for low and basic levels of education. Moreover, it provides evidence that not only education is a predictor of future development, but also that analyses of this kind must take into consideration spatial autocorrelation in order to be accurate.
Acknowledgements

To my supervisor, Bo Malmberg, for dealing with my stubborn ideas and for the guidance through the intense process around the elaboration and constant revision of this work.

Above all, I am immensely grateful for having such loving and supporting parents and grandmother, who have always inspired me on moving forward and helped me in the many moments I decided to “take a step longer than my legs” – as the endeavour of pursuing this Master’s degree in Stockholm. Thank you for teaching me the importance of pursuing what we believe is meaningful and right.

I also thank my brother, for all adventures here and there and for being such a fantastic and supportive person. Can’t wait to see where our next adventure will take us.

Lastly, I am grateful for having the opportunity of meeting and exchanging experiences with so many incredible people along this journey – no matter where we are, there is always someone we will be missing and a place we long for.

Obrigado!
List of Figures

1. “Blue Marble” picture, in its original orientation and the south pole on top..............................8
2. Paraná’s location in southern South America.............................................................................9
3. Forest cover in Paraná, 1890-1990(est)..................................................................................10
4. A. Share of the state GDP per sector, 2013; B. Share of employment per sector, 2010...............13
5. Distribution of average years of education per municipality, 2010; Household Income Gini Index...14
6. Municipal Human Development Index, 2000..........................................................................15
7. Satellite image of Paraná, depicting the main urban regions...................................................16
8. Iconic covers from The Economist on Brazil’s frustrated growth, 2009 and 2013......................17
10. Average Years of Education distribution per census year........................................................39
11. Univariate LISA depicting spatial clustering and outliers for A. AYE in 1970; B. AYE in 1980; C. AYE in 1991; D. AYE in 2000; E. AYE in 2010 and F. Location of the three largest urban areas......40
12. Univariate LISA depicting spatial clustering and outliers for the three sociodevelopment variables for each census year (1991, 2000 and 2010) and relative change (1991-2010) .........................41
13. Bivariate LISA depicting spatial clustering and outliers for local development per census year and spatially weighted education............................................................................44
14. Bivariate LISA depicting spatial clustering and outliers for local development and spatially weighted education in 2010, by education level (Low, Primary Education, Secondary Education or Tertiary Education) .........................................................................................................................46
15. Bivariate LISA depicting spatial clustering and outliers for development in 2010 and time-lagged education (A, C, E) and time-lagged development and education in 2010 (B, D, F).................................48
16. Univariate LISA depicting spatial clustering and outliers of the residuals OLS (A,B and C) and ML with autoregressive spatial error (D, E and F) models........................................................................51
1. Introduction

1.1 Aim, objectives and research design

It can be argued that one of the longest-lasting discussions in the field of political economy is the causal structure behind the enormous and time-resistant contrast between different economies when it comes to wealth and equality. Since the very first works that would come to be the underlying foundations of political economy, mentions of the role of education and learning in this context have been present – and still the vivid debate on whether formal education is capable of generating sustained development is far from achieving a consistent conclusion. While most developed nations have significantly higher educational scores, education itself has at times been argued to be a result rather than the cause of development as such, and more recent theories might even argue that education, under certain circumstances can be a means of perpetuating inequality.

This work attempts to grasp these complex dynamics by assessing a concrete state in a developing region in southern Brazil, during a 40-year period of very intense transformations and the start of the shift to a more knowledge-intense economic structure. In the scope of this study, the idea of development draws from the work of Nobel-prize winner Amartya Sen (1999), exploring development as a combination of “freedoms” ranging from political, economic, social, insight/planning and safety spheres of public and private life. Development as freedom, in the definition employed by Sen, enriches and emancipates the lives of individuals simultaneously as they become more capable of affecting and deciding upon their local realities – in a sense that emphasis is given to the capability of endogenously improving one’s own life conditions. Consequently, the quantitative approach of development present in this study explores three facets of underdevelopment that play a decisive role in the aforementioned capability – namely extreme poverty, income inequality and children vulnerability.

Bearing that in mind, the aim of this work is to verify and discuss the existence of spatially concentrated and causal relations between education and development over time, exploring the extent to which education can be considered to induce development. The main hypothesis of the study is as follows, divided into four concrete statements:

a) Education and development present a spatially correlated interplay over time, in a clustered dynamics in which some regions experience increases in both education and development, and others of concentrated disadvantage in a cumulative causation manner.

b) This spatial interplay between education and development is not constant across different educational levels (primary, secondary and tertiary education).

c) Municipal level of education can be seen as a predictor of future local development,
d) even though this relation is not homogenous in space.

The following chapter has the ambition of motivating the choice of the State of Paraná, in southern Brazil. It presents a historical-economic overview of the region since this country’s independence from Portugal, focusing on the factors that determined the current economic landscape of the region and on the most recent transformation process, which took place under the period observed by this study. The chapter has a quantitative approach, touching upon matters of growth, inequality and cases of endogenously-generated transformation that made its capital a role-model in terms of sustainable development despite of the deplorable conditions of most of the state.

The third chapter outlines the theoretical basis of this deductive study, elaborating on the growth imperative for this underdeveloped region and by that indicating the choice of the three main variables accounting for socioeconomic development. The main bulk of theories regarding the traditional role of education are commented and discussed, with focus on the potential for endogenous growth and transformation through the direct and indirect effects of education. The role of education is nevertheless assessed by contrasting this somewhat mainstream theoretical body to the so-called conflict approaches, in which education can come at play as a means of perpetuating inequality in developing regions. The author aims to make a spatial sense of both theoretical standpoints through the formulations of cumulative causation, by Nobel laureate Gunnar Myrdal, and the dimension of the dual-economy, widely employed in Latin America when exploring path-dependent dynamics.

A methods and data chapter describes the two main methodological approaches of this study, namely the spatial-statistic tool of Local Indicators of Spatial Association by Luc Anselin and the econometric approach with spatially auto-correlated disturbances. This chapter also comments on the data employed and the effort of creating a 40-year long time-series for educational attainment in the 399 municipalities of the state, taking into consideration that over 100 of them did not exist during the first two census rounds of the study.

A results chapter explores and tests each objective of the main hypothesis, divided into the spatial and the causal aspects for practical reasons. These results are then discussed in relation to the theory responsible for originating the hypothesis, with focus on the three clusters identified along the spatial analysis.

The final remarks of this study reflects upon its results and implications from a concrete, policy-oriented perspective, indicating future studies that could assist the utilization of this research for regional planning purposes.
1.2 Limitations

The empirical contribution of this work is built upon proxies that, in the view of the author, should capture the largest possible spectrum of the observed variables taking into consideration accuracy and availability of reliable data. Nevertheless, the discussion on how to measure education (and development, for that matter) is and has been worth of a rich discussion, which the author has no intention of devaluing. The variables built and created in this study are open for further discussion.

Due to the availability of data, a small discrepancy might be present in this study as the nation-wide Brazilian census of 1990 was postponed to 1991 due to resource limitations, increasing the gap between the previous census and reducing the distance to the next. The variables explored as proxies for socioeconomic development became available in this census of 1991.

1.3 Significance

This study is novel in the sense that it is the first examining education (including its different levels) and development in space and time simultaneously, providing a dynamic visualisation of this interplay that hopefully goes beyond static, single-moment analyses. In order for this endeavour to be possible, a database for education has been created and elaborated so as to account for all 399 municipalities in the state between 1970 (when municipal-level data on education became available in Brazil) and 2010, and this is the first study to do so in Paraná (perhaps even in Brazil). It overcomes the challenge of inconsistent census methodologies and major alterations in municipal borders, expecting that the data can be of use for further studies in the field of education.

The study is also significant to the extent that it provides a complex geographical set of analyses in a scale unit that is lower than the region as an entity, which allows both for the identification of intrastate clusters and a better understanding of the regional dynamics with less regard to artificial political boundaries. The results of the study indicate a concrete interplay between education and development, sustained over time and with the occurrence of spatially-concentrated dynamics in a cumulative causation manner. The spatial evidences are tested in a comprehensive econometric analysis, which is then assessed with the use of spatial statistics, reaffirming its robustness and raising the reflection on whether studies that are concerned about the effects of education and do not take into account spatiality can have their results questioned. The centuries old yet contemporary discussion on the role of education in development is contextualised in space with regards to its relevance for regional transformation and overcoming path-dependence.
1.4 Note on the south-up geographical orientation

As the reader might perhaps notice, all 58 maps used and designed for this work use a so-called south-up orientation. The effort in elaborating them so is motivated by the understanding of cartography as a subjective and scientifically inaccurate representation of a limited location, in an attempt to reflect upon one of the main tools employed in the department that hosts this study. Maps, as inevitably flawed representations, contain “arbitrary contours that function as visual devices normalising singular worldviews” (de Armendi, 2009 pp 5), which becomes especially relevant when dealing with social and political constructions and their effects in local and regional realities.

The use of south-up maps is, then, a political statement. The smooth rebellion against the standardisation of the widely used even though distorted Mercator projection, created for navigation purposes in the 16th century and increasing the north in size, is not of the author’s to claim – this movement has been present in Latin America and Australia since the early 20th century. Apart the examination of the current standard of world maps as a perpetuation of a Eurocentric, colonial mind-set, further research has also indicated that the north-up south-down association has a psychological consequence of an unconscious association of south as poorer and even inferior in various ways, which disappears when using a south-up representation (Meier et al, 2011; Nelson & Simmonds, 2009). In order to avoid “things going south” (and apologising for the contradictory but illustrative joke), the author hopes that the south-up representations can provide an interesting (and perhaps even exciting, for map lovers as the author himself) perspective on this rather unknown region up there in the south. Should the south-up orientation pose any difficulty for the interpretation of the results of this study, maps with north-up orientation can be provided by the author upon request alongside with the database created for this study.

Figure 1. The famous “Blue Marble” picture, taken by the crew of Apollo 17 spacecraft in 1972, in its original orientation and the south pole on top. Source: NASA

1 This projection visually increases both north and south latitudes, which are mostly comprised by Antarctica and ocean in the south. As a consequence, locations in northern latitudes have their areas distorted in a more serious way than locations in southern latitudes.

2 The author has taken the final decision in keeping this orientation after a positive response from his opponent, critical reader and moderator of the thesis seminar. Nevertheless, this feature is not meant to pose any difficulty for the reader – please do not hesitate to contact me should that be the case.
2. Paraná as a geography of inequality

2.1 Introduction

The economic landscape of Paraná displays a painfully clear pattern of spatial inequality, reproducing in its own territory one of the features Brazil is most famous for. Not only in terms of plain spatial inequality can Paraná be understood as a miniature “Belindia”, this very appropriate term used since the 70’s to describe Brazil as a country resembling India and Belgium simultaneously. This state displays some of the finest examples of path dependence from colonial times and clustered disadvantage, at the same time as it presents some national (and perhaps international) examples of endogenously driven transformation and sustained development.

Figure 2. Paraná’s location in southern South America.
Source: Google Maps

3 This expression was originally coined in 1974 the Brazilian economist Edmar Lisboa Bacha.
Paraná is one of Brazil’s younger states, as it only became a separate unit in what would come to be the Brazilian Federation when it detached from the São Paulo province, a few decades after Brazil’s proclamation of independence in the early 19th century. Originally part of the few strips of land given to Portuguese noblemen upon the conquest of the New World, this state (as many others) remained under the control of a handful of families well into the 20th century, and (the concentration of) land ownership still poses as a hot topic4.

The formal independence of Brazil from Portugal – and Paraná’s, for that matter - brought about a new range of possibilities with enhanced trade with the world and with the other regions within the Brazilian Empire, as industry was no longer illegal. The violent transformations that this state underwent from the early 20th century on are all but subjective: the forest cover of this state decreased from 83.41% in 1890 to mere 5.20% in 1990 (Gubert, 1988 – see Figure 3) – for the first, indicating the explosive dynamics of the economic expansion throughout the state; and for the second pointing out the resource-intensive, primary sector driven economic structure that established itself across an area half the size of Sweden.

Through most of its history (and, to some extent, still nowadays), the economy of the region has followed the ups and downs of the international commodity market. Its overall downward trend, in accordance to the Prebisch-Singer Thesis of declining terms of trade of primary commodities in relation to manufactured goods (Prebisch, 1950; Singer, 1950), has seen the emergence and disruption of a few commodity cycles – from mate tea to wood, followed by coffee and, more recently, a slight diversification with soybeans on the lead.

The industrial sector in the state orbited the primary sector since its origins, taking advantage of temporary booms and keeping a rudimentary technological level. When burning coffee as fuel for steam locomotives in a desperate attempt to keep the prices from falling during the Great Depression came an end, the coffee economy

4 Just while this work was being written, two members of the Landless Workers’ Movement, possibly the largest organised social movement in Latin America, were killed in a military police raid in one of their camps in Paraná.

Figure 3. Forest cover in Paraná, 1890-1990(est).
experienced an expansion strong enough to lift the industry and the state as a whole, in rates even higher than the neighbouring state of São Paulo. Paraná’s agriculture-based industry, during the period when coffee was the main crop, was responsible for 3.2% of the national industrial output – even during the heavy industrialisation process that had its epicentre in São Paulo in the 1950’s (Leão, 1989 pp 33). It is quite a significant figure, having in mind the modest size of the population and the low technological level of the industry at the time.

The northern portion of the state, directly exposed to this process, experienced this economic and demographic boom most intensively – the birth of the second and third largest cities in the state (Londrina and Maringá, respectively) date from this period and both cities are still heavily dependent on agriculture as of today. This specific area grew from 340,000 thousand inhabitants to over a million in 1950 in only 10 years (Padis, 1981 pp 94).

2.2 Modernisation and the knowledge economy

The largest and most crucial demographic and economic transformations in Paraná’s modern history, however, were set in motion with the intense process of agricultural modernisation in the 70’s. As larger landowners had easier access to capital and took the first steps towards the introduction of heavy machinery in the fields, the remaining family-owned properties had very reduced chances in competing with the increasingly large scale of the more technology-intensive latifundios. The immediate consequences of this process are twofold: a vertiginous urbanisation process was set in march, with the expulsion of the rural workers resulting in the urbanisation rate increase from 36% in 1970 to 59% in 1980 and 78% in 1990; and a significant migratory flow out of the state, consisting of 1.2 million individuals. In contrast with the rest of the country, Paraná’s population growth stagnated in the 70’s, after tripling since 1950 (Moura, 2004).

The absorption of more technology-intensive production processes was not exclusive to the primary sector during this period. Concomitantly with the massive out-migration from the fields and the urbanisation process, a nation-wide development plan with emphasis on heavy industry took place, which resulted in the diversification of the industrial structure until the early 80’s (Rodrigues et al, 2007). Paraná became the proud host of automotive and a few other technology-intensive industries, attracted by a wide array of fiscal benefits offered by both the state government and the municipal administration.

---

5 Latifundios are by definition large (over 500 hectares) privately owned commercial estates, which dominate the land tenure structure across Latin America.

6 The 2nd National Development Plan (II Plano Nacional de Desenvolvimento) took place between 1975-1979, under one of the most repressive moments of the authoritarian regime. It relied on heavy external debt in order to establish a solid industrial basis in a ISI-manner. Its legacy remains ambiguous, achieving some success in terms of transforming the productive structure at the same time as it triggered the debt crisis that lasted for most of the following decade.
of its capital city, Curitiba. This coordinated development plan resulted in the creation of the state’s largest industrial park, “Cidade Industrial de Curitiba”, within the municipal limits of its largest urban centre.

The proximity to Brazil’s oldest university, the richest consumer centre in the south of the country and reasonably good infrastructure connections to both regional and global markets were pointed out as strong competitive factors, which depended however on the creation of industrial credit by the Paraná State Development Bank and the dynamism of the primary sector as factors that turned feasible the development of local industry (Castro, 2005). The knowledge-intensive companies that moved to the new industrial region also referred to direct fiscal incentives through tax exemptions or even direct participation in the initial investment as decisive advantages (Castro, 2009). Despite the intense transformative character of this process, it was unable to generate enough growth and inclusiveness to accommodate the intense influx of mostly unskilled workers to the urban centres, most remarkably the capital - the unemployment rate in the capital was permanently higher than the state average during this period (Moraes Neto, 2005).

These two parallel forces, namely the agricultural modernisation resulting in higher land concentration and the interplay between urbanisation and industrialisation, were not directly addressed by regional policy-makers in regard to their spatial character. The vast majority of smaller municipalities was excluded from this transformative and dynamic process of induced development, which deepened the pre-existing disparities between the urban and the rural and formed much of the spatial pattern one can perceive today.

The livelihood of the nowadays over 11 million paranaenses reflects the transformations of the 70’s in many ways. It can be argued, even further, that this process has yet to be completed – the outflow of migrants from the fields still takes place, and the index for land concentration is higher at every new census as displayed in Table 1.

The rapid urbanisation process, in its turn, established the dominance of a service economy at the same time as the industrial sector surpassed the agriculture – in terms of outcome and employment (see the current economic structure of Paraná in Figure 4). The massive shift from a primary, resource-intensive production structure to a more knowledge-dependent economy with a larger participation of the services and industrial sectors laid a heavy burden on the state – the municipal average for years of education, considering the population above 25 years of age, was of 1.47 years in 1970. The challenge of kick-starting a transition to a knowledge-based economy in a region where the endowment of knowledge was so scarce helps understanding the outcomes of the new spatial arrangement after the urban-industrial
transformation: at the starting point of this process, Curitiba’s population scored over 4.5 years of formal education on average for the adult population – whereas the lowest value in the state was of 6 months only. 53 of the 289 municipalities in 1970 (nowadays 399) scored less than one full year of formal education at that time.

Being unable to connect to this dynamic process not only deprived these municipalities from the outcomes of it – but actually rendered them incapable of making the costly investments required to improve basic education. The federative distribution of attributions between the different governmental levels (municipalities, states and the federation) has been structured in a way that the final responsibility for basic education is of the municipalities alone, a sometimes unsolvable challenge for the smaller municipalities who do not benefit from the outcomes of the new economy and thus cannot invest to "produce" the requirements to take part in this process. In one of the poorest regions, the central north, municipalities with less than 20,000 inhabitants generated on average only 3.80% of their funds by 2002, the remaining being direct transfers from state and national government (Organisation for Economic Co-operation and Development - OECD, 2011).

This endless cycle of disadvantage takes a spatial dimension when such municipalities are surrounded by other municipalities in similar conditions – the timid advances in physical infrastructure that took place from the 70’s shortened the distance between places increasing interaction between municipalities, but the proximity to disadvantaged neighbours will share a very limited range of assets – if any at all. These disadvantaged municipalities account nowadays for a cumulative set of relative low education, high income concentration and lower living conditions in general – the regions from which most migrants fled in the 70’s are also those with lowest education scores nowadays, which coincides with

**Figure 4.** A. Share of the state GDP per sector, 2013; B. Share of employment per sector, 2010. Source: Own graphs with data from IPARDES
the municipalities that could not take part in the industrial transformations that began in that decade and today account for the highest levels of income concentration.

Even in qualitative terms, the spatial distribution of education throughout the state follows a similar pattern (see Figure 5) – the average scored by primary level students in Curitiba is the highest among all Brazilian capitals, while the result for the rest of the state (excluding its capital) is the worst among all 10 states in Brazil’s south, southeast and midwest regions.

Taking the risk of being redundant, Figure 6 displays the municipal scores of Human Development Index, comparing Paraná and the neighbouring states of São Paulo, Santa Catarina and Rio Grande do Sul: the proportion of municipalities with HDI scores below the Brazilian average in Paraná reaches over 70% of the total. In the other southern states, the percentage is below 30%. (Paraná Institute for Socioeconomic Development – IPARDES, 2003).

It is not unexpected that this disparity would remain regarding the income distribution within the state – the 10% richest municipalities average twice as much as the national average (with a few outliers reaching Swedish levels of per capita income), over 4 times more in relation to the 10% poorest in 2013. It is rather unsettling, however, that quite a few municipalities in both deciles are found within the limits of the Metropolitan Area of Curitiba, clustered according to their income levels, indicating that perhaps there are stronger spatial forces at play that prevent the disadvantaged municipalities from connecting to the dynamism of Curitiba.
Despite its internal patterns of inequality, Curitiba is often seen as a role model in terms of innovation and sustainability - as of 2010, it won the Swedish-based “Global Sustainable City Award”*, beating competitors such as Sydney and Malmö. Despite its motto of “Green Capital” in Brazil, half the industrial production of the state is located within its Metro area. With over one third of its population holding a university degree, Curitiba has been the environment for a few vanguard urban innovations, such as the first pedestrian street in Brazil and the Bus Rapid Transit system, now exported and further improved by over one hundred other cities across the globe. Visiting Curitiba would make it nearly impossible to visualise the reality of its surrounding state, if it weren’t by the fact that even within the limits of its municipal boundaries the patterns of spatial inequality are very well reproduced: in terms of average income, its richest neighbourhoods possess the same income levels per inhabitant are those found in Norway, whilst others score Fiji’s level of income – ten times poorer* (Floriani, 2013). Even the most innovative facets of the capital Curitiba cannot detach from the dynamics of power and income concentration that prevail throughout the state – nearly 70% of its renowned bus fleet, which serves over two million inhabitants as the only means of public transportation, are under the hands of one single family.


* This calculation was made to the average income of each neighbourhood, transformed into annual per capita GDP following the same proportion observed for the city as a whole. The amount was converted into PPP US Dollars and compared with data from the World Bank for per capita GDP. An article utilising this data as a base for interviews on how local inhabitants see this explicit inequality can be found at http://www.teianoticias.com/2013/09/13/curitiba-comporta-pib-de-singapura-e-africa/ (Moreira & Kolb 2013)
While Curitiba struggles to keep its image of innovativeness and sustainability, the rest of the state seems to have no difficulty to live up to its nickname as “Brazil’s Granary”. Accounting for over one fourth of Brazil’s agricultural production in the 90’s despite representing less than 3% of its total area (Wons, 1994) Paraná’s latifundios still break productivity records (IPARDES, 2016) as of 2016, drawing more attention in the national context as its export-driven primary sector manages to help balance the national balance of trade by keeping a steady inflow of international currencies through exportation – as it has been doing in through many crises in the past (Castro, 2005). Even though having a steady inflow of external currencies and less dependence on the U.S. market come as strategic in the short term, the concentration of land (and thus power and income) within a few wealthy families creates further barriers on the way to a more just distribution of resources and even a more sensate view towards the environment. While Curitiba’s mayor travels to Stockholm to receive a sustainability award, a few hundreds of meters away from Curitiba’s City Hall the workers of the building that hosts the government of Paraná are concerned on how more strict/sustainable environmental laws may affect their next harvest.

The list of examples on the dichotomy between the more developed and the primary sector-based structures within this same state goes on, adding on experiences of sustained and self-reproducing inequality that are very much dependant on its spatial arrangement. The key role of education in the very meaningful transformations that this state underwent since 1970 motivates the further study of the inter-relation between this endowment and developmental outcomes of the localities – in terms of poverty, inequality and vulnerability. The manner on which this inter-relation seems to be bound to space justifies the spatial approach of this study. The next chapter discusses the interplay between education and development, as well as a brief discussion of its spatial dimension.

Figure 7. Satellite image of Paraná, depicting the main urban regions (from most populated) – Curitiba, Londrina, Maringá, Ponta Grossa and Cascavel.
Source: Google Maps
3. Education, Development and the importance of Space

3.1 Introduction – the growth premise

This study embraces and defends the view that economic growth remains a crucial political goal for the specific object of this work – the state of Paraná, in southern Brazil. This is not to disregard the existence of an exciting debate on whether growth should continue to be the central economic target of the world’s richest economies, naturally. Brazil’s annual per capita income in terms of current PPP US dollars reached $15,950.64 as of 2015, below one third of the amount scored by the G7 (the group formed by the 7 richest economies in the world, concentrating 64% of the net global wealth) – in 1980, the Brazilian income per inhabitant was nearly half of that of the same group of countries (International Monetary Fund - IMF, 2015). The widening gap between rich and poor countries, in this case one of the emerging “BRICS” markets, could perhaps be enough of an argument to hold fast to the pro-growth politics – how should one expect the reduction of the income gap between richer and poor/“emerging” markets by fighting against the latter’s efforts to achieve higher economic outcome?

The first argument used to back the need of further increases in the economic output is thus the imperative of moving away from poverty. The comparison with the “developed world” only intends to illustrate the global process of income concentration along which many of the underdeveloped regions only see the distance towards development widening further on. Naturally, this perspective does not want to imply development as an obvious path that will inevitably lead all countries towards equilibrium, as other theories have indicated in the past. Development here is seen as process and a goal that needs to be pursued actively, in which wealth figures as an important enabler but never as a final target by itself. Thus the first role of growth in the development process, as a crucial means of overcoming poverty.

Figure 8. Iconic covers from The Economist on Brazil’s frustrated growth, 2009 and 2013. Sources: The Economist.
A second argument, and equally relevant for the Brazilian context of chronic inequality, is that economic growth is vital in order to sustain a distributive economic policy. In a country where a few (very) rich individuals control most of the political system and, consequently, policy elaboration and implementation, it is difficult to imagine a continuous income redistribution programme in times of economic retraction – reducing the Gini index through times of crisis can only be done by transferring from the richer to the poorer. Having in mind Brazil’s regressive tax system, this “Robin-Hood” strategy is simply unrealistic, as it is easier to imagine a scenario in which all layers of the income distribution become richer – and the lowest ones do so more rapidly. Evidence has been found that growth has had a significant role in poverty and inequality reduction in Brazil, indicating that poor economic performance was the main barrier for a greater income distribution between 1985 and 2004 (Ferreira, Leite and Ravallion, 2010), even when social security and social assistance transfers were put in place. The current political turmoil and withdraw of a series of social security structures following the recession in 2015 is a clear illustration of the above.

It is equally important to note, however, that the effects of growth in development (be it in terms of poverty and inequality, for example) are not to be taken for granted. The growth elasticity of poverty reduction (to use the example of the previous study) can vary tremendously, depending for example on the initial endowments of each specific region – human capital, in the Brazilian case (Ferreira, Leite and Ravallion, 2010). After the military coup in Brazil during the 60’s, the leading economic strategy was, as put by the military themselves, to “grow the cake first and split it later” – this “later” would have to wait some 50 years to take place, a couple of decades after the democratisation, when the Gini index showed some minor improvement. In other words, understanding that growth might be necessary for sustainable poverty and inequality reduction is not to say that growth itself automatically ensures these outcomes.

The third and last argument in favour of growth-aware policies is that it is intimately connected to investment. Taking the risk of remaining in the realm of pure theory, economic growth enables and fosters productive investment, essential in times of change. A growing economy can more easily accumulate capital and strengthen or reshape its economic basis, building the basis to a less import-dependent economy or perhaps investing in the formation of human capital for a shift to a productive structure that adds more value to its products. Whilst countries can, most of the times, resort to external sources of credit (even if with debatable consequences), poorer regions mostly experience that credit is not as readily accessible, rendering them more susceptive to the up- and downturns of the economic cycles, which are especially violent within commodity markets. A growing economy is expected to have higher capability of making long-term investments, for example increases in education.

In line with the aforementioned arguments, the effects of economic growth cannot be expected to be the same (or even positive, for that matter) across different locations. If the current endowments and the economic structure of a given locality influence its outcomes in terms of development in relation to
growth, at the same time as the first are directly dependent on this locality’s capacity of accumulating capital and making productive, long-term investments. In this sense, and emphasizing the caution that should be taken when advocating in favour of growth-based policies, increases in the economic output are a necessary, yet not self-fulfilling means of achieving long-term development. While growth can bring an array of opportunities to a given locality, the dynamics through which it came about may also help understanding to what extent its outcomes will benefit the local population – an increase in commodity prices affecting a municipality where a family owns more than half the land and thus concentrate the earnings of this externally generated growth will certainly have different short- and long term effects compared to increases in the competitiveness and on the market share of the local industry in a urban location.

3.2 Heterogeneous growth dynamics within a region – the struggle for development

The argument advocating for growth does not need to be tested too harshly to raise questions on whether growth in itself has all the transformation potential to generate development in localities with very different economic structures. It is a pre-requisite for development, at the same time as it is incapable of achieving and sustaining it through unregulated market mechanisms – in fact, in conditions found in most underdeveloped regions, growth is captured by the unequal structures in a locality in a dynamic that enhances what Myrdal (1957) would come to define as the circular cumulative causation. The observed lack of convergence between localities, be it the municipalities within a state or the growing disparities between poor and rich countries, present a very decent illustration of how “virtuous” economic dynamics tend to achieve and sustain an elevated performance, whereas in other places this cumulative causation moves the system downwards, exacerbating the existing inequalities in a “vicious” pattern.

The system is by itself not moving towards any sort of balance between forces, but is constantly on the move away from such a situation. In the normal case a change does not call forth countervailing changes but, instead, supporting changes, which move the system in the same direction as the first change but much further. Because of such circular causation as a social process tends to become cumulative and often gather speed at an accelerating rate.

(Myrdal, 1957 pp 12–13)

Myrdal’s proposition is central to this work, which will attempt to see it as a starting point towards the discussion on how the negative, vicious patterns could be broken. It is important as it denies any kind of spontaneous development brought about by market mechanisms, and focuses rather on endogenously designed endeavours as the one behind the previously mentioned transformations that took place in Curitiba since the 1970’s.
The second main theoretical body of this work regarding the spatial traits of economic growth stem from Boeke’s (1953) formulations on the dualistic economic systems. This approach was vastly embraced by ECLAC in Latin America – complementing Myrdal’s theory in the sense that it explores the dynamics between regions that move ahead of others due to some initial endowment (Binns, 2012), as previously indicated, and lagging regions that sustain pre-development or colonial features.

Boeke’s inspiration on his seminal work was the economic disintegration afflicting Asian countries halfway through the 20th century, where the heritage of colonial domination presented itself as the coexistence of a somewhat modern economic sector and a largely underdeveloped, agricultural one. In the original theory, these two different social and economic systems are perpetually conflicting, in a dynamic that finally hinders any integrated growth strategy. With the refinement of the original theory by Arthur Lewis (1954), the interplay of these two sectors begun to be seen as a relation of exploitation, in which the labour surplus of the low-income sector acts as a downward force on the salaries of the expanding urban sector.

This spatial approach on Marx’s ([1867] 1967) concept of reserve army of labour describes quite precisely the dynamics of rural exodus and urban unemployment experienced in the dualistic structure still present in Paraná. The emphasis on the productivity differential given by the dualistic theories (Higgins, 1959) occupies a central position in this theoretical approach – even though little or no differentiation is made between growth and development is made, the dual economy theory is relevant in the sense that it explores the intra-state relationships between modern and “pre-developed” regions, as well as the additional challenges they pose in terms of development policies (Baran, 1957). A typical analysis restricted to the most dynamic and modern sectors of a region’s economy, focusing on them as such as the main economic forces, will most likely result in a perpetuation of the regional disparities between the locations where these sectors are located and the remaining detached localities in the same region or state. This sensibility is perhaps the main contribution of the dualistic perspective, as it inserts the imperative of inclusiveness and spatial-awareness to any policy statement that aims to be truly devoted to socioeconomic development in the long run.

The common ground of the complementary theorisations of cumulative causation and dual economy is that both indicate the strong influence of path dependence, be it due to circular causation processes or to the early endowment differentials evolving into dual – and exploitative relations in space. In Latin America as a whole, studies on path dependence and its relations to economic growth and development are intimately related to the continent’s postcolonial heritage and its struggle to develop an adequate strategy of endogenous growth. Postcolonial development theory in Latin America, still rather influential since the counter-hegemonic works of ECLAC in the 60’s and 70’s, argues that variations in the level of colonisation during the mercantilist and the liberal phases of Iberian control over Spanish and Portuguese America played a crucial role in determining the pre-conditions for any development prospects. A strong imperialist grip in any given region during the mercantilist phase, enhancing
structures of inequality and exploitation, would ensure that this specific region would face long-term development difficulties, whereas being a colonial centre during the more liberal period of European domination could help forming the economic bases for commerce (Mahoney, 2010 pp 250).

Embedding the analysis with this (too briefly mentioned) notion of postcolonial development helps visualising the centuries-long struggle of all Latin American states and regions in overcoming the path-dependent structures of deprivation in a myriad of endeavours aiming for achieving a successful, long-term endogenous growth strategy that deviates from the original dynamics of cumulative causation. This struggle became even more intense when the U.S. hegemony over the continent, which begun after European domination was replaced by the motto “America for the Americans”⁹, started fading away simultaneously with the decline of a dozen of dictatorships implanted by the U.S. across the continent since the 60’s.

Overcoming path-dependence as protagonists of their own localities has been having a multitude of facets since the re-democratisation processes, with varying spatial and social outcomes. In fact, even the extent to which democracy exists in practise became subject of intense discussion and deconstruction, in terms of human rights (and especially sexual rights (Htun, 2003), LGBT rights (Encarnación, 2011) governance and minority rights (Eisenstadt et al, 2013)), the effects of globalisation when it comes to power relations and bottom-up democracy (Santos et al, 2005), and the emergence of the Landless Workers Movement (nowadays with approximately 1.5 million members across the country). These processes and discussions rise along an infinitude of flourishing movements that emerged with the coincidence of the decline of the North-American hegemony (Williams, 2012; Fernandez-Armesto, 2003), the end of the oppressive dictatorship and the momentum gained during the anti-IMF movements during the liberal crisis in the 80’s.

This myriad of forces struggling to pro-actively break with the historical and vicious circles of deprivation in the many facets related to a development process, however, were not accordingly followed by a consistent improvement in terms of spatial inequality throughout the state of Paraná. Through the ups and downs of the few nationalist “development”-inducing projects implemented during the military government, the spatial outcome of the Import Substitution Industrialisation strategy (Furtado, 1986) was the reaffirmation of the hierarchy within the state, perhaps deepening the distances between the livelihoods in the urban and in the rural regions, hardening the dual pattern in the state as previously discussed. While all facets of development are of relevance, due to the scope of this work emphasis will be given to the interplay between growth and socioeconomic development, seeing education as its main engine having in mind the economic transformations discussed in the previous

⁹ Motto of the Monroe Doctrine, issued in 1823 along the independence process of most Latin-American countries, as an affirmation of USA supremacy over the remaining American nations.
chapter. The following section aims to explore the different approaches on the role of formal education in the prospects for growth – and, most importantly, development.

3.3 Education and Development

If there is any chance of achieving some sort of consensus among economists on any given question, it is likely to be that, direct or indirectly, all major economic theories throughout the history of economic thought deal with the issue of growth. The infinitude of economic “prophecies” dictating the destiny of all nations around the globe, in what comes to their wealth, can be divided into two major groups: those that derive from theories predicting an unconditional convergence among countries in the long run, and those who would rather preach for more protagonism as convergence would depend direct and exclusively on the concrete conditions and struggles of each individual country. In practice, the consequence of this thought is all but superficial: understanding that convergence will not take place on its own implies a whole different approach than relying on the “wisdom” of pure market economy.

In general terms, history gives us very little evidence of involuntary convergence, which had been theoretically defended as an undeniable result of the decreasing returns in any production function. This theory would argue that classical production factors, if unaltered, yield fewer returns to the locations where they have been employed most extensively, ceteris paribus (most famously known as the Solow (1957) model of growth). If the contrary was to be valid, poorer economies should perceive higher initial returns to the same production factors, which does not seem to have been the case in most African, Latin-American and Asian low-income economies in modern times.

The search for the real determinants of economic growth began questioning the residual of the Solow model, assigned as exogenous, spontaneous and readily available to all nations’ technological progress. Despite the (much appreciated) failure of Thomas Malthus’ infamous predictions on how humankind would not have the means of producing enough food for its growing population, the fact that starvation still persists indicates that this exogenous technological progress is perhaps far from being accessible (or absorbable) everywhere. *Endogenous* growth theories, then, cast the light on the internal factors in the concrete region being analysed, attempting to identify and explore not only the internal potentials of growth generation but also the capacity of absorbing and adapting external innovations, incorporating variables such as knowledge spill over, human capital, expenditure in Research and Development (R&D) and other activities related to innovation (Além, 2010). These theories see technology and technological change as non-spontaneous processes, consciously induced with the final purpose of obtaining increases in the economic output and wellbeing (Cypher and Dietz, 2002).

The analysis of which factors play the most crucial roles in escaping diminishing returns through innovation has been vast, and a fair share of it stem from Schumpeter’s seminal work on innovation, entrepreneurship and creative destruction (in “Capitalism, Socialism and Democracy”, Schumpeter,
This intermittent process is expected to have the ability of revolutionising the economic structure of a given location, as long as it can be put together through the interplay between credit, entrepreneurs and the inventions themselves\(^\text{10}\) (Schumpeter 1982). The entrepreneur, being entitled by the society to the employment of production factors through the availability of credit (be it from private or public sources), is then the responsible for transforming this invention into an efficacious and productive innovation, making the jump from inventions to functioning innovations. In the original Schumpeterian theory, the social nature of this process is present from the moment when bankers, speaking in the name of society as a whole, decide to provide the entrepreneur with credit for purposes that benefit the society as a whole. Later theories would examine the larger role of the public supply of credit in what comes to the bigger social interest, due to the heterogeneous and perhaps insufficient supply of long term credit in the private sector of less dynamic regions (Romero, 2007).

At the same pace as innovations played an exponentially bigger role in the growth of the larger economies, the attention given to knowledge as an asset and pre-requisite for the participation in the increasingly knowledge-intensive new economy increased significantly. The gains obtained through education and learning have been discreetly present in the economic theory since what many consider its formal birth, in the works of Adam Smith (1776). In these original thoughts, the skills and abilities acquired through professional experiences, education and learnings of different kinds, if useful, become part of one’s fortune – and of the society as a whole. It was not before the incognita of the aforementioned Solow Residual that the phenomena of innovation and its stark correlation with formal education gained proper attention – not without a fair dose of resistance, it was argued at that time that individuals could and should not be seen as tradeable market objects (Savvides and Stengos, 2009). The milestone work of Theodore Schultz, in the early 1960’s, first developed the concept of “human capital” and enabled it to integrate a production function alongside work capital and labour. His pioneering work argues that a meaningful share of the national income derives indeed from the investment in people, which, after being accounted as increases in the stock of human capital, was able to explain the growth differentials between nations and even regions within a given country (Schultz, 1960).

Schultz observed the transformations experienced in the United States during the first half of the 20\(^{\text{th}}\) century, especially the changes in physical capital and labour – on average lower than the total economic growth in the period. This difference, namely the “excess” of growth in relation to the total change in the employed production factors (labour and physical capital) had been “explained” as a residual, which now was to a large extent attributable to changes in human capital. Schultz’s measures for the period indicate that human capital experienced growth in a larger rate than both other production factors, perhaps suggesting a higher return rate for human than for physical capital (Schultz, 1961).

\(^{10}\) \textit{In the sense that an innovation as such needs to complete the market implementation process after its creation as an invention.}
The methodology used for empirically estimating the stocks in human capital extended into calculating the bulk of investments required for its formation, comparing the gains of workers in different ages and occupations with the foregone wages of those in the same age who invested their time in formal studies instead – which was then compared with the traditional investments in education (building the schools, investing in and hiring teachers, and so forth). The result of this comparison is that more than half of the total investment required to increase the stocks of human capital, which accounted largely for the economic growth in the period, came from the individuals themselves – in the form of opportunity cost. Between 1990 and 1956, the participation of the foregone wages and production due to the time privately spent on education instead of working increased its share in the total investments in human capital formation in the United States (Schultz, 1960), which is critical in the poorer regions where individuals cannot afford not to work. Schultz alerted for the fact that this notion, at that time, was simply absent in national policies for education and development.

The result of investing in education, according to Schultz, is that individuals increase their possibilities in terms of future opportunities, as well as productivity gains and, naturally, income gains. Moreover, human capital formation incurs the formation of social benefits that are not necessarily appropriated by individuals themselves, as the possibility of incorporating and employing innovations in a more efficient manner. In a duly supply and demand function, the formation of human capital (dictated in a large extent by the individual “supply” and both individual and social “demands”), will never reach a hypothetical social optimum as individuals do not envision social gains when investing their resources in their own education. As a direct consequence, the formation of human capital requires some sort of public stimulus or subsidy in order to increase the supply side (individual choice) until it reaches the adequate equilibrium (Cypher e Dietz, 2002).

Quantifying human capital, however, has ever since been an object of intense debate. Schultz suggested a typology in which the stock of human capital was formed through five different channels, including health services, people’s strength and vigour, work training, formally organised education (including primary, secondary and tertiary schooling), and even migration as an optimiser of capital allocation through changes in the labour market (Schultz, 1961). A glimpse of these variables is perhaps enough to perceive how challenging it might be to quantify human capital as such, which must not reduce the importance of qualitative measures of education by any means. As indicated by Schultz, even though the largest share of the education costs relied on the individual itself (as an opportunity cost), the actual gains of the investment in education were a direct result of its quality, beyond individual control. Current proxies aiming for a fair representation of both quantitative and qualitative aspects of education have been vastly debated in econometric studies, commonly using the measure of years of education in an attempt to measure the effects of investment in education for the formation of human capital.

Needless to say, these notions are even more relevant in developing regions, for which development theorists employ the concepts of “human capital broadening” (expanding the reach of human capital
formation) and “human capital deepening” (the quality and efficiency of human capital formation) (Cypher et Dietz, 2002). A broad coverage of formal education systems, as it is the case of richer developing countries such as Brazil, does not ensure all enrolled individuals will have equal gains from it – the way access to higher levels of education is still a privilege is a good example of how the inequality in the quality of schooling plays a crucial role and will be discussed further on.

In examples from more recent models that include human capital in the production function, as in Lucas (1988), the economic growth rate presents a high correlation with the time and resources deliberately spent on human capital formation – and, most importantly, with the efficiency with which this process takes place, emphasising the role of quality of education. Their model does not see human capital as a production factor side by side with physical capital, but explores the efficiency of its formation in an endogenous manner. The growth rate in this model is directly proportional to the efficiency of the human capital accumulation and the time spent in this process, controlling for exogenous technological appropriation.

Other empirical and theoretical works, including milestones in the field, indicate the presence of mechanisms through which education leads to economic growth. In Mankiw, Romer and Weil (1992), education is seen as a production factor that can be accumulated within the neoclassical framework and under the label of human capital. Aguion and Howitt (1998), as well as Romer (1990), suggest that it enhances an economy’s potential for innovation, whereas Benhabib and Spiegel (2005) and Nelson and Phelps (1966) argue that education eases the knowledge sharing processes that are required for the implementation of technology-based innovations. Moreover, in the work of Becker, Murphy and Tamura (1990), initial stocks of human capital present a stark correlation with further investments in physical capital formation and the possibilities for economic catch-up, aligned with the findings of Barro’s (1991) work in which poor countries potential for catching up is directly dependent on their per capita levels of human capital stock.

In more aggregate terms, the paths through which the formation of human capital is further translated into economic growth can be divided into two main groups. Firstly, human capital is expected to generate direct increases in individual income through productivity gains, also referred to as the marginal returns of education in relation to years of study, or direct gains. The second contribution of human capital, also known as indirect, are related to the generation and absorption of technology in the productive process (Nakabashi and Figueiredo, 2008). These indirect gains, as previously argued, are one of the strong arguments for the public supply of education – beyond the individual returns. Furthermore, these indirect contributions of education must be distinguished into two different proficiencies, namely the “Independent Capacity of Technological Creation” and the “Independent Capacity of Technological Learning” (Dore, 1984). While the first is most commonly associated with knowledge and the knowledge economy, the capacity of adapting technology to a region’s own specificities plays an even more crucial role in poorer regions’ potential of catching up – as long as they
can rely on a sufficient stock of human capital and accomplish the required connections (Cypher and Dietz, 2002). Creating technology internally is a process achieved through human capital deepening as previously discussed, enabling the region to reach a sustained stance of economic growth from the moment when the gains from technology learning start to decline (Dore, 1984).

The real possibility of increasing returns through technological absorption admits the potential of relatively higher growth in relation to economies that create technology, resulting in a very welcome catch-up process turned feasible through the accumulation of human capital (Benhabib and Spiegel, 1994). As a consequence, lagging regions see the possibility of overcoming the income and development gap through the appropriation of technology generated elsewhere, even more than struggling with the endogenous creation of technology. Both processes, nevertheless, depend on endogenously generated stocks of human capital.

In sum, the many explored contributions of education in economic growth through the formation of human capital have been delimited as direct increases in production factors; softening of the effects of diminishing returns by enabling the appropriation of positive externalities (Nakabashi and Figueiredo, 2005); and generating capacity of technology absorption or creation, alongside with turning feasible activities of Research and Development. Examining these approaches alone, human capital can be argued to be a crucial factor in the struggle for overcoming underdevelopment, presenting a concrete possibility for development and social transformation throughout the time – the role of education as a positive means for development has been wrapped-up by Lauder et al (2006) as the consensus theory on education, in which it organises a system of certification that, beyond the aforementioned arguments, eases the process of sorting workers and structuring the labour market according to the supply and demand of specific skills, abilities and knowledge.

3.4 Education as a means of perpetuating inequality

What could then be the role in education in a developing region with stark dualistic features, as well as a few nodes of cumulative causation at place? Having in mind the example of this study, it is perhaps intriguing to imagine how the capital city of the state, the sole centre of the region’s knowledge economy and largest concentration of human capital, still exhibits a violent income inequality.

Moving further on from the growth-centred theories of human capital formation, research on eventual causal relations between education and development have also indicated that the first can be directly implicated in the reproduction of social class advantage, in the sense that exclusion (in its many forms, including economic, political, cultural exclusions) are perpetuated through education, and not despite its existence (Lauder et al 2006). This approach, also known as the conflict approach on education in
relation to development, suggests that, in a similar manner as the approach on growth and development, causal relations are not ensured or even simplistic so as to have results in one direction only.

A classic example of this diverse causality is exemplified in Marrero and Rodríguez (2013) work examining data between 1970 and 1990 in the United States, indicating relevant positive effects of formal education on growth streaming from inequality of effort, that is, individual choices and actions that lead to a higher income level. Choosing to invest in education and actively doing so, in other words, has a positive result in future income. Simultaneously, unequal educational scores (be it in terms of quality or quantity) that are beyond the scope of individual responsibility (family context, quality of schooling), or inequality of opportunity, reduced the overall growth rate and, consequently, the individual income level. Despite suggesting evidence for a positive relation between education and growth, the access to it is then not equally distributed throughout the population, with negative effects on the overall outcome.

Castelló-Climent (2008), exploring the contrast between schooling and democracy levels, indicates a strong influence of the equality of the education distribution in the results predicting democracy. Her study suggests, moreover, that the effects of the distribution of education are actually stronger than the aggregate average of years of education, in accordance with Bourgignon and Verdier’s (2000) results indicating political participation as a direct result of educational outcomes. When education as an asset is concentrated in a relatively small middle and upper class, it plays a negative role in a developmental perspective as it may even hinder reforms that would benefit the uneducated, in a class struggle manner (Rajan and Zingales, 2006).

During Brazil’s peak of income concentration during the early 90’s, evidence suggests that the expansion of university levels contributed to a higher level of inequality (Reis and Barros, 1991), as mostly the elites can reach tertiary education. Even though education is publicly provided at all levels of education without any tuition fees whatsoever, the high demand for university-level education and the precarious conditions of primary and secondary education in the public sectors result that, before the recent reforms introducing quotas for black and low-income students, the majority of new enrolments in the most renowned, public universities in Brazil referred to upper middle-class students. Research on the relations between human capital and inequality in Brazil, especially during the military government in the 70’s and their openly concentration-friendly policies, collect a fair amount of evidence on the correlation between these two variables, as in the works of Senna (1976), Castello Branco (1979), Medeiros (1982), Ferreira da Silva (1987), Lam and Levison (1989). Langoni (1973) found similar results for the 60’s, as 35% of the large increase in inequality for that period was due to increases in education average. Knight and Sabot (1983) and Reyes (1988) found similar results for east Africa and Colombia, respectively. What emerges as the main effect of education on inequality is not education per se, but the access to it across space and income levels and the variations in quality in relation to these very same variables. As the actual demand for education (and specialised education)
varies depending on the skills available at a given region (Iwahashi 2007), beyond income inequality, spatiality adds another layer on the causality analysis between education and development.

### 3.5 Education and Development from a geographical perspective

These differentials, in accordance with the propositions from the cumulative causation theories, pose an additional challenge to developing regions in the sense that low-income regions with a poorly developed economic structure may require a more incisive approach in order to be able to benefit from the gains of education. Balancing the supply and demand of human capital between the three most common levels of education (primary, secondary and tertiary) differs through space, with diverging outcomes depending on the emphasis given. In an example from a World Bank Study (1993), investments in education in Bolivia and Indonesia, albeit in the same proportion of the national GDP and in countries with similar levels of per capital income, literacy rate and gender equality in 1980, obtained very different results in the following years as Bolivia directed more investments to secondary and tertiary levels of education (mostly reached by the elite), on the contrary of the Indonesian equivalent. Bolivia experienced an increase in inequality, whereas in Indonesia the gender gap in school age virtually disappeared (World Bank, 1993). Even though Latin American countries scored a reasonable school attainment half way through the 20th century, in relative terms, the results of the investments in education in the following decades – and most importantly, the resulting quality of the educational structure – did not materialise in a proportional development in the continent, with human capital accounting for up to two thirds of the income differentials in relation to the rest of the world (Hanushek and Woessmann, 2012).

The effects of education on growth and/or development, diverse as they seem to be, might be perceived more precisely when the scope of the analysis is a more homogenous region in terms of educational systems and institutional structures, supporting the use of this approach on intra-regional analysis (Fleischer and Zhao, 2010). In Brazil, previous evidence point towards a significant effect of education on economic growth and aggregate inequality reduction in the long term simultaneously as it seems to be related to inter- and intraregional differences in developmental outcomes, especially when it comes to income and spatial inequality.

This polarisation between consensus and conflict theories becomes thus non-exclusive and highly permeable, perhaps indicating a possibility that elements of both approaches are at play simultaneously in time and space – regardless of the nearly proved contributions of education to the formation of human capital and growth, its distribution through space and its variations in terms of quality seem to have strong negative effects in terms of inequality of opportunity. Understanding that many of the factors that directly affect education quality are experienced locally, such as concentrated disadvantage, income and
employment volatility or even the lack of financial markets (Flug, Spilimbergo and Wachtenheim, 1998), adds relevance to an intraregional, spatial analysis of the interplay between education, as supported by Fleischer and Zhao (2010), within the framework of the struggle for development in the highly unequal Latin American context. The geographical scale of a state deals with the level in which education policy is developed and implemented in this specific case, hopefully providing an analysis of the regional spatiality of education and development with a somewhat concrete outcome for a dimension that has not been extensively explored.

The following chapter lays the hypothesis of this study, departing from the theoretical assumptions discussed up to the current point. Furthermore, it presents and discusses the two main methodologies employed in testing the hypothesis and its sub-statements, attempting to place them in a broader discussion of spatial econometrics, its start and expansion in the more recent decades.

4. Data and Methods: Spatiality and Causality

4.1 Introduction – main hypothesis

Following the deductive approach of this thesis, the previous theoretical reflections are the basis for the formulation of the central hypothesis of this work, as follows:

a) Education and development present a spatially correlated interplay over time, in a clustered dynamics in which some regions experience increases in both education and development, and others of concentrated disadvantage in a cumulative causation manner.

b) This spatial interplay between education and development is not constant across different educational levels (primary, secondary and tertiary education).

c) Municipal level of education can be seen as a predictor of future development,

d) even though this relation is not homogenous in space.

For convenience reasons, sub-statements a and b will be referred to as the spatial aspect, whereas c refers to the causal aspect of the hypothesis. Lastly, d will be commented through an attempt of merging these two spheres in a final discussion. This separation is relevant in the sense that the spatial aspect at times deliberately ignores matters of causality, casting light upon matters of spatial correlation and dependence. Nevertheless, it does include a time perspective so as to avoid presenting an ephemeral and static picture of the explored municipalities, providing a spatiotemporal approach that will hopefully
suggest what kind of causal relations might be at place – which will then be addressed separately as the *causal aspects* through an econometrical assessment. Needless to say, the spatial aspects require a visualisation of the transformations over time and space, between the analysed variables. This poses an additional challenge when dealing with a period of a few decades, multiple variables in terms of development and equally diverse variables in terms of education – in its qualitative, quantitative and formal aspects (primary, secondary or tertiary education).

The research design of this study draws inspiration from the work of Abhishek Singh *et al* (2011), in which for the first time the relations between poverty, female literacy, child malnutrition and child mortality were explored in a space-time manner, with India as the object of study. With the objective of determining if the underprivileged geographic regions also presented higher child mortality and exploring the causal relation between these phenomena, Singh *et al* employ a set of tools for exploratory spatial data analysis (ESDA – comprised by Moran’s I, uni- and bivariate LISA statistics) and complement it with the comparison between regular OLS regressions and a regression model with autoregressive error parameter, followed by a spatial visualization of the spatial regression’s residuals – basically the same tools used in the present study, which are presented further on in this chapter. The novel work of Singh *et al* (2011) indicates a diminishing role of poverty and the increase of the effects of female literacy on development (in this case, reduction of child mortality). The spatial approach for somewhat similar variables, and the special interest on identifying spatial relations that are not limited by political borders but reproduce themselves in clusters within (and, in the case of Singh *et al*, also between) regions make this comparison valid and fruitful.

Even though the method toolbox employed is equivalent and even the ESDA software is the same (as it is appropriate for “advanced geospatial analyses” (Singh *et al* 2011, pp 4) and “the latest software tool devised by the Centre for Spatially Integrated Social Sciences, CSISS, to implement various exploratory spatial data analysis including data manipulation, mapping, and spatial regression analysis” (Anselin, 2005), it’s application differs in what comes to the insertion of the time perspective – due to data constraints, Singh *et al* (2011) could not use a consistent time series for the examined variables, which was possible after some data processing in the current work. Being that so, this work adds to the previous analysis in the sense that it incorporates time over the course of 40 years, exposing not only places with significant spatial clustering of the explored variables but also geographic locations where these relations remain *over time* instead of a static representation. Finally, both studies rely on spatial econometrics for assessing and discussing causal effects, having spatiality as the point of departure.

The following subsection gives an overview of the mentioned methodological tools, its origins and specificities, as well as describes the data source and refinements that have been made in order to allow a consistent time-series analysis of the census data.
The origins of this methodology stem from the “field” of spatial econometrics, officially conceived under the mission of providing the methodological foundation for regional and urban econometric models (Paelinck and Klaasen, 1979), most notably under the “Annual Meeting of the Dutch Statistical Association” in Tilburg, in 1974 (Anselin, 2010). On a large and comprehensive overview of the last 30 years of spatial econometrics, Anselin (2010) argues that it moved to the mainstream of quantitative methods in the social sciences (Anselin, 2010 pp 4), achieving its maturity phase over the shift to the third millennium – which is measurable through the exponentially growing number of citations and mentions of the field in textbooks, in the generation of more specialised software and the emergence of jobs that list spatial econometrics as a desired skill (Anselin, 2010 pp 15).

Well synched with the quantitative revolution in geography, works employing spatial econometrics advocated for the shift from analysis based on individual behaviour of traditional atomistic agents to the interaction between these agents, generating effects that have been largely explored under the labels of peer effects, neighbourhood effects, spatial spill over and so forth, indicating the need of an explicit accounting for spatial effects (Brock and Durlauf: 2001, 2007). In sum, this approach is based on the premise that “space matters”, as in the extensive and multi-approach defence of neighbourhood effects in Sampson (2012), which is considered valid from urban to intra- and interregional studies.

Among the top four concerns of this emerging paradigm are local spill overs and regional income convergence, and it has been cited in a Swedish dissertation for the first time in 2000 only (Saratoglou and Paelinck, 2007 pp 498). Since the seminal works of Paelinck and Klaasen (1979) and Anselin (1988), publications have been concentrated in the fields of regional science, geography and economics (Saratoglou and Paelinck, 2007), dealing with two main spatial effects: spatial dependence and spatial heterogeneity (Anselin, 2010). While the first argues that the correlation between different variables or even the autocorrelation of a single variable depends on its relative position in space, the latter presents a crucial standpoint in which causality does not have fixed effects over space – spatial causation might be stronger or weaker depending in the interaction between spatial agents, as previously mentioned in the spatial heterogeneity of educational outcomes and development.

In what comes to policy implications, this approach is relevant to the extent that it anticipates the local reactions to changes in the explored variable, to some extent predicting its spatial outcome and capturing the effects and responsiveness of local networks – for example in the study of poverty and unemployment by Case (1991). With the broader availability of data and computational alternatives comes the possibility of combining space with time, allowing not only the identification of where these spatial dependencies take place but also the understanding of how these relations behave through external influences along a predetermined time period. This spatiotemporal approach (LeSage and Pace, 2015) adds a fair amount of understanding of the spatial patterns generated between the interaction between the predictor and the response variables (Fotheringham et al, 1998), or dependent and independent variables.
4.2 The Spatial Aspect

One of the most extensively used methods of measuring spatial dependence is the so-called Moran’s I (Moran, 1950), indicating the degree of correlation between the variable $i$ and the average of its neighbours $j$:

$$I = \frac{N}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij} (X_i - \bar{X})(X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2}$$

Where $N$ is the number of spatial units indexed, $X$ is the examined variable $\bar{X}$ is the mean of $X$; and $w_{ij}$ is an element of a matrix of spatial weights. A value close to 1 indicates the existence of clusters of similar values for the given variable, and a negative value will indicate a perfect distribution across space in a non-random pattern. A result tending to zero indicates that the spatial distribution is perfectly random, with no spatial correlation of the explored variable within the predetermined boundaries.

While this indicator has been used as a test of spatial dependence throughout the years, it only goes that far when the goal is to observe the evolution of the regional distribution instead of the total average – as a global indicator, the Moran’s I will only allow the visualisation of the localities in a scatter plot, making it rather inconvenient to identify the clusters in space. This becomes even more critical when the same region presents positive and negative relations between two variables, as it is perfectly possible here having in mind the different roles of education and the dual economy.

A solution for the cases when more “cartographic detail” is needed in terms of visualising the spatial dependence is the use of Anselin’s Local Indicator of Spatial Association (LISA) (Anselin 1995), or a local version of the Moran’s I. Attributing one value per location, it allows the detection of outliers as a region/cluster with a higher contribution to the global indicator of spatial correlation in relation to the mean (López-Baza et al, 1997). In other words, a LISA representation map with significant results implies a proportional result for the global indicator, to some extent facultating its use. In Anselin’s own words, the advantage of the LISA technique is that it “provide(s) a measure of the extent to which the arrangement of values around a specific location deviates from spatial randomness” (Anselin et al, 2000 pp 233-234), being adequate for the exploration of the spatial interaction of municipal economies (Anselin 1988, Arbia 2006). The calculation of the LISA indicator can be expressed as:

$$I_i = \frac{X_i - \bar{X}}{SD_x} \sum_j w_{ij} z_j$$

Where $z_j$ is the standardised form of the spatially explored variable in the neighbouring spatial units, with the local significance calculated by simulations. Unlike more elaborate alternatives such as Geographically Weighted Regressions (GWR) (Fotheringham et al, 1998), LISA-maps do not require
model specification and pose no computational challenges, at the same time as it allows a very clear identification of (significant) spatial clusters and their nature – the score of the municipality is visually perceived through a colour scale, depending on the relative position of the examined variable(s) and the location itself and the neighbouring average. The result of the bivariate LISA analysis is a colour-coded map that indicates the municipalities that seem to integrate one of the four types of possible clusters, using the combinations of relatively high or low value of the two variables in question. The four-colour scale divides locations with significant results between High-High (HH), High-Low (HL), Low-Low (LL) or Low-High (LH) – basically the four quadrants of the Moran scatterplot, depending on the relative score of the local value and the neighbouring average, respectively, indicating the locations that deviate from spatial randomness. A bivariate analysis on development and spatially weighted education, as the one following to this introduction, indicates municipalities with non-random high scores of both (spatially weighted) education and development (HH), or low for both scores (LL). In other words, it measures and indicates where the local value of development is related to the educational attainment of the neighbouring municipalities in a spatial pattern that diverges from spatial randomness, which is expected according to the traditional theory. The presence of diverging results, nevertheless, is still interesting and easily observable through the LISA methodology.

In this study, the LISA variable will be used more extensively to cover the spatial aspects of the main hypothesis. As suggested in LePage and Sage (2015), the matrix of spatial weights is defined as one of ”queen” dimensions, that is, it is constructed on the principle of contiguity – the spatial correlation takes in the consideration all and only the direct neighbours of a given municipality. Including time in this spatial analysis virtually creates animated maps to some extent, in which the clusters where the chosen variables present significant correlation through decades instead of a static photography. These spatiotemporal maps indicate the spatial organisation of space-dependent regional systems, where there is significant spatial correlation between the transformations in the educational outcomes and socioeconomic development in terms of the chosen variables.

4.3 The Causal Aspect

Given the research design of this study and the time lag included in some of the spatial analyses, some considerations regarding causality are touched upon throughout the spatial section of the result chapter. In order to further discuss these preliminary outcomes and help making sense of the observed sets of maps, a simple regression model with spatially auto-correlated disturbances is run for each of the variables and the two possibilities for time lag in terms of education: between 1991 and 2010, which is the same time frame as for development, and the change from 1970 to 2010 – covering all the 40 years of the dataset and referred to as the “longer time lag”.

33
The regression model includes in its parameters the autoregressive error, spatial weighted in with the same spatial matrix with “queen” dimensions of contiguity as the one used in the LISA analysis.

Given a basic model of Y dependent variable and X independent variable with β parameter and ε errors:

\[ Y = \beta X + \varepsilon \]

The error term is then replaced by

\[ \varepsilon = \lambda W\varepsilon + \nu \]

Where W is the previously mentioned spatial matrix with dimensions N x N, λ the spatially autoregressive parameter and ν a N+1 vector of random variables (in other words, the “new” residual).

In order to preserve the efficiency of the estimators, the method of Maximum Likelihood is applied as Ordinary Least Squares does not hold the principle of efficient regression coefficients in the presence of biased standard errors (due to the autoregressive residuals).

High and significant values for λ in robust regression models will indicate that the original residuals of the given estimation are spatially biased, and the R² value for this regression can be compared to the one of a regular ML regression in order to assess the degree in which spatiality increases the explanatory power of the regression model – and thus indicate which model seems more appropriate, as in the benchmark study from Singh et al (2011). In this work, however, the regression models with include time-lagged values for education both in absolute and in relative (change over time) terms, in order to approach the causality questions of this study. Two regression models are elaborated, then:


In which development will be measured through the three aforementioned variables, and education as average years of education weighted by quality of education (denoted AYE). The results of both regressions are then compared to regular regression models without the spatially auto-correlated disturbances.

The following chapter begins with the results of the spatial aspect, with five sets of maps addressing the first two subsections of the main hypothesis. They are followed by the regression analysis, which attempts to make sense of the spatial analysis with a discussion of causality and path dependence – thus covering subsections c of the central hypothesis and reflecting upon section d.

### 4.4 Data

The empirical part of this study is built upon municipal-level data retrieved from Brazil’s decennial census, organised by IBGE (“Brazilian Institute of Geography and Statistics”) and made available by
IPARDES ("Paraná Institute for Socioeconomic Development"). All data used is publicly available and free of charge, originated in the census of 1970, 1980, 1991, 2000, and 2010. As in Singh et al (2011), the data sources dismiss the need of an ethic statement as the data is entirely anonymous, public and with no identifiable info. The first step attempts to outline the spatiality of the interplay between education and development, implying but deliberately not measuring the concrete causal effects between them.

4.4.1 Education
The most frequently used indicator of human capital in studies concerned about economic growth is the measure of “Average Years of Education” (Lutz and Samir 2011; see examples in Barro and Lee 1993) – from now on referred to as AYE. This proxy has been used extensively, and it refers to the average years of formal education attained by the population above 25 years of age. In other words, this measure refers to the stock of human capital in every municipality, seen as a result of the past flows of human capital formation – it is prudent to note, however, that the original concept of human capital encompasses a far wider array of factors, even though they are commonly explored through the proxy of education (Hanushek and Woessmann, 2012; Castelló-Climent, 2008). As previously discussed in the theoretical section, one of the crucial factors determining the ”success” of human capital formation is the quality of this process, and this qualitative aspect is included by weighting the measure of AYE by the percentage of students that do not quit studies – in a hypothetical scenario in which the evasion rate was null, the measure of AYE would be multiplied by 1 and thus remain unaltered. Due to data restrictions\footnote{Data on evasion rates became available from the mid 2000’s – this variable takes into consideration the average between 2006 and 2010. The percentage of students that did not quit studies is calculated as (100% - average evasion rate) per municipality.}, quality measures from the year of 2010 are replicated throughout the time series, assuming that most changes in the quality of formal schooling will also be captured by the aggregate change in AYE over the years.

The methodology for calculating educational attainment changed in Brazilian censuses from 2010, moving from AYE to the shares of educational attainment per education level as just mentioned. Up to the date of the last census, primary education was 8 years long, followed by 3 years of secondary education and at least 4 years of university-level education. Resorting to a methodology employed by Lutz et al (2007), the results from 2010 were converted into regular AYE, arbitrarily attributing a value of 2 years for LOED (no education or incomplete primary), 9,5 years for PRIM (full primary plus 50% of secondary, in the original study), 13 years for SEC (full secondary plus 50% of tertiary) and 15,5 for TERT (full bachelor’s degree, plus 0,5 years for the small share of the population that pursues further tertiary education). This conversion has been employed in similar terms in other studies (Barro and Lee,
2010; De La Fuente, 2006; Cohen and Soto, 2007), although their coverage in terms of country calculations is not as wide as in Lutz et al (2007).

When exploring the spatiality of educational attainment through the different levels of education (primary, secondary and tertiary), four variables will be used, in function of the available data for the year of 2010: LOED, for the proportion of individuals from no education at all up to incomplete primary; PRIM, for the share of individuals with complete primary school up to incomplete secondary school; SEC, for the account for complete secondary school and/or incomplete tertiary school; and TER for the share of individuals with completed university-level schooling (first tier, bachelor’s degree). For the time being, it is not possible to explore the causality behind different levels of education as the data only became available in 2010 – the methodology employed to transform educational attainment per level into AYE would not provide accurate results if used in the reversed direction, regrettably.

Since attention will be given to the different levels of education, and the initial educational outcomes of many municipalities was virtually zero, the author has opted for not disaggregating the AYE measures between across the demographic structure of the municipalities for the time being, even though that is an interesting possibility for further studies as it is not expected that the eventual effect of education is stable across different generations and age structures. After completing the conversion from educational attainment per level of education to AYE for 2010, the trend of increase of 1 year of education on the municipal averages across the state on every census remains the same. The average of 1.46, among all municipalities in 1970, increased to 5.66 in 2010 after 40 years.

4.4.2 Socioeconomic Development

The measures of socioeconomic development were chosen according to the match between the available data and the previous discussion on the participation of growth on development, on which education plays a major role. The three arguments in favour of economic growth (overcoming poverty and income inequality, as well as creating the possibilities for future transformation) will be represented by measures of extreme poverty (hereafter “EXTPOV”), income inequality (or share of income, “SHAINC”) and percentage of vulnerable children (“VULCHI”).

4.4.3 Extreme Poverty - EXTPOV

This measure of poverty is explored as the share of population living in households with less than per capita BRL 70 (approximately 150 SEK) per month – classified in Brazil as extreme poverty. This variable is available in three census rounds, from 1991 to 2010, with municipal average values of 20.9% and 3.4% respectively. A positive outcome in terms of development is a reduction of this indicator, meaning that a smaller share of the population lives in deprivation of basic needs.
4.4.4 Income Inequality - SHAINC

Inequality is measured as the share of income of the 20% poorest was used. The variable is also available from 1991 to 2010 – an increase (decrease) in this indicator indicates a relative increase (decrease) in the income of the poorest. increase. The average value for those years is 3.8% and 4.7%, respectively.

4.4.5 Child Vulnerability - VULCHI

The last proxy of socioeconomic development, not encountered in the researched literature, refers to the proportion of individuals below 14 years of age living in households with per capita income below BRL 255 (approximately 570 SEK), or half a minimum salary as of August 2010. For the years of 1991 and 2010, the average values are 53.4% and 35.1%. As the other development variables, child vulnerability is also available between 1991 and 2010.

Child vulnerability is valuable as it indicates the proportion of children with a higher risk of abandoning studies or achieving a lower performance due to their socioeconomic background, as it indicates disadvantaged families with less disposable resources to invest in the child’s education. A desirable outcome for this variable, then, would be its relative decrease.

4.4.6 Municipalities that came to exist along the time series

The effort in processing the data from the original source until the refined and adequate database was then fourfold. The first and already mentioned change was to estimate the measure for AYE in 2010 departing from the educational attainments per scholarship level, using the methodology of similar studies in the field. Secondly, all variables were prepared in both absolute and overall change terms, that is, the value for each census year and the percent change from the first year until 2010. In the case of education, two percent changes were included in the database: one from 1970 to 2010, and another from 1991 to 2010 so as to follow the period of time for which development data is available. Third, measures of education (both AYE and scholarship levels) were multiplied by quality proxies in terms of school evasion. This was not available to the less expressive rate of tertiary education.

The fourth and perhaps most crucial effort was perhaps the estimation of the education data for municipalities that had not become independent spatial units before 1991 – even though data for education exists since the 1970 census, only 288 municipalities existed at that time. The approach to this challenge was to “recreate” these new municipalities using the current political division of the state, now with 399 municipalities, and trace the origin of all the 111 new municipalities so as to determine how they were divided along the way. The methodology for projecting these new municipalities back until 1970 was simplified by the fact that at least one of the new entities held the original name of region – for illustration purposes, imagine a municipality A being divided into A¹, B and C, where A¹ and A share the same name even though A¹ is smaller and most likely does not have the same values for its educational and developmental indicators as these accounted for both A¹, B and C previously (then
under the same geopolitical unit, “A”). The steps for projecting values for A¹, B and C in previous decades are as follows:

a) Using a historical database from the Brazilian Institute of Geography and Statistics, the author outlined which municipality (-ies) originated from every dismembrated unit.

b) Pairing these municipalities for the years of 2000 and 2010, when all of them already existed, the deviation from the mean value of these units together was calculated for every unit, generating a multiplier – the relation of the given municipality to the average distance to the mean for years 2000 and 2010.

c) With this multiplier, the values for 1991, 1980 and 1970 were estimated. Using the example above, the value for B was calculated as the value for A (old municipality that contained A¹, B and C) multiplied by B’s individual deviation from the means in 2000 and 2010. Two notions are important at this stage: firstly that, after estimating the new values, the old value for A was no longer used as this municipality had now been artificially dismembrated into A¹, B and C. Secondly, even when the values for pre-existing municipalities were changed (in the cases when they originated a new municipality), the global average of the state remained the same – as the average for A¹, B and C is equal to the previous score for A. Pre-existing values for municipalities that did not “dismembrate” into new municipalities remained unchanged up to this step.

d) The quality weight was calculated for every municipality, as per the previous discussion. It was applied on all years and municipalities, from 1970 to 2010.

e) The yearly values were saved, as well as the municipal change from 1970 to 2010 and from 1991 to 2010.

The resulting data, composes a unique dataset in the sense that it allows the spatial exploration of the current political division of the state with a time-span of 40 years, covering 5 censuses – which was not possible up to now. This opens new possibilities in terms of long term analysis, which includes a more solid basis for studies focusing on causal effects.

Addendum about demography: the author has decided not to include demographic controls or variables in this dataset for two main reasons. Firstly, even though Brazil should now be experiencing the benefits of its “demographic bonus” (i.e. historical low of the national dependency ratio, which has an estimated conversion point around 2025 according to the Brazilian Central Bank (Banco Central do Brasil, 2011), little evidence of such gains can be found in the latest trends of GDP growth – despite historically low unemployment rates. The national dependency ratio has decreased from 63% to 45% between 1991 and 2014, but it is debatable that it has had a strong influence in the economic growth of the country having in mind the near full-employment periods that took place in parallel with low growth recently (see Figure
In fact, there has been evidence that demographic opportunity alone has been insufficient as an engine of economic shift in Latin America, which can be attributed to the lack of investment on good general education and technical skills, among others (Bloom and Canning, 2003). Secondly, and having in consideration the specific object of this study, Paraná’s municipalities at the start of the analysed period scored on average one year of formal education among their adult citizens, as previously mentioned. Since the major improvements took place from 1970 on and most of the municipalities started off with an extremely low stock of human capital, it is not entirely false to assume that most of the human capital stocks formed after that refers to young, working-age individuals – which is the cohort with presumably higher impacts on growth based on their individual accounts of human capital.

5. Results and Analysis

5.1 Introduction

The results of the study are divided in two major sections: one regarding the spatial effects and a second part devoted to a more specific analysis of causal relations. Before proceeding to these two components, a brief, descriptive introduction aims to present the changes observed in education over the 40 years under analysis and the 20 years for which data on development is available. This preliminary analysis not only provides a statistical contextualisation but also helps assessing a few of the sub-sections of the main hypothesis.

Firstly, it is remarkable the enormous transformation that the state underwent over these 40 years – the highest scores in 1970, around 3,5 years, are now the lowest in 2010 – on average, the total municipal average (of the population above 25 years of age) increased by slightly over 1 year per decade.

![Figure 9. Unemployment and GDP growth in Brazil, 1991-2015](source: own graph with data from the Brazilian Central Bank)

![Figure 10. AYE distribution per census year](source: own data and graph elaborated with aggregate data from IPARDES)
Simultaneously, though, the distribution became more unequal – the standard deviation increased from 0.6 to 0.9, and these aspects can be visualised in Figure 10.

The spatial distribution of this process is allows us to understand and identify the possible existence of eventual clusters of low educational scores in the along the census years of the time series and, most importantly, eventual clusters of fast change. Exploring the relations between education and development requires, as a starting point, understanding the individual spatial behaviours of each variable before attempting to identify eventual “overlaps” of these spatial relations. The following set of maps displays the univariate LISA analysis for AYE in all years, depicting the formation of clusters of relative high and low education:

![Maps showing spatial clustering and outliers for AYE](image)

**Figure 11.** Univariate LISA depicting spatial clustering and outliers for A. AYE in 1970; B. AYE in 1980; C. AYE in 1991; D. AYE in 2000; E. AYE in 2010 and F. Location of the three largest urban areas. 1% significance. Sources: own maps and data, GeoDa software and IPARDES aggregate data.
The expected main clusters in from and including 1970 representation are that higher educational scores orbitate and include the capital (which has the highest score for all years, cluster formed by municipalities in red in the easternmost portion of the state), and that a low education cluster exists in the interior of the state (dark blue). Most likely not by coincidence, these are also the most and least developed regions of the state, respectively. The cluster of higher education is also present in a smaller scale in the westernmost portion of the state, in a smaller spatial arrangement that faded out throughout the years. On the contrary movement, a few municipalities show significant results for spatial correlation in terms of higher education in the northern part of the state, where two of the three largest urban locations are situated – in the more recent years, the areas of higher education clustering orbitate around the two major urban areas of the state – the capital, in its easternmost portion, and the Maringá-Londrina pole in the northern part of the state. The disadvantaged area in the central portion of the state experiences the establishment of cluster of low education, growing in size and significance throughout the years.

Figure 12 displays the univariate LISA analysis for development variables, both in static terms for the three census rounds between 1991 and 2010, and for the overall change in this period:

*Figure 12 (below).* Univariate LISA depicting spatial clustering and outliers for the three sociodevelopment variables for each census year (1991, 2000 and 2010) and relative change (1991–2010)
Sources: own maps and data, GeoDa software and IPARDES aggregate data.
The Univariate LISA analysis for the relative change (maps D, H and L) do not present a well-defined pattern of clusters – which can be partially attributed to the lower spatial concentration of these variables. The Moran’s I for VULCHI, EXTPOV and SHAINC was of 0.11, 0.20 and 0.06 in 1991, increasing to 0.24, 0.24 and 0.30, respectively. On the contrary movement, the Moran indicator for education gradually decreased from 0.51 to 0.29 through the course of the 40 years between 1970 and 2010, reaching a spatial concentration similar to the one observed in the development variables. Even though the variables behave in their own manner throughout the three censuses, a few common patterns can be observed. Firstly, the number of clustered municipalities increases through time for the education variables, in a concentrative pattern – developed regions become more concentrated in some hotspots, while disadvantaged areas establish in others. Secondly, the clusters reproduce to some extent those observed in the education analysis – the central, disadvantaged area, and the urban area in the northern portion seem most significant. It is interesting that, at this point, the capital cluster does not figure among the significant municipalities. A minor cluster, fading cluster in the westernmost region, poses a challenge in analytical terms as this portion of the state was barely explored at the first decades of this study (see the forest cover map, in Figure 3).

When examining the relations of most interest for this study – the interplay between education and development, it is interesting that the central part of the state seems to some extent to concentrate higher shares of vulnerable children, extreme poverty and low education, at the same time as it indicates a significant cluster of low share of income of the 20% poorest. The “overlapping” of clusters the abovementioned, when present, imply that the concentration of the observed variables takes place in the same geographical region at the same period of time – for example, if regions of non-random concentration of low educational scores are also clusters of concentrated disadvantage. In order to assess this more closely, the next section makes use of bivariate LISA analyses, testing for the existence of spatial correlation between the local scores of development (VULCHI, EXTPOV or SHAINC) and the neighbouring scores of education.

5.2 The Spatial Aspects – Education and Development over time

The following set of illustrations explores thus the spatial correlation between local development and spatially weighted education throughout the three rounds of census for which the data exists for all variables. Figure 13 presents evidence that regions with lower scores of education are also more likely to hold lower scores for development (that is, higher VULCHI and EXTPOV, and lower SHAINC), regardless of the development variable used and, to a large extent, the census year.
Figure 13. Bivariate LISA depicting spatial clustering and outliers for local development per census year and spatially weighted education. 1% significance. Sources: own maps and data, GeoDa software and IPARDES aggregate data.
Across all maps, the largest, central cluster accounts for lower education and development, in accordance with consensus-like theories. At this point, however, it cannot be inferred that the first causes the second, as these maps focus on the correlation between the variables in space – which does not necessarily deny, nevertheless, that a causal relation might be at place. Apart from the ever-present central cluster of disadvantage, two other spatial structures can be observed in this illustration – the capital region and the northern urban region, previously mentioned.

The smaller, urban municipalities that form the northern cluster yield higher scores for both education and development, and this spatial correlation seems somewhat more expressive over the years for SHAINC even though it is equally present in EXTPOV and VULCHI representations. This cluster is interesting as both urban regions within its limits were founded between 1934 and 1947, basically surrounded by large monoculture estates and are one of the main locations that received migrants during the transformation process that begun in the 1970s, as mentioned in Chapter 2. Moreover, the latest census seems to include a few municipalities aligned with the conflict theorisation on education – that is, education as a means of perpetuating inequality. This result can be observed around the capital region since 1991, even though also in the capital region this phenomenon seems to be more significant on the more recent representations.

The significant of the results up to now, regardless of the theory they could be related to, support the first sub-segment of the hypothesis, that education and development present a spatially correlated interplay over time, in a clustered dynamics in which some regions experience increases in both education and development, and others of concentrated disadvantage in a cumulative causation manner. The bivariate set of maps allows a clearer verification of this spatial “overlapping”, especially when dealing with different variables and multiple periods of time.

Figure 14 aims to deal with proposition b of the central hypothesis, that this spatial interplay between education and development is not constant across different educational levels (primary, secondary and tertiary education). Due to data restraints, the bivariate analysis between the four educational levels (LOED, PRIM, SEC and TERT) and development is carried out for the year of 2010.

The first observation, common to all the three variables, is that the number of municipalities with significant results is reduced at every step towards university-level education, resulting in merely any significance at all. This initial assessment is consistent with the one of the World Bank previously mentioned, in which investment in primary education may yield more results in terms of overall development if compared to investment in tertiary education, especially in the case of developing (or underdeveloped) regions.

Exploring these results more closely, it is possible to notice the change in colour code from LOED to the other educational levels (easily noticed from LOED to PRIM), regardless of the fact that the clusters fade throughout them. The central cluster in these maps indicate that a low result in terms of
Figure 14 (above and next). Bivariate LISA depicting spatial clustering and outliers for local development and spatially weighted education in 2010, by education level (Low, Primary Education, Secondary Education or Tertiary Education). 1% significance.

Sources: own maps and data, GeoDa software and IPARDES aggregate data.
of LOED and low values of PRIM and SEC, with no relevant changes in the location of the cluster even if compared to the previous analyses. The cluster around and including the capital Curitiba displays a majority of municipalities indicating a positive relation between education and development, even though a few of them do display results aligned with the conflict theory. A reflecting, lesser scale behaviour can be observed in the northern urban area.

Before proceeding to the next exploration of the spatial portion of this chapter, it is interesting to note that results of this last set of maps represent the current status of the interplay between local development and the spatial effects of education, as of 2010 – even after these 40 years of expressive transformations, both in terms of education and in the economic structure as a whole, primary education (and secondary to a lesser extent) still seems more significant when it comes to the spatiality of development. Areas with relatively low development are also those with higher number of individuals with no or low education attainment.

As an introduction to the causal aspects of this study, the following set of maps explores time-lagged versions of the analysed variables, keeping development as the local unit and education as the spatially-weighted variable. Through the theoretical portion of this work, it was discussed how the main bulk of theories touching upon the issues of education and development see a causal link of education on development – in other words, (one of) the expected outcomes higher education in $t-1$ is a higher stance of development in $t$, regardless of how it is measured, *ceteris paribus.*
This straight-forward notion, nevertheless, should also be understood as a circular causality structure – as mentioned earlier, higher development will also increase the possibility of further investment in education, in a “virtuous” cumulative causation, and the reverse is equally valid. Lower scores of education reduce the possibilities for growth and supposedly impact development negatively, which in its turn is expected to generate poor conditions for further growth, investment and increases in education. In a perhaps philosophical discussion that goes beyond the scope of this study, the mere division between education and development is debatable by itself, as one can also see education as an expression of development per se. The analyses that follow, with a higher focus on causality, will focus on the effects

Figure 15. Bivariate LISA depicting spatial clustering and outliers for development in 2010 and time-lagged education (A, C, E) and time-lagged development and education in 2010 (B, D, F). 1% significance.
Sources: own maps and data, GeoDa software and IPARDES aggregate data.
of education in development – which by no means denies a very likely circular causation that might be at place.

As observed in Figure 15, both versions of the time-lagged exercises return significant spatial correlation, even though the versions in which development is lagged are perhaps more diffuse in its cluster representation. Once again we observe the same pattern, with a central cluster of concentrated disadvantage in both terms and the urban locations concentrating higher education and development, with a few indications of conflict-like relations. The next and final approach will deal with time and space simultaneously, in the form of spatial error models of regressions. It includes models both with and without autoregressive error, as well as shorter and longer time-lag for the education variables, in an attempt to make sense of the complexity of perspectives involved in this spatial interplay.

5.3 The Causal Aspects – and the importance of space

The results of both sets of regression models (see below in Table 2), with and without the autoregressive error, indicate a consistent effect of past education, be it the aggregate value for the previous decade or the overall change, on the outcome in terms of development. This statement holds valid for all three development variables, and the coefficients change from positive in SHAINC to negative in EXTPOV and VULCHI – suggesting stronger effects of consensus theory-supporting relations, as visualised in the geographical analysis. It is important to note, nevertheless, that the eventual existence of conflict theory-inclined causality cannot be captured simultaneously through a regression model in these terms, as an aggregate regression does not fit plural causal effects as observed in the spatial analyses.

While the inclusion of the longer time lag in the independent variable (from 1970 instead of from 1991) did not yield significant increases in the $R^2$ value, including the autoregressive spatial error accounted for a higher explanatory power of the regression model. A robust value for the $\lambda$ coefficient strengthens the hypothesis of robust spatial correlation, in this case not only between the variables themselves but also within the dependent variable. As observed in the previous spatial analyses, the interplay between the variables is not stable or fixed across the state as a whole – in fact, the existence of clusters itself is evidence of this statement. It is rather intuitive to imagine that the effects of education on development and vice versa do not behave the homogenously through different geographic landscapes, which has been indicated in the maps and in the robust results for the spatial error regression.

The results of the regressions alone bring about two highly relevant reflections. Firstly, including the time-lag in the regular OLS regressions reduces the explanatory power of all education coefficients – no matter if it is the 10 year-lagged or the two overall change coefficients with shorter or longer time-
Table 2: OLS and ML regression results, per dependent variable and time-lag model

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>VULCHI</th>
<th>EXTPOV</th>
<th>SHAINC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AYE00</td>
<td>-8.105</td>
<td>-8.117</td>
<td>-1.756</td>
</tr>
<tr>
<td>AYE91-2010</td>
<td>-6.071</td>
<td>-1.756</td>
<td>-2.585</td>
</tr>
<tr>
<td>AYE70-2010</td>
<td>-1.007</td>
<td>0.075</td>
<td>0.203</td>
</tr>
<tr>
<td>Spatial Lag (Lambda)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heteroskedasticity - Breusch-Pagan Test</td>
<td>2.245</td>
<td>4.189</td>
<td>38.822</td>
</tr>
<tr>
<td>Likelihood Ratio test</td>
<td>38.822</td>
<td>245.996</td>
<td>1.182</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>399</td>
<td>399</td>
<td>399</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.195</td>
<td>0.190</td>
<td>0.164</td>
</tr>
</tbody>
</table>

Ordinary Least Squares (no account for space)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>VULCHI</th>
<th>EXTPOV</th>
<th>SHAINC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AYE00</td>
<td>-7.022</td>
<td>-7.261</td>
<td>-1.515</td>
</tr>
<tr>
<td>AYE91-2010</td>
<td>-4.162</td>
<td>-1.614</td>
<td>-0.933</td>
</tr>
<tr>
<td>AYE70-2010</td>
<td>-0.284</td>
<td>-0.303</td>
<td>0.093</td>
</tr>
<tr>
<td>Spatial Lag (Lambda)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heteroskedasticity - Breusch-Pagan Test</td>
<td>0.727</td>
<td>1.129</td>
<td>42.199</td>
</tr>
<tr>
<td>Likelihood Ratio test</td>
<td>42.199</td>
<td>33.256</td>
<td>3.543</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>399</td>
<td>399</td>
<td>399</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.244</td>
<td>0.247</td>
<td>0.206</td>
</tr>
</tbody>
</table>

Maximum Likelihood with Autoregressive Spatial Error
lag. In fact, some of them become insignificant (assumed here as with probability above 5%). The existence of spatial relations, indicated in the previous analysis, is thus reinforced through the econometric modelling. The robust results of the spatial error coefficient ($\lambda$) in all regression alternatives also point towards this conclusion.

The second result that can be drawn from the econometric analysis is that previous municipal level of education can be a predictor of future development. This is especially valid for the results of AYE2000, significant for the shorter time-lag models with results that, as mentioned, support the idea of positive effects of education on development. Testing for the effects of overall change in education over the period returned relatively weaker coefficients, only significant (<5%) for short time-lag in SHAINC and longer time-lag in EXTPOV – perhaps partially explained by the intense labour mobility from disadvantaged to urban areas still happening at a stronger pace in the first years of the time series. The predominant predictor of the effects of education in development was the static variable of education with a static 10-year time-lag.

These results do not deny the existence of a circular causation structure – in which education also benefits from increases in development variables. While not the focus of this study, this other “direction” of causal effects give a hint of their existence in the significant bivariate analyses (especially the last set of maps in the spatial section), and further studies on the effects of development in education are very likely to find causality in that direction as well.

Figure 16 displays the univariate LISA of the residuals from both regression models (with and without attention to space), more specifically those with shorter time-lag in education due to their more robust results. The last set of maps clearly indicates the advantage of the spatial error model over OLS, as the Moran’s I value for all three variables dropped to nearly zero – meaning that nearly all of the spatial
effects has been captured in the model. In all three maps, the spatial pattern becomes indistinguishable from randomness (as they would in fact present a perfectly random distribution when Moran’s I reached 0), which not only strengthens the results of the regression but also indicates that the consensus-like causal structures are to a large extent dominant – should there be a stronger spatial structure of conflict-associated causality, it would be expected to be visible in the residual maps above.

5.4 Education as a means of transformation

The previous sets of analyses brought about empirical evidence that, despite (or perhaps due to) its complexity, allows us to elaborate a few thoughts on the spatial interplay between education and development – and, most importantly, on the practical and policy implications of this relation. The object of this study, Paraná, underwent a significant transformation process throughout the time period of the observed data. In terms of education, the substantial increase in years of education (even with consideration to quality measures) took place alongside a slight concentration in terms of development, along the overall increase of AYE by nearly 300% over 40 years.

This substantial increase, however, also presented a spatially-sensitive pattern, being concentrated in a few specific regions of the state. Along the 40 years observed in this study, the concentration pattern observed for education did not experience any drastic changes, with the dominance of a central, disadvantaged cluster and two urban clusters of high outliers. The cluster accounting for higher educational scores concentrated in space increased from the capital region to a new polarisation around the second and third largest urban areas of the state.

Even though the spatiality around development was less obvious than the one concerning education, the bivariate analysis indicated a significant overlapping of these two spatial structures, in the sense that the likelihood of encountering lower development scores are higher when in the regions with lower educations, and vice-versa. This spatial concentration of education and development was sustained across the three census rounds for which data is available, and mirrored the education clusters in the sense that the northern, urban and recent clusters became more significant in recent years.

When assessing if this correlation still holds across different educational levels, the results indicate that spatiality plays a larger role for the first years of the education cycles – which could be expected due to the extremely low educational scores of the municipalities at the first census. Another factor that might be at play is the higher mobility of individuals with higher education (and, very often, income), which nevertheless does not deny the importance of examining the spatial relations between lower/basic education and development, as they demonstrated a significant spatial pattern.

Perhaps a novelty of this study, moreover, was the spatial illustration of heterogeneous relations of education and development across space, as a less expressive but still significant cluster of conflict-like
municipalities could be identified surrounding both urban areas, at different moments in time. The main bulk of the spatial inequality, nevertheless, reported consensus-like behaviours in which higher education is associated with higher development – and so is the contrary. As the maps themselves cannot properly account for causality, at this point no conclusion can be drawn upon the existence of a spatially heterogeneous causal structure, in this case mirroring the dual economy at place in the state in which a few regions thrive and others remain trapped in a cumulative causation manner. Despite the encompassing changes that took place in the state during the observed period, the spatiality of education and development remained to a large extent constant.

In a state where a transition to a more knowledge-intensive economy seems to have been set on march, lacking the primordial asset to take part in this transformation incurs in reduced gains – and, as a consequence, even lower possibilities of investing in posterior human capital formation. This second link, and its consequence, seems to be well synchronised with Myrdal’s formulation, in which the cumulative causation process strengthens the existing concentrations of (dis)advantage and poses as a barrier for the effective overcoming of path dependence and the dualistic structure of the state’s economy (and society). Overcoming polarisation in a regional economy is still a matter of the regional ability to “change paths” (Gertler, 2005), taking into account the concrete historical conditions and forces that shaped its geography and institutions at the same time as it is necessary to look for what transformation potentials might be capable of breaking negative cumulative causation.

The mainstream bulk of theories that started exploring the diffusion of knowledge and, consequently, the relation between technology and geography in the 1980s and 1990s\textsuperscript{12}, while focusing on the effectiveness of local operations and the importance of the organisational component, end up by reaffirming the high geographical concentration of innovative activities and thus present a contradiction in terms of the idea of complete diffusion of R&D (Gallaud and Torre, 2005). Such endeavours of creating poles of productivity and knowledge-based progress seem to have fallen short of achieving a comprehensive regional stance of development, as in the best of cases it generates a spatially restricted dynamics of positive cumulative causation. Policy aligned between the three spheres of government (municipal, state and national), as the renowned case of Curitiba, if aiming to achieve long-term and region-wide endogenous growth, needs to include a serious equality concern – also as the effects of geographical proximity not always restrict themselves to administrative borders (Tsipouris 2005; Singh et al, 2011).

Once the effects of education seem to predominantly range around the promotion of growth and development (in this example through the reduction of income inequality, poverty and vulnerability), as

\textsuperscript{12} These theories include the ideas of the innovative milieu (Ratti et al, 1970; Crevoisier, 2001); technological districts (Antonelli, 1986); Technopoles or Science parks (Monck et al, 1988, Longhi, 1999); Localized systems of production and innovation (Lundvall, 1992; Maskell and Malmberg, 1999) and innovation clusters (Porter, 2000).
well as productivity increases and higher catch-up capability, this asset seems to have all but a secondary role in the pursuit of sustained development. The results of the regression model indicate a large predominance of consensus-aligned causality, in which education is a significant predictor of future development. The regression model also indicated a robust spatial structure, which must be accounted for in order to obtain accurate estimators for these spatially-sensitive variables.

The presented evidence that it has a significant potential as a transformation tool due to the higher effects of the recent scores of education than the longer term changes strengthen the possibilities of including education in a serious, encompassing development strategy that takes into consideration current path-dependent structures. An integrated policy with concern for education and equality should thus take into consideration spatiality – be it for the current spatial inequalities, the persistent spatial, dual dynamics and the lack of investment capacity of the disadvantaged regions.

6. Final Remarks

This study has carried out a bidimensional analysis of the interplay between education and socioeconomic development in a concrete region in southern Brazil. Lenses of time and space were applied in the ambition of making sense of a complex structure of path dependence and concentrated transformation, navigating the centuries-old research effort on growth and development with help of a rather modern set of methodologies that, unlike most of previous research, allows the identification and exploration of heterogeneous spatial relations through time and thus provide valuable insights on the issue of overcoming path-dependence.

Viewing path-dependence as a species of technological determinism (Cooke, 2005) that favours a few in detriment of the majority and assuming a will of closing these gaps, the tension between the current structure of inequality and any serious change efforts tends to persist (Shapira, 2005) as far as those capable of issuing changes continue to act as protectors of the actual structure of exploitation. In the concrete region and state of Paraná, inequality reproduces itself in a wide range of facets, perhaps one of the most evident being the spatial one. Be it income inequality, extreme poverty, educational endowments or living conditions, the maps of inequality in Paraná present a similar pattern, and shifting the scale of this analysis from regional level to more local examinations will only shed light on the daily struggle for basic rights and the aforementioned tension between the protectors of exploitation and the disadvantaged.

In the specific case of education, the struggle has escalated in the recent years, starting with a poor management and nearly cynical attempt of the state governor of changing the state schools curriculum transferring a large share of weekly study hours from 10 of the 12 subjects in basic education to
mathematics and Portuguese - as these are the only subjects measured in the national performance index for basic education in public schools, in which Paraná’s result had been continuously dropping. A massive teacher protest erupted throughout the 2,100 state schools in Paraná forcing the governor to withdraw the measure, but as recently as 2015 a violent repression of a teacher strike resulted in 213 injured in the state capital after the state police employed its shock forces, assault dogs and bombs thrown from helicopters on the mass of protesting teachers, resulting in worldwide repercussion.

As the fight for education goes on, academic evidence on the dynamics of education and development piles up and outlines a complex relation, initially concerned about economic growth and overcoming of poverty, and most recently the role of the knowledge economy and possibilities of catch-up for less developed or even historically disadvantaged regions. The role of education, nevertheless, cannot be taken for granted or assumed to be homogeneous – not only the conditions and effects vary across different localities based on the quality of education and human capital formation, but education (especially when dismembrated into the different educational levels) has been reported to account for the reproduction of inequalities when under certain conditions. If its transformational potential is instead used for the benefit of the elite, it is rather simple to expect that the structures of inequality may even become more solid over time.

The methods employed in this study include somewhat traditional spatial-econometric tools and a dynamic approach of spatial analysis that allows the user to account for space and time simultaneously. Along this path, the author created a comprehensive dataset for educational attainment for all 399 municipalities in the state, which had not been done before as over 100 of these municipalities did not exist in the first two censuses – 1970 and 1980. Handling and creating this data, including quality-weighted measures of education, was necessary to be able to address the causal relations between education and development.

The findings of this work support most of the original hypothesis, which has been tested and discussed. The outcome, as outlined in the main hypothesis, is that education and development present a spatially correlated interplay over time, in a clustered dynamics in which some regions experience increases in both education and development, and others of concentrated disadvantage in a cumulative causation manner (a). This spatial interplay between education and development is not constant across different educational levels (primary, secondary and tertiary education; subsection b of the hypothesis), with stronger spatiality observed in the lower and primary education levels, and to a large extent indicating that poor attainments in education spatially overlap underdevelopment, in a non-random manner. The municipal level of education can be seen as a predictor of future development (c), and the estimation of this causal relation must take into consideration the spatial structure which embeds this process.

---

13 In the Swedish media, the event was covered by Dagens Nyheter (http://www.dn.se/nyheter/varlden/forsta-majfirandet-stalls-in-efter-polisvald/).
The last statement of the hypothesis, in which the relation between education and development are not spatially homogeneous, is supported only to the extent that the geography of this interplay exhibits heterogeneous clusters; when it comes to causality, however, the regression analysis and its comparison with the residual maps and statistics indicate that the main bulk of spatiality between the variables was captured in the regression model, supporting the idea of an overwhelmingly positive effect of the municipal level of education in future development. The evidence of significant, positive effects of education in future development, moreover, does not deny a circular causation – in which achieving higher stances of development fosters increases in educational attainment. Despite not being the focus of this study, its results support the existence of time-resistant cumulative causation.

The robust effects of education and the existence of time-persistent clusters reinforce the need of a spatial approach on education and development, as this dynamics is experienced locally and, perhaps even more importantly, a fair deal of the policies ruling over education and a few developmental features are a municipal obligation. As the difference between the spatial-econometric and the spatial analyses exposed, a purely econometrical approach might fall short on grasping the complexity of these relations – as it per definition assume a (in this case) linear, homogenous causal relation throughout the analysed sample, being incapable of identifying the location of eventual clusters. At the same time, the spatial approach is limited when the analysis is concerned with eventual causal relations, as in the case of this study. The results of this study indicate that, when spatiality is not accounted for in the econometric model, the results cannot be read and employed in their full extent. The research design of this study was built upon a theoretical discussion with geographical concern, followed by a combination of statistical and econometric tools that allowed a thoroughly testing of the theory-derived hypothesis.

The spatial imperative indicated in both analytical approaches of this study calls for a geography-sensitive politics of education and development, which maintains the autonomy of municipal authorities. At the same time, policy should take into consideration their concrete capability of making the necessary investments in order to escape path-dependent cumulative causation dynamics and engage and benefit from the gains of a more dynamic knowledge economy.

In order to assess the concrete perspectives of achieving such an ambitious symbiosis between local, regional and national authorities, further studies could benefit from an agent analysis that takes into consideration the power relations and agency potential of the entities involved, having in mind that the financial and administrative burdens of promoting quality schooling may be beyond the reach of the smaller, historically deprived municipalities.

Intra-state migration flows of educated workers, combined with a liveability analysis of the different clusters identified in this study could also help casting light upon the dynamics of education and development as labour mobility might play a more significant role from the moment educational attainment reaches higher outputs throughout the state. A closer look at the demographic structure across
municipalities might also bring clarity to this complex theme, having in mind that the effects of education can be expected to differ according to the age structure in relation to working age. It is possible that this analysis can find significant results for the more recent years, now that education has reached a more substantious level in comparison to the nearly null accounts in 1970.

Following to the results indicating a stark differential between the levels of education, another potential for further studies is generating time-lagged educational data that accounts for education attainment level, in order to better assess the causal relations at play and thus assist the formulation of spatially aware education policy.
References


Castro, Demian. 2009 *Paraná: Economia, Finanças Públicas e Investimentos nos Anos 90*. Brasilia, Brazil: IPEA.


Eisenstadt, Todd A.; Danielson, Michael S; Bailón Corres, Moisés Jaime & Sorroza Polo, Carlos eds. 2013: *Latin America’s Multicultural Movements- The Struggle between Communitarianism, Autonomy, and Human Rights*.


Gallaud, Delphine and Torre, André. 2005. “Geographical Proximity and the diffusion of knowledge”. In Fuchs, P. and Shapira, G. (Eds.) *Rethinking Regional Innovation and Change – Path Dependence or Regional Breakthrough?* Springer.


International Monetary Fund. 2015. World Economic and Financial Surveys - World Economic Outlook Database.


Moraes Neto, J. 2005 O Emprego e as Políticas Governamentais. IPEA.


Romero, João P. 2006. *Os impactos do crédito no desenvolvimento regional: uma análise dos diferentes tipos de banco que integram o sistema financeiro brasileiro*. Universidade Federal de Minas Gerais.


Tsipouri, Lena J. 2005. “Can less favoured regions change their destiny? Lessons from Europe”. In Fuchs, P. and Shapira, G. (Eds.) *Rethinking Regional Innovation and Change – Path Dependence or Regional Breakthrough?* Springer.


