

da Mata, Daniel; Deichmann, Uwe; Henderson, J. Vernon; Lall, Somik V.; Wang, Hyoung Gun

Working Paper

Examining the growth patterns of Brazilian cities

Discussion Paper, No. 156

Provided in Cooperation with:

Institute of Applied Economic Research (ipea), Brasília

Suggested Citation: da Mata, Daniel; Deichmann, Uwe; Henderson, J. Vernon; Lall, Somik V.; Wang, Hyoung Gun (2015) : Examining the growth patterns of Brazilian cities, Discussion Paper, No. 156, Institute for Applied Economic Research (ipea), Brasília

This Version is available at:

<https://hdl.handle.net/10419/220245>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

156

DISCUSSION PAPER

Originally published by Ipea in August 2005 as
number 1113 of the series Texto para Discussão.

EXAMINING THE GROWTH PATTERNS OF BRAZILIAN CITIES

**Daniel da Mata
Uwe Deichmann
J. Vernon Henderson
Somik V. Lall
Hyoung G. Wang**



Originally published by Ipea in August 2005 as number 1113 of the series Texto para Discussão.

Brasília, January 2015

EXAMINING THE GROWTH PATTERNS OF BRAZILIAN CITIES¹

Daniel da Mata²
Uwe Deichmann³
J. Vernon Henderson⁴
Somik V. Lall⁵
Hyoung G. Wang⁶

1. Agradecimentos/Acknowledgements

This paper is a product of a joint research program between the World Bank and the Instituto de Pesquisa Econômica Aplicada (Ipea), Brasília. This research has been partly funded a World Bank Research Grant and by the Urban Cluster of the World Bank's Latin America and Caribbean Region, and is also an input to the World Bank's urban strategy for Brazil. We have benefited from discussions with Carlos Azzoni, Pedro Cavalcanti Ferreira, Ken Chomitz, Dean Cira, Marianne Fay, Mila Freire, João Carlos Magalhães, Maria da Piedade Moraes, Marcelo Piancastelli, Zmarak Shalizi, Christopher Timmins and Alexandre Ywata de Carvalho. All errors are the authors'. A preliminary version of the paper was presented at the World Bank/Ipea Urban Research Symposium in Brasília (April 2005). The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of Ipea or the views of the World Bank, its Executive Board of Directors, or the countries they represent.

2. Dirur, Instituto de Pesquisa Econômica Aplicada, Brasília.

3. Development Research Group, The World Bank, Washington DC.

4. Department of Economics, Brown University, Providence, RI.

5. Development Research Group, The World Bank, Washington DC.

6. Department of Economics, Brown University, Providence, RI.

Federal Government of Brazil

**Secretariat of Strategic Affairs of the
Presidency of the Republic**
Minister Roberto Mangabeira Unger



A public foundation affiliated to the Secretariat of Strategic Affairs of the Presidency of the Republic, Ipea provides technical and institutional support to government actions – enabling the formulation of numerous public policies and programs for Brazilian development – and makes research and studies conducted by its staff available to society.

President

Sergei Suarez Dillon Soares

Director of Institutional Development

Luiz Cezar Loureiro de Azeredo

Director of Studies and Policies of the State, Institutions and Democracy

Daniel Ricardo de Castro Cerqueira

Director of Macroeconomic Studies and Policies

Cláudio Hamilton Matos dos Santos

Director of Regional, Urban and Environmental Studies and Policies

Rogério Boueri Miranda

Director of Sectoral Studies and Policies, Innovation, Regulation and Infrastructure

Fernanda De Negri

Director of Social Studies and Policies, Deputy

Carlos Henrique Leite Corseuil

Director of International Studies, Political and Economic Relations

Renato Coelho Baumann das Neves

Chief of Staff

Ruy Silva Pessoa

Chief Press and Communications Officer

João Cláudio Garcia Rodrigues Lima

URL: <http://www.ipea.gov.br>

Ombudsman: <http://www.ipea.gov.br/ouvidoria>

DISCUSSION PAPER

A publication to disseminate the findings of research directly or indirectly conducted by the Institute for Applied Economic Research (Ipea). Due to their relevance, they provide information to specialists and encourage contributions.

© Institute for Applied Economic Research – **ipea** 2015

Discussion paper / Institute for Applied Economic

Research.- Brasília : Rio de Janeiro : Ipea, 1990-

ISSN 1415-4765

1. Brazil. 2. Economic Aspects. 3. Social Aspects.
I. Institute for Applied Economic Research.

CDD 330.908

The authors are exclusively and entirely responsible for the opinions expressed in this volume. These do not necessarily reflect the views of the Institute for Applied Economic Research or of the Secretariat of Strategic Affairs of the Presidency of the Republic.

Reproduction of this text and the data it contains is allowed as long as the source is cited. Reproductions for commercial purposes are prohibited.

JEL: R11, 01, 047

SUMÁRIO

SINOPSE

ABSTRACT

INTRODUCTION **7**

1 URBAN GROWTH PATTERNS **7**

2 SPECIALIZATION ACROSS CITIES **19**

3 INDUSTRIAL DECENTRALIZATION **22**

4 QUALITY OF LIFE IN URBAN AGGLOMERATIONS **24**

5 PROXIMATE DETERMINANTS OF GROWTH **26**

6 CONCLUSIONS **28**

ANNEX 1 **30**

ANNEX 2 **32**

REFERENCES **33**

SINOPSE

O parcela urbana da população do Brasil cresceu de 58% em 1970 para 80% em 2000 e o crescimento populacional dos próximos trinta anos é previsto para somente ocorrer nas grandes cidades. O presente trabalho analisa o crescimento populacional e suas implicações para a dinâmica da economia e de geração de renda de 123 aglomeração urbanas do Brasil. O nível de renda é mais elevado em aglomerações urbana maiores e nas regiões Sudeste e Sul, mas um indicativo de convergência regional, com maiores taxas de crescimento em áreas pobres, é verificado. Particularmente, aglomerações urbanas das regiões Norte e Centro-Oeste estão crescendo mais do que os centros urbanos já estabelecidos do eixo Sudeste-Sul. A dinâmica dessas economias apresenta um processo de diversificação crescente entre grandes cidades e de maior especialização econômica em cidades de porte médio. Os grandes centros urbanos mostram uma tendência a uma desconcentração da atividade econômica em direção às periferias. O trabalho, da mesma forma, realiza uma análise das variáveis correlacionas com o crescimento da oferta de trabalho, mensurado pela crescimento da população, e da produtividade econômica, aproximada por mudanças na renda *per capita*.

ABSTRACT

The share of urban population in Brazil has increased from 58 to 80 percent between 1970 and 2000 and all net population growth over the next thirty years is predicted to be in cities. This paper explores population growth and its implications for economic dynamics and income generation among 123 urban agglomerations. Incomes are higher in larger agglomerations and in the South, but there is some indication of regional convergence with higher rates of income growth in poorer areas. In particular, agglomerations in the North and Central-West are growing faster than the more established urban centers in the South. Economic dynamics point to a process of increased diversification among larger cities, and greater specialization among medium sized agglomerations. In bigger centers there is a trend towards deconcentration towards the periphery. We close by providing a simple analysis of correlates of labor supply, as measured by population growth, and economic productivity, which is proxied by changes in per capita income.

INTRODUCTION

There is significant persistence in the economic fortunes of regions. Areas that have been poor for generations often stay poor, while dynamically growing regions continue to leave others behind. Genuine convergence in the well-being of regions does not occur frequently and outright reversal of patterns of growth and wealth is very rare. The difficulties of influencing economic growth patterns perplex policy makers who have the mandate – and face the political pressure – to ensure an adequate degree of equality in living conditions and economic opportunity throughout the country.

In Brazil, public debate has recently centered on the role of the urban system in driving regional economic dynamics. In particular, various levels of government have examined the potential for balancing growth by promoting “secondary cities”. The concern is both to distribute economic gains more broadly and to relieve the increasing strain experienced by fastest growing cities. This debate occurs at the national level, where the focus is on second tier cities in the lagging regions of the North and Northeast, as well as at the regional level, where states promote development of smaller and medium sized towns.

The objective of this paper is to contribute to this debate by analyzing the dynamics of the Brazilian urban system over the last several decades. Our analysis is mostly descriptive and focuses on two aspects of urban growth – population and income of agglomerations – that can be consistently measured over the last three to four decades. In Section 0, we begin by describing urban growth patterns between 1970 and 2000. We then investigate two processes in the productive sectors of the Brazilian economy that have accompanied the maturing of the Brazilian urban system. In Section 3, we look at industrial specialization, and in Section 4 we discuss trends of industrial deconcentration both across the urban hierarchy and within agglomerations. Section 5 presents a brief assessment of the patterns of indicators of quality of life by agglomeration size and welfare. Finally, we provide a simple analysis of some of the proximate correlates of urban growth in Section 6. Section 7 concludes.

1 URBAN GROWTH PATTERNS

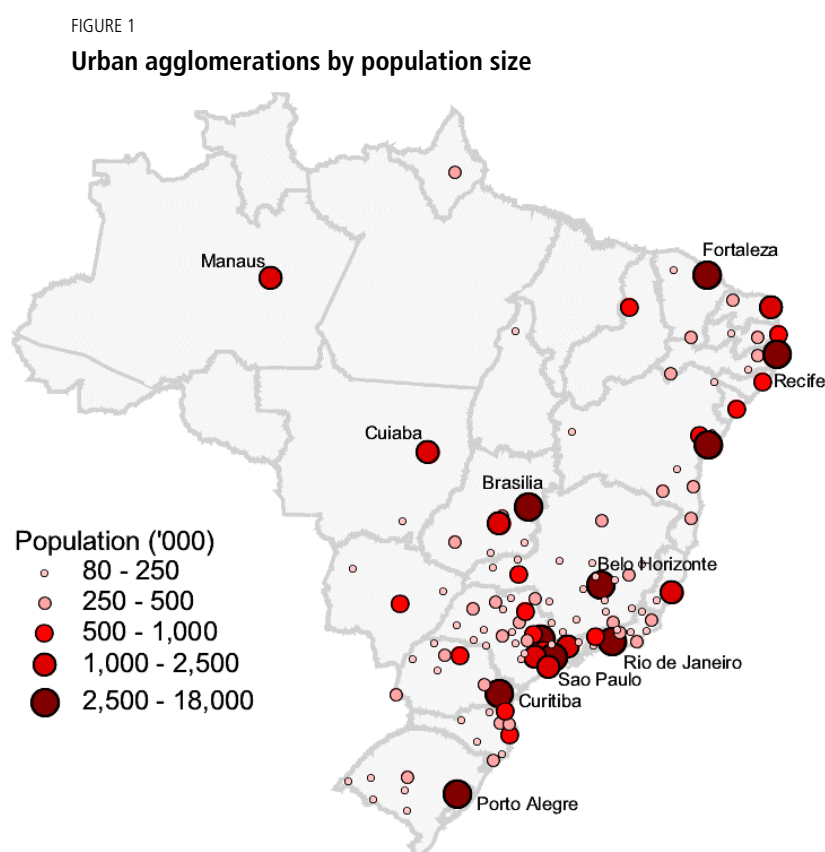
Our examination of urban growth patterns in Brazil focuses on changes in population size and economic productivity. Both are interrelated indicators of city “success”. In the presence of free movement of labor and capital, factors of production will move to the areas that promise the highest returns. Workers and employees will therefore seek out places in which they can maximize wages given their skills and experience. Successful cities are also able to provide infrastructure and administrative support to businesses which will enhance productivity and, in turn, raise wages. High quality public services and amenities will also attract new residents, especially higher skilled workers that add disproportionately to productivity gains.

In the following sections we describe population and income dynamics in Brazilian urban areas. For this purpose we require a working definition of city, urban area or agglomeration, since there is no official statistical or administrative entity in Brazil that reflects the concept most appropriate for economic analysis: a contiguous

built up area that operates as a functional economic entity. Socioeconomic data in Brazil tend to be available for municípios, the main administrative level for local policy implementation and management. Municípios, however, vary in size. In 2000, São Paulo município had a population of more than ten million, while many other municípios had only a few thousand residents. Furthermore, many functional agglomerations consist of a number of municípios, and the boundaries of these units change over time. Our analysis therefore adapts the concepts of agglomerations from a comprehensive urban study by Ipea, IBGE and Unicamp (2002) resulting in a grouping of municípios to form 123 urban agglomerations (Figure 1). Details about the geographic definitions employed and construction of the database are included in Annex 1. Throughout this paper we refer to these units of analysis as agglomerations, urban areas, or cities.

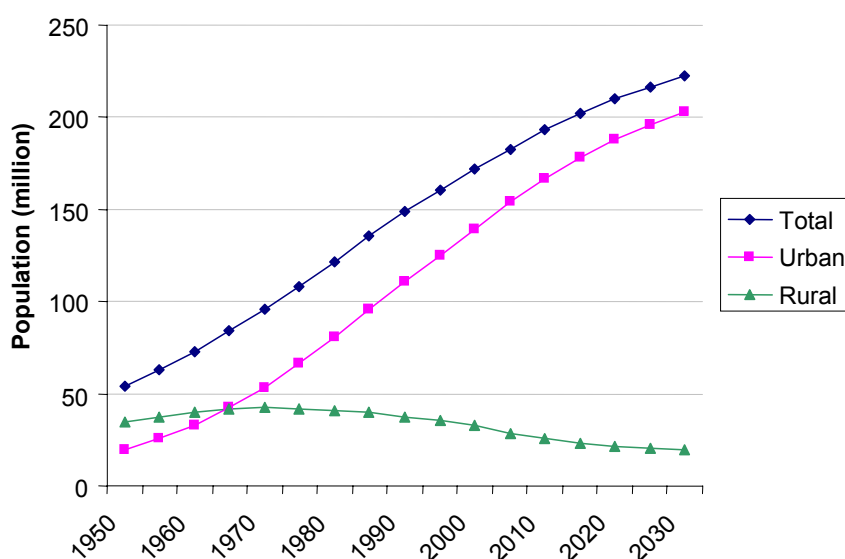
1.1 PATTERNS OF POPULATION GROWTH

For the last 30 years, Brazil accommodated its growing population through both increasing sizes and numbers of individual cities. Over 80 percent of the country's population lives in urban areas, up from 56 percent in 1970. According to estimates by the UN Population Division, the entire growth in population that is expected over the next three decades will be in cities when the urbanization rate is expected to exceed 90 percent (UN 2003 Figure 2). This will add about 63 million people to Brazil's cities, and total urban population will be over 200 million.



Source: Ipea, IBGE.

FIGURE 2

Historic and projected population dynamics in Brazil

Source: United Nations World Urbanization Prospects, 2003.

Population growth is occurring across the Brazilian urban size distribution (Table 1, see also Lemos *et al.* 2003). Of the 123 major urban agglomerations in Brazil, only three were above 2 million people in 1970 versus ten in 2000. In the middle of the size distribution in 2000, there were 52 agglomerations with population between 250,000 and 2 million people compared to 25 in 1970. Since we are limiting analysis to cities that were agglomerations in 1991, we cannot track dynamics at the lower end of the distribution. This is because our set includes cities that were not yet agglomerations in 1970, while excluding cities of similar size in later years. However, among the 72 agglomerations that had at least 100,000 people in 1970 (Table 2), the average population more than doubled from 553,000 to 1,250,000 over the thirty year period.

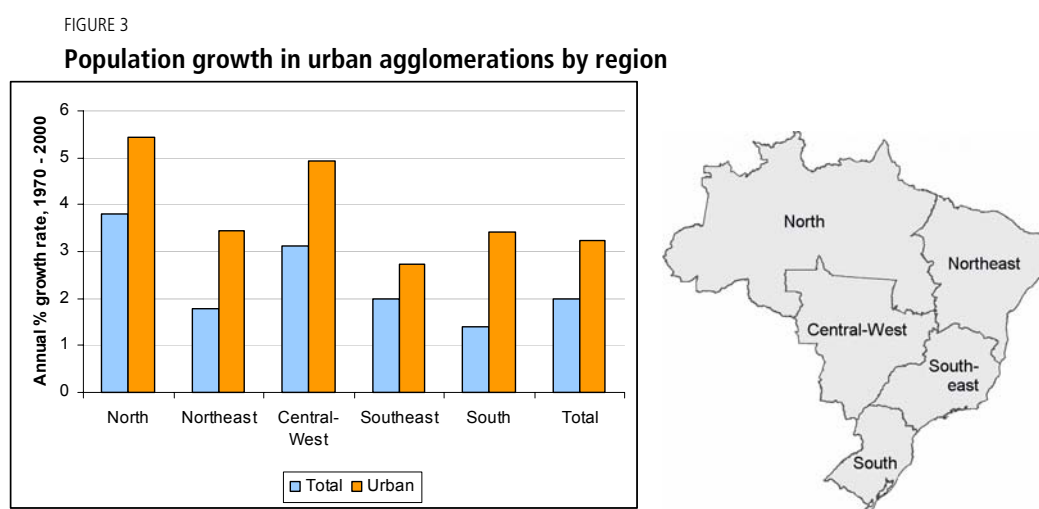
TABLE 1

City size distribution

Population size	1970	1980	1991	2000
> 5 million	2	2 ¹	3 ²	3
2 million - 5 million	1	3	7	7
1 million - 2 million	4	5	5	8
500,000 - 1 million	5	10	15	14
250,000 - 500,000	16	21	23	30
100,000 - 250,000	44	43	44	46
< 100,000	51	39	26	15
Total number of cities	123	123	123	123
Average size	350,857	507,242	657,602	788,222
Min	20,864	41,454	76,816	86,720
Max	8,139,705	12,588,745	15,444,941	17,878,703

¹ "São Paulo" and "Rio de Janeiro".² "Porto Alegre" is newly added.

Geographically, the strongest population growth has been in the North and Central West regions (Figure 3). Growth has been slowest in the South and Southeast, where rapid urban expansion occurred in an earlier period. The Central-West region experienced the second highest urban population growth (4.9 percent annually), but has only 11 agglomerations – compared to 60 in Southeast, and 25 and 24 in the Northeast and South, respectively. In Table 3, we list the seven fastest growing cities between 1970 and 2000 among the 72 existing cities in 1970. Over the period the average annual city population growth of the top seven cities was 4.5 percent, considerably higher than the 2.5 percent growth rate for all other cities with population above 100,000 in 1970. Most of the high growth agglomerations (four out of seven) are located in the Central-West region. The fastest growing agglomeration was Campo Grande, with an increase from 140,000 in 1970 to 664,000 in 2000 (5.2 percent annually). Like Campo Grande, the seven fastest growing agglomerations did so from a relatively small base populations in 1970, except for Brasília (762,000) and Manaus (534,000).



Source: Population Censuses of 1970 and 2000.

TABLE 2

The 7 fastest growing cities between 1970 and 2000*

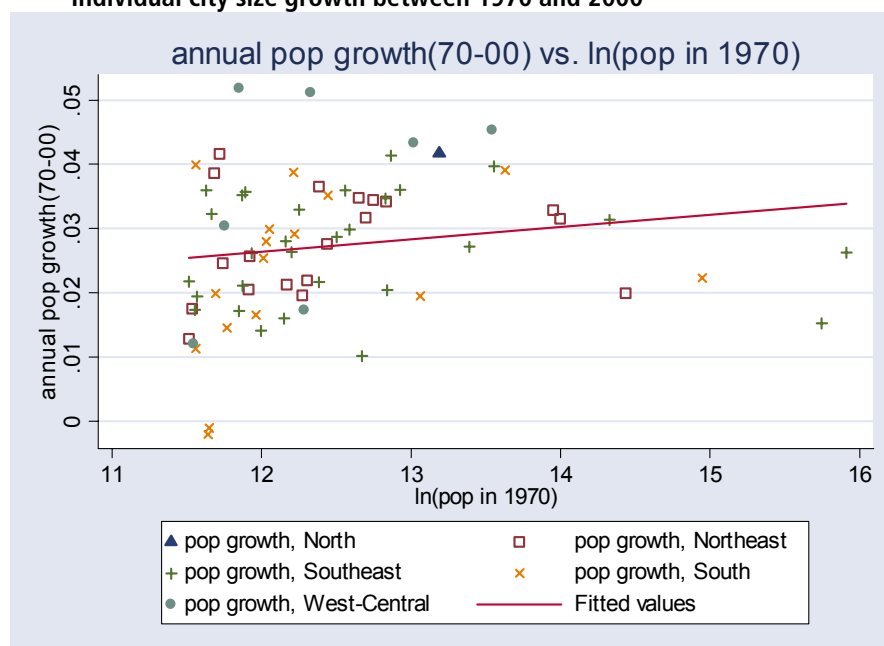
Top 7 cities	Region	Population in 1970	Population in 2000	Annual pop growth (1970-2000, %)
Campo Grande	Central-West	140,233	663,621	5.2
Cuiabá	Central-West	226,437	1,051,183	5.1
Brasília	Central-West	761,961	2,965,951	4.5
Goiânia	Central-West	450,538	1,651,691	4.3
Manaus	North	534,060	1,865,901	4.2
Petrolina	Northeast	122,900	428,841	4.2
Grande Vitória	Southeast	385,998	1,337,187	4.1
Average of the top 7 cities		374,590	1,423,482	4.5
Average of others (65)		571,805	1,231,759	2.5
Total (72)		552,631	1,250,398	2.7

* For the cities with population greater than 100,000 in 1970. 72 cities meet this cutoff criterion.

The unusually high city population growth, particularly in the Central-West region, may be due to a number of factors such as greater technological change in that region, greater localized degree of rural-urban migration, changing roles of cities in a region, or greater difficulty in formation of new cities forcing the urbanizing population into existing cities in that region. A lack of developers, city governments, and policies that facilitate formation of new cities can lead existing cities to be oversized (Henderson and Wang, 2005). In Figure 4 and the corresponding OLS regression result reported below the figure we examine the determinants of relative city growth rates. Initial agglomeration size in 1970 does not influence population growth afterwards. There is a positive relationship between agglomeration growth and its manufacturing share in non-agricultural employment. Growth is also positively related to the average years of schooling in 1970 which is used as a measure of human capital accumulation in a city and potential for technological change. However regional differences, after controlling for initial size and education, are important in explaining city size growth as indicated by the Wald test that shows that regional dummies are jointly significant. As noted above, these differences could be due to institutional factors affecting city formation or due to local migration processes. However changes in the role of cities in the Central-West may also be at play.

FIGURE 4

Individual city size growth between 1970 and 2000¹



¹ For the cities with population greater than 100,000 in 1970. 72 cities meet this cutoff criterion.

OLS results

Dependent variable: average annual population growth rate 1970-2000

	Coefficient	t-value	
Ln (population in 1970)	-0.0002	-1.39	Adj R ² = 0.28
Manufacturing share in 1970*	0.025	2.04	N = 72
Average years of schooling	0.008	4.02	
North	0.006	0.59	Wald test for all regional dummies =
Northeast	-0.0004	-0.92	0: F(4, 64) = 6.54,
Southeast	-0.016	-3.85	p-value = 0.0002
South	-0.017	-3.95	
Constant	0.034	2.11	

* Non-agricultural employment share of manufacturing, 1970: Manufacturing / (Manufacturing + Services).

The rapid growth of Central-West cities parallels changes in their industrial composition.¹ As shown in Annex 2, the three fastest growing agglomerations have high employment shares of food and beverage manufacturing, commerce and construction and public services including education and healthcare. It suggests that their success in attracting new residents comes in part from their roles as hubs for serving rural demand in the rapidly expanding soybean growing regions (Motta, Muelle and Torres, 1997).

Brazil is often viewed as having a spatially unequal urban system with a few large cities increasingly dominating the size distribution. To examine this notion, Table 3 shows the spatial Gini coefficients (Krugman, 1991) for the country and each of the regions for 1970 and 2000. These coefficients are a measure of inequality of population distribution across the 123 agglomerations. The larger the coefficient, the further is the urban system from an equal size distribution. Overall, the spatial Ginis have increased slightly over the period, which is mainly due to the downward movement of small size cities. While the highly concentrated Southeast region has virtually no change in spatial inequality around 0.76, there has been a significant increase in spatial inequality in the Central-West region, which had been the least concentrated in 1970. As a result, the entire southern region, including the Southeast (0.76), South (0.66) and Central-West (0.58), is more spatially concentrated in 2000 than the North (0.46) and Northeast (0.57).

TABLE 3

Spatial gini coefficients in 1970 and 2000

	1970 (a)	2000 (b)	(b-a)
Total (123)	0.692	0.700	0.008
North (3)	0.456	0.463	0.007
Northeast (25)	0.561	0.569	0.008
Southeast (60)	0.760	0.761	0.001
South (24)	0.626	0.658	0.032
Central-West (11)	0.441	0.583	0.142

Number of cities in parentheses.

Another way to examine changes in agglomeration size in Brazil is via a transition matrix. It helps examine the degree of mobility of cities up and down the urban hierarchy and test for the stationarity of the processes affecting the 123 agglomerations (Eaton and Eckstein, 1997; Dobkins and Ioannides, 2001). Following Black and Henderson (2003), we divide the 1970 agglomeration size distribution into five groups or cells containing approximately 35%, 30%, 15%, 10% and 10% of all cities starting from the bottom, with fixed relative cell cut-off points.² Table 4 presents the resulting transition matrix. The transition probabilities of the transition matrix, P_{jk} , are calculated as the total number of cities moving from cell j to k over three decades divided by the total number of cities starting in cell j in the three decades. Diagonal elements are the probabilities of staying in the starting state, and off-diagonals the probabilities of moving lower or upper cells.

1. We exclude Brasília, since its growth is mainly due to its role as the capital city in Brazil.

2. The relative size (city population/mean(city population)) upper cut-off points are 0.256, 0.469, 0.812, 1.340 and the maximum.

TABLE 4

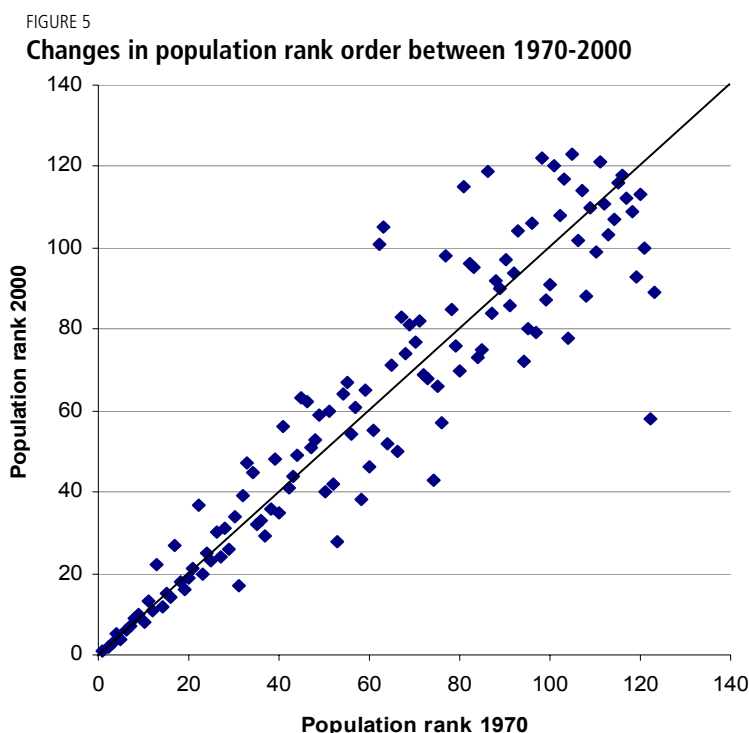
The transition matrix

		cell in t+1 (2000)				
		5 (smallest)	4	3	2	1 (largest)
Cell in t (1970)	5	0.987	0.013	0.000	0.000	0.000
	4	0.183	0.720	0.098	0.000	0.000
	3	0.000	0.091	0.800	0.109	0.000
	2	0.000	0.000	0.029	0.882	0.088
	1	0.000	0.000	0.000	0.000	1.000

The probability of staying in the same state is the highest at 100 percent for the cities at the top of the hierarchy (cell 1), which implies no downward mobility for the largest agglomerations. Also the mobility is extremely low for the smallest agglomerations in cell five. This extremely high probability of smallest cities in cell five staying in the same state (98.7 percent) is quite different from the finding of Henderson and Wang (2005).³ The cities in the middle portions of the hierarchy have a relatively high degree of mobility moving up and down in response to changing demands for their products, product readjustment, and local entrepreneurship or lack thereof. In particular the lower-medium size cities in cell 4 have only 72.0 percent probability of staying in the same state and the probability of moving down a state exceeds that of moving up (18.3 percent versus 9.8 percent). However the upper-medium size agglomerations in cell two have a higher probability of moving up a state than moving down (8.8 percent versus 2.9 percent). The stationarity of the transition matrices is just accepted,⁴ implying it is reasonable to assume the city size distribution evolves over time according to a homogeneous stationary first-order Markov process. Figure 5 provides a continuous view of the dynamics of city rankings between 1970 and 2000. Points below the 45 degree line represent cities that have increased their population and have moved up in the ranks. Points above the line are cities that dropped in the relative size distribution. The largest changes are among the middle and lower ranked agglomerations.

3. For the metro areas of the world with population over 100,000, the probability of the smallest cities staying in the same state was 78 percent, and that of the largest cities 96 percent (Henderson and Wang 2005).

4. The χ^2 statistic is 27.07 with 40 degrees of freedom (p-value 0.059).



Source: Ipea, IBGE.

1.2 PATTERNS OF INCOME GROWTH

The second aspect of city performance that we investigate here relates to economic performance. We employ average household income as a proxy for productivity increases, since neither firm level factor productivity, nor data on real wage rates are consistently available for the time period 1970-2000. However, income and wages are strongly correlated in both levels and rates of growth for the years in which both are available at the município level (1991 & 2000). Annex 1 provides details.

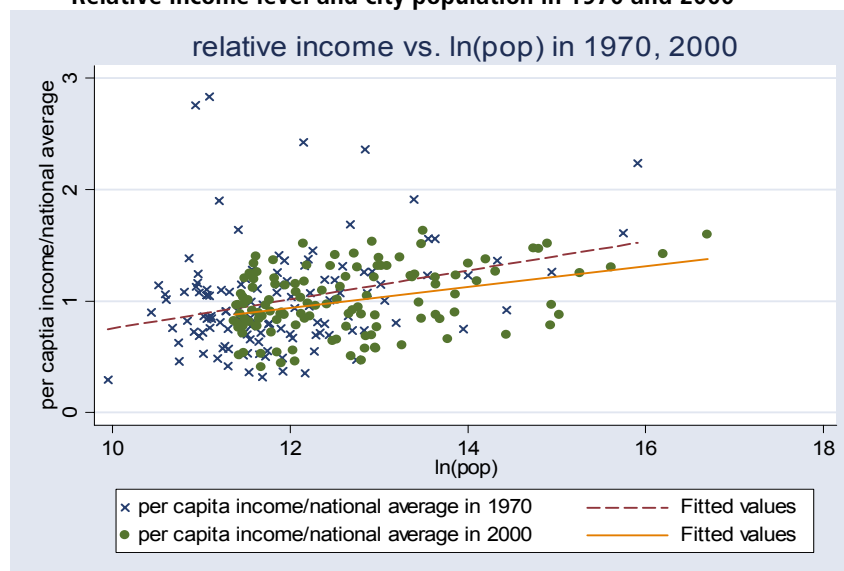
As a second caveat, our data represent “nominal” incomes per capita, not “real” incomes. While the average agglomeration income figures have been adjusted for inflation over time, they do not reflect purchasing-power-parity [PPP] estimates across space – i.e., they do not consider local price indexes. Housing costs vary significantly across cities, reflecting commuting costs and rent gradient shifts. As land prices rise, asset price increases will spill over into the prices of retail goods sold in the city. If everyone is a home owner, as land prices rise, residents will recoup implied rent increases in the form of returns on land investment. But many people working in Brazilian cities are renters. Thus a rise in “nominal” incomes may overstate the rise in “real” incomes that translates into tangible welfare gains. Despite these qualifications, however, we believe that the broad patterns discussed in the following paragraphs hold.

During the period 1970-2000, Brazil’s economic performance has fluctuated considerably, ranging from economic boom in the 1970s to a sharp decline in the 1980s and a recovery in the 1990s. We focus on the broad trends between 1970 and 2000. The first pattern discussed here is that relative to the national average, wages

are higher in larger agglomerations. Figure 6 plots per capita income levels relative to national averages in 1970 and 2000 against the agglomeration populations in those periods. The figure and the corresponding OLS regression result indicate a positive relationship between the per capita income level and the size of a city. A Chow test shows no statistical difference between the 1970 and 2000 patterns.

FIGURE 6

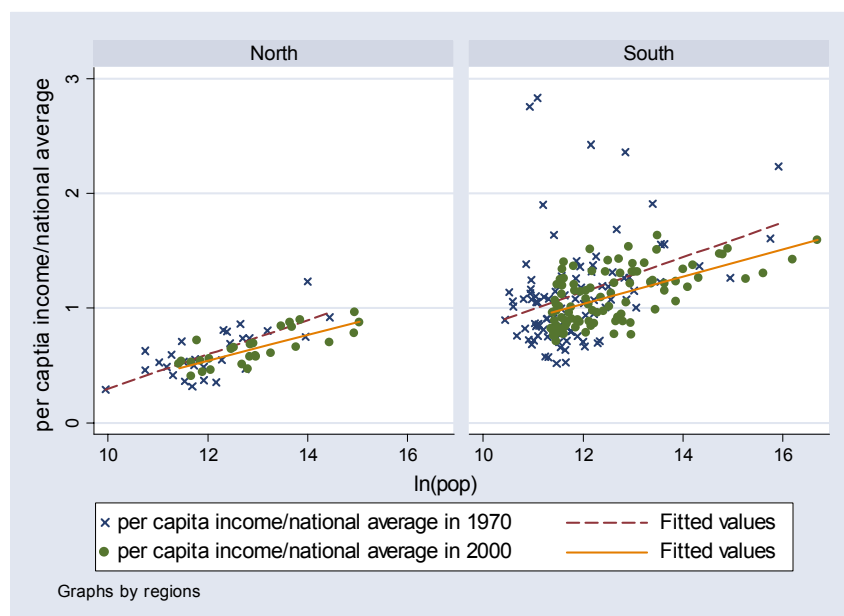
Relative income level and city population in 1970 and 2000



Pooled 1970 & 2000 OLS results

Dependent variable: $\ln(\text{income}/\text{average agglomeration income})$

	Coefficient	t-value	
$\ln(\text{population})$	0.130	4.04	Adj $R^2 = 0.09$
$\ln(\text{population}) * \text{year 2000 dummy}$	-0.037	-0.85	N = 246
Dummy for year 2000	0.369	0.69	
Constant	-0.542	-1.41	



An issue especially relevant to measuring city success is whether there is income convergence across Brazilian cities or regions over time. And if there is convergence, is it related to migration or to convergence in total factor productivity and technologies (see, e.g., Barro and Sala-i-Martin (1995), for the USA versus Japan)? To make these comparisons we compare levels and growth rates in real per capita income across Brazilian cities to see if gaps have narrowed over time and the variation across cities has dropped. Recently, Andrade et al. (2004) tested income convergence across Brazilian municipalities from 1970 to 1996.⁵ Their empirical finding suggests a club convergence (a conditional convergence) between the poorer Northern region (the North and the Northeast) and the richer Southern region (the Southeast, the South and the West-Central).

Conceptually convergence can be measured by (i) β convergence in which poor cities tend to catch up with the rich ones in terms of per capita income, and (ii) σ convergence where the dispersion of per capita income declines over time. β convergence of per capita income across cities can be tested by regressing the annual per capita income growth rates on the log of base year's per income levels.

Table 5 reports the OLS estimation results for convergence across urban agglomerations. The speed of convergence is calculated using the coefficient estimate and is reported in the last row in the table.⁶ The results strongly suggest “ β convergence” across Brazilian agglomerations. The speed of convergence, when regional dummies are added, is stable around 3.4 percent, which is slightly higher than other countries.⁷ In the last two columns, we examine the possibility of conditional convergence between agglomerations in the Northern and the Southern regions as a group. The coefficient of the Southern dummy is significantly positive when the same speed of convergence is assumed (column (3)), potentially indicating a higher steady-state growth rate of the Southern region cities. This is consistent with the finding of Andrade et al. (2004). However, overall, we cannot reject the hypothesis of identical speed of convergence and steady state growth rates between the two regions (column (4)).

Figure 7 and Figure 8 confirm these findings. Figure 7 shows a negative (linear) relationship between the annual income growth rate between 1970 and 2000 and the log of per capita income level in 1970. Figure 8 shows the pattern between 1991 and 2000. The fitted lines of the Northern and the Southern regions seem to have a similar slope but different intercepts.

5. They evaluated convergence of Brazilian municipalities by directly examining the cross-section distribution of income, suggested by Quah (1993, 1997).

6. The speed of convergence (β) is calculated using the formula of Barro and Sala-i-Martin (1995), such that

$$\hat{\beta} = -\frac{1 - e^{-\beta T}}{T} \text{ where } \hat{\beta} \text{ is the coefficient estimate and } T=30.$$

7. Most published studies have investigated convergence across administrative regions rather than urban areas. With regional dummies added, the convergence speed across U.S. states for 9 subperiods between 1880 and 1990 was 1.9 percent, Japanese prefectures for 7 subperiods between 1930 and 1990 was 2.3 percent, and European regions for 4 subperiods between 1950 and 1990 was 1.9 percent (Barro and Sala-i-Martin (1995)).

TABLE 5

 β Convergence of per capita income¹

	(1)	(2)	(3)	(4)
	Basic equation	Basic equation + 5 regional dummies ²	Basic equation + 2 regional dummies ²	(Chow test) Basic equation + 2 regional dummies ²
ln(income in 1970)	-0.015 (10.21)	-0.021 (12.63)	-0.022 (13.62)	-0.018 (5.43)
ln(income in 1970)* Dummy(south)				-0.005 (1.20)
Constant	0.104 (14.66)	0.136 (16.72)	0.126 (18.32)	0.111 (7.77)
Dummy(south)			0.011 (6.75)	0.031 (1.84)
Number of observations	123	123	123	123
Adj. R ²	0.46	0.60	0.60	0.61
Speed of convergence (%)	2.03	3.44	3.47	

¹ Dependent variable = $(1/30) * \ln[\text{income}(2000)/\text{income}(1970)]$.

² Five regional dummies correspond to the North, the Northeast, the Southeast, the South and the West-Central regions, with the West-Central as a base. Two regional dummies are for the northern (the North and the Northeast) and the south (the others) regions, with the northern regions as a base. The estimated coefficients for five regional dummies in eq. 2 are not reported.

³ T-values are in the parentheses.

FIGURE 7

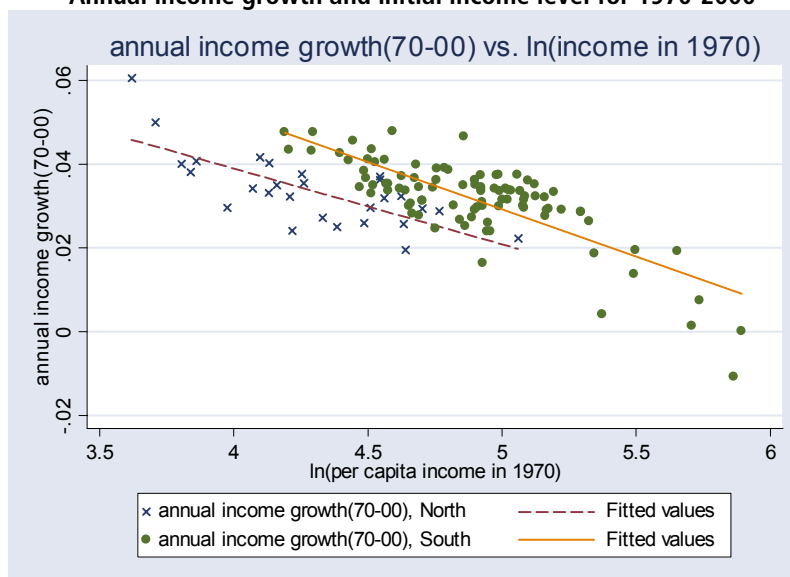
Annual income growth and initial income level for 1970-2000

FIGURE 8

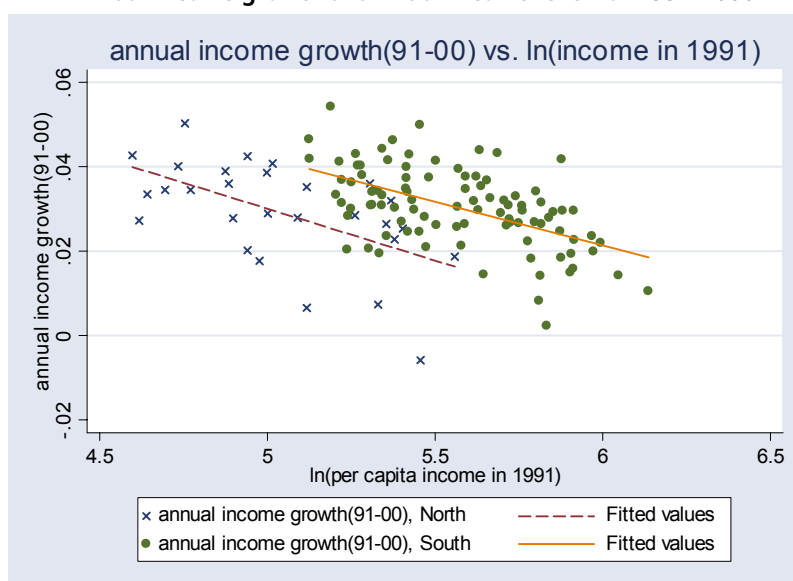
Annual income growth and initial income level for 1991-2000

Table 6 presents the standard deviation of the log of city per capita income over time. The overall dispersion declined from 0.43 in 1970 to 0.32 in 2000, suggesting a strong tendency for σ convergence. When grouped into the Northern and Southern regions, both regions show the same trend of decreasing dispersion. The standard deviations in both regions are similar to each other but smaller than the overall standard deviation. It also signifies conditional convergence between the Northern and the Southern regions. Interestingly, the level of average real income in 1991 is lower than in 1980 and 2000 but the standard deviation is higher than those years. It suggests a nationwide adverse shock in 1991, which decreased the real income, increased the dispersion of income distribution across Brazilian cities. High per capita income cities, usually large cities, absorb adverse shocks better than low income cities or small cities.

TABLE 6

 σ Convergence of per capita income

		ln[income (1970)]	ln[income (1980)]	ln[income (1991)]	ln[income (2000)]
Total	count	123	123	123	123
	mean	4.759	5.544	5.450	5.719
	std dev	0.431	0.328	0.339	0.316
Northern	count	28	28	28	28
	mean	4.290	5.114	5.039	5.301
	std dev	0.350	0.272	0.280	0.236
Southern	count	95	95	95	95
	mean	4.897	5.670	5.571	5.843
	std dev	0.348	0.218	0.248	0.214

2 SPECIALIZATION ACROSS CITIES

Cities manufacture different types of goods and as such production patterns differ across the urban hierarchy. The factors driving these differences are basic underlying fundamentals affecting the transport costs of different types of goods, their sources of demand, and their production technology. Urban productivity is also influenced by economic composition. Both, a concentration in closely related industries (*localization economies*) and a diversity of economic activities (*urbanization economies*) tend to enhance the productivity of urban areas. Here we first examine the concentration of different types of industries across cities. Then we examine city specialization per se. Finally in the next section we examine how manufacturing overall has tended to decentralize out of the largest cities over time. Due to limitations in the available employment data we cannot investigate changes over time and therefore focus only on patterns in 2000.

A typical measure of concentration of industry j spread over m urban areas is a variation of the well-known location quotient (e.g., Ellison and Glaeser, 1999):

$$G_j = \sum_{i=1}^m (S_{ij} - E_i)^2$$

where S_{ij} is the share of city i in industry j employment nationally and E_i is the share of city i in total national employment. This index has a value of zero, if an industry is spread evenly across all cities according to their sizes, as is typical for personal and retail services. If an industry is highly concentrated it has a value approaching two. Table 7 shows urban concentration for each two-digit level industry across the urban hierarchy.

The first column reports the measure of industry concentration, G_j of each 2-digit level industry j . Industry concentration is relatively low for “ubiquitous” industries which are hard to transport and available in many places. Food and beverage manufacturing (0.0042), Metal products (0.0046), Furniture and miscellaneous manufacturing (0.0041), and service industries (excluding Finance service) are in this category. The concentration is higher for the natural resource based industries (Tobacco product (0.3698) and Leather products (0.2013)) with their high transport costs of moving materials, and for the technology intensive industries, including Electrical and electronic machinery/equipment (0.0417) and Transportation equipment (0.0486), which may be subject to greater scale economies.

The third column of Table 7 shows the shares of each industry in the total employment of all urban agglomerations, and the last five columns show the relative importance of each sector in urban agglomerations of a given size category. Shares above 100 percent indicate that the industry is more prominently represented in that group of agglomerations compared to the national average share. Several patterns emerge. First, high and medium-high technology industries are concentrated in large cities (Publishing and printing, Chemical products, Electrical and electronic machinery/equipment and Transportation equipment). In particular, computer related industries and financial services are heavily concentrated in large cities. Second, medium technology industries are relatively more concentrated in medium size cities (Textile products and Pulp and paper products). Third, low technology industries that are usually related to natural resource extraction are concentrated in

small cities (Agriculture and forestry, Mining and wood products). Finally, “ubiquitous”, industries producing non-tradable goods and services are fairly evenly distributed across the urban hierarchy. Overall, among 123 cities in Brazil 65 percent of national employment is concentrated in the 15 largest cities, whereas the 57 smallest cities accommodate only eight percent of national employment.

TABLE 7

The concentration of industry in 2000

2-digit industry classification	G_j	Share in national employment	Share relative to the national average, % ¹				
			Cell 1 (large cities)	Cell 2	Cell 3	Cell 4	Cell 5 (small cities)
Agriculture and forestry	0.0452	5.0	63.0	118.0	172.2	177.6	238.7
Fishing	0.0500	0.2	83.8	145.3	126.8	173.7	76.7
Mining	0.0240	0.3	77.6	98.8	118.2	135.0	238.3
Food and beverage manufacturing	0.0042	2.3	88.9	111.8	128.8	116.6	129.7
Tobacco product manufacturing	0.3698	0.1	128.8	60.8	60.6	22.7	27.2
Textile product manufacturing	0.0102	3.4	88.4	107.6	161.6	115.7	107.5
Leather processing and products manufacturing	0.2013	1.0	101.6	34.7	43.2	286.8	95.7
Wood products manufacturing	0.0199	0.4	80.3	110.5	137.5	134.4	179.0
Pulp, paper and paper products manufacturing	0.0296	0.3	103.5	60.6	144.1	84.5	99.0
Publishing, printing, reproduction of recordings	0.0282	0.9	118.4	72.7	73.3	53.7	55.8
Coal products, petroleum refining, alcohol prod.	0.0262	0.1	110.2	66.0	66.1	109.9	96.0
Chemical products manufacturing	0.0291	1.0	120.0	67.9	62.3	67.2	50.4
Rubber and plastics product manufacturing	0.0484	0.7	114.0	79.6	102.5	55.4	49.9
Metal product manufacturing	0.0046	2.9	95.3	104.5	144.9	73.1	107.3
Machinery and equipment manufacturing	0.0185	0.8	104.6	103.6	116.9	74.5	59.6
Electrical, electronic machinery & equipment	0.0417	0.5	123.3	69.8	70.4	31.1	41.7
Transportation equipment manufacturing	0.0486	1.1	123.6	48.9	65.1	40.0	69.5
Furniture and miscellaneous manufacturing	0.0041	1.5	98.2	98.3	120.4	98.6	97.2
Finance service	0.0230	2.0	121.3	72.9	60.7	48.5	49.0
Transportation, warehouses, communication	0.0030	6.9	109.2	86.5	79.8	85.5	77.5
Commerce	0.0003	21.4	100.2	101.5	99.0	103.4	94.3
Construction	0.0005	8.7	99.6	101.3	99.7	103.1	99.3
Domestic service	0.0010	9.1	99.8	101.7	91.6	102.8	105.7
Public service	0.0063	6.1	99.6	121.8	84.5	87.7	95.5
Education service	0.0006	6.7	99.0	110.9	98.7	94.7	97.3
Health service	0.0020	4.8	108.2	97.5	80.2	72.9	78.8
Other service	0.0013	5.0	106.2	94.5	84.5	90.6	81.5
Other industry	0.0013	6.8	103.7	96.5	88.4	96.4	90.0
(High tech industry) ²		(0.8)	(126.2)	(69.6)	(54.1)	(35.1)	(30.3)
Number of cities		123	15	14	17	20	57
Employment share in a cell		100.0	65.2	12.2	8.2	6.4	8.0

¹ The relative size cutoff points are calculated for 1970 city size distribution to be divided into five cells containing approximately 35%, 30%, 15%, 10% and 10% of all cities starting from the bottom.

² High tech industry covers i) Manufacture of machines and equipment of computer science (Cnae 30000), ii) Activities of computer science - exclusive maintenance and clerical repairing of machines and computer science (Cnae 72010) and iii) Maintenance of machines clerical and computer science (Cnae 72020).

As a country develops, industrial concentration tends to decrease as a result of improvements in transport, utilities and communication. In earlier stages of development, most modern economic activity is located in one or a few centers where scarce labor and capital can be employed most productively. Manufacturing and higher end services will spread to smaller cities in later stages, allowing these places to specialize in sectors where they have a comparative advantage. As these cities continue to grow in size, other modern-sector activities will locate there, resulting in a diversified economy that offers greater economic opportunity and a lower susceptibility to sector specific downturns.

In general, as suggested by the discussion of industrial concentration, smaller and medium size cities tend to be fairly specialized, for instance in food and beverage production, textiles, shoes, or pulp and paper products. Bigger cities tend to have a more diverse industrial base, with providers of niche products and services who can find a market in a large agglomeration. High-tech, specialized production and complex business services also tend to be found more in larger cities, since they require an educated, highly skilled workforce that is attracted to places that offer a greater range of amenities. As development proceeds, manufacturing processes become more complex with more stages of production and greater out-sourcing. This allows smaller and medium size cities to capture some of these activities and become more diverse.

Specialization and diversity is measured by (Henderson, Lee and Lee 2001):

$$SP_i = \sum_{j=1}^k (s_{ij} - E_j)^2$$

where E_j is the share of industry j in national employment, s_{ij} is the share of industry j in total employment of agglomeration i , and the sum is over k industries locally. The index measures for each industry how much the local production share differs from the national share. If all industries mimic the national share the index has a value zero and the city is perfectly diverse. A highly specialized city would have an index approaching two.

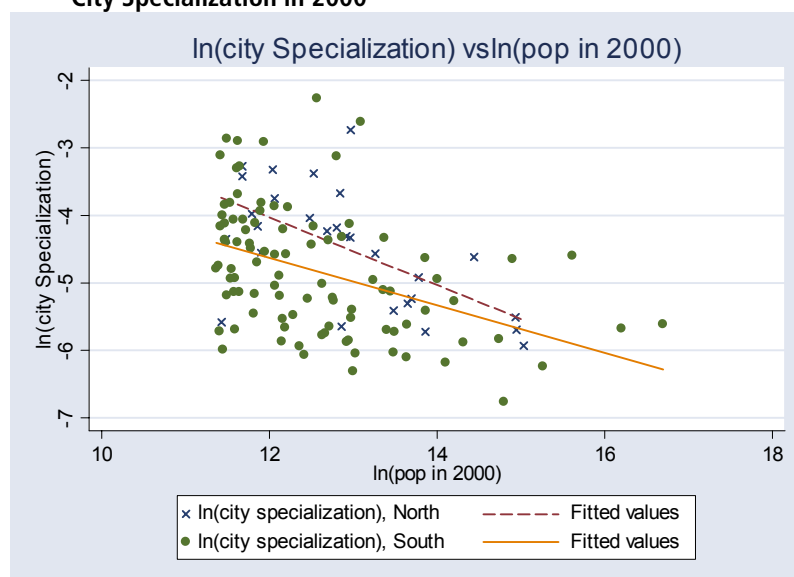
TABLE 8
City specialization in 2000

City sizes ¹	Number of cities	SP_i
Largest (1.593 ≤ pop/mean)	15	0.0047
(0.847 ≤ pop/mean < 1.593)	14	0.0052
(0.498 ≤ pop/mean < 0.847)	17	0.0156
(0.288 ≤ pop/mean < 0.498)	20	0.0165
Smallest (pop/mean < 0.288)	57	0.0166
Total	123	0.0137

¹ The relative size cutoff points are calculated for 1970 city size distribution to be divided into 5 cells containing approximately 35%, 30%, 15%, 10% and 10% of all cities starting from the bottom.

Table 9 shows how this index varies across the urban hierarchy in Brazil. As expected, the specialization index increases as agglomerations get smaller. Or conversely, as a city becomes bigger, diversification increases. In 2000, the specialization index in the largest agglomerations (0.0047) is just 28 percent of that in the bottom agglomerations (0.0166). Figure 9 and the corresponding regression also show a significant negative relationship between agglomeration specialization and size in 2000. A Chow test shows no statistical difference between the Northern and the Southern regions.

FIGURE 9

City Specialization in 2000**Dependent variable: ln(specialization index for 2000)**

	(1)	(2)
ln(population 2000)	-0.358 (-5.28)	-0.502 (-3.37)
ln(population)*south dummy		0.151 (0.91)
Dummy for south region		-2.413 (-1.12)
Constant	-0.220 (-0.25)	1.997 (1.03)
Adj. R ²	0.18	0.22

T-values in parentheses.

3 INDUSTRIAL DECENTRALIZATION

As the urban system develops, typically manufacturing decentralizes out of the biggest cities first into their suburbs and nearby ex-urban transport corridors and then into smaller cities, with their lower cost of living, lower wages, and lower rents (Henderson *et al.* 1995). Decentralization as noted above is spurred by inter-city and hinterland infrastructure investment and increasing overall sophistication of the labor force. In a modern system of cities the share of manufacturing in local economic activity tends to rise as we move down the urban hierarchy. As part of a domestic product cycle, traditional standardized products are manufactured in smaller cities and more high tech, innovative products in the biggest cities. In contrast to manufacturing, as we move down the urban hierarchy, the share of business services such as financial and legal activities in local economic activity declines. Conversely, the ratio of manufacturing to business services falls as we move up the urban hierarchy, reflecting the service orientation of bigger cities (Kolko 1999).

As suggested by theory, Brazil has experienced a manufacturing decentralization process between 1970 and 2000. In Table 9 we list the ratios of employed population working in the secondary and the tertiary industries in 1970 and 2000 (see also Figure

10). We group agglomerations into five size groups as before based on the relative population cutoff points. A comparison between 1970 and 2000 employment shares shows a typical manufacturing decentralization process, albeit less than we anticipated. In 1970 the secondary industry share in overall local employment was positively related to agglomeration size. Similarly, the manufacturing share in total non-agricultural employment increases from 29.0 percent among the smallest agglomerations to 34.7 percent in the top group as we move up the urban hierarchy in 1970. But by 2000 there is a dramatic drop in the manufacturing share of the cities in the top two cells to about 25 percent. While the manufacturing share drops in smaller cities as well, the decline is more modest, so that by 2000 smaller cities have more local manufacturing concentration than bigger ones. We therefore observe decentralization of manufacturing industry out of big cities.

TABLE 9

Employment share by industry in 1970 and 2000

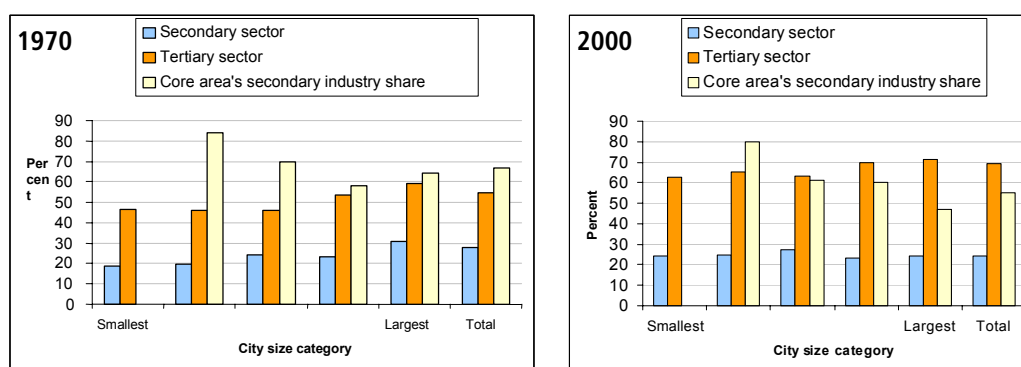
Agglomeration size groups ¹	Number of cities	Employment share, %			Core area's secondary industry share ²	Core area's tertiary industry share ²
		Secondary industry (a)	Tertiary industry (b)	$\frac{a}{a+b} \times 100$		
1970						
Largest: 1.340 ≤ pop/mean	12	30.9	58.1	34.7	64.2	76.1
0.812 ≤ pop/mean < 1.340	12	23.4	53.8	30.3	58.0	72.1
0.469 ≤ pop/mean < 0.812	19	24.1	46.1	34.4	69.7	71.9
0.256 ≤ pop/mean < 0.469	36	19.7	46.1	30.0	83.8	86.7
Smallest: pop/mean < 0.256	44	18.9	46.5	29.0	-	-
Total	123	27.8	54.8	33.7	66.6	77.1
2000						
Largest: 1.340 ≤ pop/mean	15	24.1	71.2	25.3	47.0	61.3
0.812 ≤ pop/mean < 1.340	14	23.0	69.8	24.8	60.0	70.9
0.469 ≤ pop/mean < 0.812	17	27.3	63.1	30.2	61.1	70.3
0.256 ≤ pop/mean < 0.469	20	24.6	65.3	27.3	79.8	81.4
Smallest: pop/mean < 0.256	57	24.0	62.8	27.7	-	-
Total	123	24.2	69.4	25.9	55.2	66.5

¹ The relative size cutoff points are calculated for 1970 city size distribution to be divided into 5 cells containing approximately 35%, 30%, 15%, 10% and 10% of all cities starting from the bottom.

² Core area's secondary (tertiary) industry share (%) is the ratio of the secondary (tertiary) industry employment in core areas to the total secondary (tertiary) industry employment in an agglomeration. The ratio of the number of suburb to core areas (MCAs) in each cell is 13.7, 4.0, 3.4 and 0.9 for 1970, and 11.7, 4.0, 2.5 and 1.5 from the top cell to cell 4. The last cell with relative population less than 0.256 is not calculated since the core areas has too small suburb areas (on average 0.3).

FIGURE 10

Sector employment shares by agglomeration size distribution



Source: Brazilian Population Census of 1970 and 2000.

Overall, the share of tertiary industry has increased rapidly from 54.8 percent in 1970 to 69.4 percent in 2000. The city size decomposition of the tertiary industry shows concentration of service sector employment in bigger cities. As we move up the

urban hierarchy, the service industry share in 2000 increases from 62.8 percent among the smallest agglomerations to 71.2 percent among the largest. The manufacturing industry share in non-agricultural employment is highest in the medium size cities (30.2 percent in 2000). It suggests that manufacturing decentralization was relatively more intense from large to medium size cities.

Industrial decomposition within agglomerations shows a pattern of manufacturing suburbanization from the core to the suburb areas. The manufacturing industry share in the core areas, relative to the total city manufacturing industry employment, decreased from 64.2 percent in 1970 to 47.0 percent in 2000 (Table 9). The relative manufacturing employment share of the core areas decreases as a city becomes bigger. Manufacturing suburbanization is more distinct in bigger agglomerations and this process is also observed in the tertiary sector. The suburbanization of service industry shows a similar pattern as those of manufacturing. The service industry has experienced an overall increase in suburbanization over the period, and the suburbanization is relatively more intense in the largest cities. Still, overall, the service industry in 2000 is more concentrated than manufacturing in the core areas (66.5 percent versus 55.2 percent).

4 QUALITY OF LIFE IN URBAN AGGLOMERATIONS

The quality of life in a city can be measured by various socio-demographic indicators. The level of infrastructure provision, community security and health status, and local government expenditures on public goods influence the welfare of city residents, which, in turn, contributes to economic growth overall (see DeMello, 2002, for an analysis at the state level in Brazil). We examine how these quality of life indicators vary according to city size, per capita income and average human capital accumulation in a city. Table 10, Table 11 and Table 12 show results from a simple regression analysis where each quality of life indicator in 2000 is regressed against $\log(\text{city population})$, $\log(\text{per capita income})$, average years of schooling and a dummy variable indicating the Southern region (the Southeast, the South and the Central-West). Our objective is not to provide detailed explanations about what determines the quality of life in a city – this requires a more rigorous analysis using time series data – but rather to see whether there are any correlations between the various characteristics of urban agglomerations in Brazil. Several distinct patterns emerge.

First, as a city size increases, the quality of life deteriorates. The deterioration is statistically significant for access to garbage collection (%), piped water provision (%), children in poverty (%), life expectancy, and child mortality rate (for children less than one year of age). We observe a quadratic relationship for car accidents and homicides (per 1000 people). The car accident rate is highest when a city has around 450,000 population, whereas the homicide rate is lowest at 4.4 million population. Second, for most of the quality of life measures, higher income cities and cities in the Southern region provide better quality of life.

Third, the average years of schooling show up and down relationships with each of the quality measures, and do not have a clear pattern. Fourth, the local government expenditures on education and health (per 1000 people) are positively related to the

city per capita income level. Also local governments in agglomerations with lower human capital accumulation spend more on education. This may contribute to diminishing inter-city disparity in educational attainment. Last, the local government expenditures on security, housing and transportation (per 1000 people) do not vary according to city size, per capita income and average years of schooling. The cities in the Southern region spend more on education and transportation when we control for other variables.

TABLE 10

The OLS results of the quality of life: infrastructure in 2000

	The number of banks (per 1000)	The number of libraries (per 1000)	The number of hospitals (per 1000)	Garbage collection (%)	Electricity use (%)	Piped water use (%)
log(population)	-0.0002 (0.11)	0.002 (0.83)	-0.001 (0.34)	-0.846 (2.56)*	-0.136 (0.69)	-1.656 (3.19)**
log(per capita income)	0.089 (6.27)**	0.006 (0.43)	-0.008 (0.62)	10.051 (4.32)**	3.02 (2.17)*	15.489 (4.25)**
Avg. years of schooling	-0.017 (3.47)**	-0.005 (1.03)	-0.012 (2.95)**	-0.529 (0.68)	0.544 (1.16)	0.563 (0.46)
Dummy (southern)	0.017 (2.41)*	0.006 (0.79)	0.011 (1.77)	3.295 (2.77)**	1.28 (1.80)	9.045 (4.85)**
Constant	-0.321 (5.97)**	0.032 (0.59)	0.138 (2.93)**	48.762 (5.52)**	78.379 (14.85)**	13.425 (0.97)
Observations	123	123	123	123	123	123
Adjusted R ²	0.61	0.01	0.21	0.60	0.44	0.74

Absolute value of t statistics in parentheses.

* Significant at 5%.

** Significant at 1%.

TABLE 11

The OLS results of the quality of life: community security and health status in 2000

	Car accidents (per 1000)	Homicides (per 1000)	Children in poverty (%)	Gini	Life expectancy	Child mortality (up to 1 year)
log(population)	0.339 (2.23)*	-2.907 (2.78)**	1.359 (4.63)**	0.004 (1.56)	-0.503 (2.64)**	1.365 (2.81)**
log(population) ²	-0.013 (2.29)*	0.095 (2.44)*				
log(per capita income)	0.144 (1.88)	0.867 (1.66)	-26.894 (13.05)**	-0.052 (2.61)*	3.414 (2.55)*	-13.686 (4.01)**
Avg. years of schooling	-0.057 (2.22)*	0.311 (1.76)	2.31 (3.32)**	0.012 (1.83)	0.281 (0.62)	-0.078 (0.07)
Dummy (southern)	-0.013 (0.33)	-0.871 (3.20)**	-6.459 (6.12)**	-0.04 (3.87)**	2.653 (3.87)**	-14.22 (8.14)**
Constant	-2.415 (2.36)*	18.147 (2.58)*	141.886 (18.10)**	0.766 (10.08)**	53.635 (10.54)**	95.873 (7.40)**
Observations	123	123	123	123	123	123
Adjusted R ²	0.05	0.18	0.91	0.46	0.59	0.81

Absolute value of t statistics in parentheses.

* Significant at 5%.

** Significant at 1%.

TABLE 12

The OLS results of the quality of life: local government expenditure in 2000

	Log (expenditure on education), per 1000	Log (expenditure on security), per 1000	Log (expenditure on health), per 1000	Log (expenditure on housing), per 1000	Log (expenditure on transportation), per 1000
log(population)	0.018 (0.58)	0.178 (1.05)	0.091 (1.52)	0.136 (1.89)	0.166 (1.56)
log(per capita income)	0.797 (3.55)**	2.239 (1.65)	1.278 (3.02)**	0.723 (1.44)	1.005 (1.32)
Avg. years of schooling	-0.228 (3.00)**	-0.578 (1.31)	-0.252 (1.77)	-0.183 (1.08)	-0.247 (0.98)
Dummy (southern)	0.331 (2.86)**	0.72 (1.01)	0.114 (0.53)	-0.019 (0.07)	0.985 (2.54)*
Constant	8.08 (9.44)**	-5.172 (1.01)	4.486 (2.79)**	5.976 (3.12)**	2.663 (0.93)
Observations	122	94	122	122	120
Adjusted R ²	0.39	0.12	0.22	0.06	0.22

Absolute value of t statistics in parentheses.

* Significant at 5%.

** Significant at 1%.

5 PROXIMATE DETERMINANTS OF GROWTH

We have examined population growth and productivity as two measures of success among Brazilian agglomerations. On the supply side, our underlying model assumes growth of the labor force as proxied by population to be influenced by: (a) wages; (b) wages in neighboring rural areas; (c) labor availability in the city's hinterland; and (d) local public services and consumer amenities. The first of these factors is assumed to be most important as workers respond to wage compensation as measured by average per capita income in a city. Assuming that fertility and mortality rates do not vary significantly across Brazilian cities, this should translate in population growth in cities that offer better returns to labor. Results reported by Timmins (2005), using migration data from the 1991 Brazilian Population Census, support these assumptions. He showed that equilibrium residential choice is affected positively by wage compensation in a city and negatively by migration distance.

Table 13 provides results of OLS regressions of the determinants of annual average population growth rates. The first three columns of coefficients give estimates for long term trends during the 1970 to 2000 period, with initial (1970) conditions of income, market potential and infrastructure provision as independent variables. The last three columns provide the same information with a more short term focus on the 1991 to 2000 period, with 1991 data as the baseline. Income generally has a significant and positive effect on population growth during the decade of the 1990s. This suggests evidence in favor of the hypothesis that migrants go to the cities with high initial per capita incomes. A Chow test shows no statistical difference between the Northern and the Southern regions. However, there is no significant relationship in the long term between 1970 and 2000, possibly because the fortunes of individual cities have fluctuated significantly during those three decades.

TABLE 13

Supply side proximate determinants – population growth 1970-2000

Variables	1970			1991		
	1	2	3	1	2	3
Intercept	0.023 (2.01)	-0.285 (1.72)	-0.290 (1.70)	-0.01 (0.74)	-0.461 (3.6)	-0.403 (3.1)
Income per capita	0.0005 (0.19)	0.0005 (0.17)	-0.010 (0.28)	0.005 (2.20)	0.012 (3.42)	0.018 (4.13)
Population market potential		0.043 (1.63)	0.450 (1.65)		0.070 (3.44)	0.059 (2.78)
Income market potential		-0.04 (1.51)	-0.418 (1.53)		-0.069 (3.37)	-0.587 (2.73)
Access to electricity			0.007 (0.67)			-0.0001 (0.36)
Piped water			-0.002 (0.23)			-0.0002 (1.21)
Adj. R	0.00	0.06	0.05	0.03	0.12	0.14
Number of observations	123	123	123	123	123	123

T-values in parentheses.

Assuming a mobility constraint posed by migration distance, people who live in neighboring areas of a city are potential immigrants to the city. Also residents in the city are potential emigrants out of the city. Their migration decisions in and out of cities depend on the relative differences in city endowments. We therefore assume that net migration, and consequently city population growth, as determined by the size of neighboring city populations discounted by geographical distances, the average per capita income of the city and per capita incomes of neighboring cities discounted by geographical distances. To test these assumptions, we calculate two measures of market potential, one which is essentially an inverse distance weighted sum of neighboring areas' population and the other with average per capita income similarly discounted by distance.⁸ We exclude a city's own population and per capita income from its market potential calculation.

Results in Table 13 provide partial support for our assumptions. In the short term between 1991 and 2000, city population growth is affected positively by its own average per capita income and the population market potential (population in neighboring cities, in-migration). It is affected negatively by the per capita income market potential (per capita incomes in neighboring areas, out-migration). However, we cannot find a significant relationship with these measures in the long term between 1970 and 2000. Finally in Table 13, we consider the impacts of local public services and consumer amenities in our simple labor supply model. The variables employed are the percentage of houses with electricity and the share of houses with piped water. In both, the short and long run specifications, local public service variables do not show any significant relationship with population growth when controlling for economic incentives or disincentives.

8. Market potential of city i is defined as $MP_i(t) = \sum_{j \neq i} \frac{y_j(t)}{(Ad_{i,j}^\delta)^{\sigma-1}}$, where $y_j(t)$ is city j 's population or per

capita income in year t , $d_{i,j}$ distance between city i and j (100 miles). σ is assumed to be 2, δ 0.3 (0.22 between two port cities), and A is such that $Ad_{i,j}^{0.3} = 1$ for the smallest land area city (Au and Henderson, 2004; Hummels, 2001).

On the demand side, we are interested in the determinants of productivity growth, which is proxied by income growth. Our underlying model asserts that income performance is driven by: (a) demand for a city's product (market potential); (b) relative specialization as indicated by manufacturing/ services ratio; (c) transport and logistics costs; (d) local amenities and innovations that expand the city's production frontier; and (e) human capital that boosts productivity. Table 14 shows for the period 1970-2000 that, controlling for base year's income, market potential, transportation connectivity and education do matter. For the period 1991-2000, controlling again for base year's income, market potential, availability of piped water and education are significant. Clearly, these results are only indicative of potential factors that contribute to an agglomeration's ability to provide a dynamic business environment and attract new residents. More rigorous analysis is required to account for potential effects of endogeneity and unobservable attributes in order to obtain more reliable evidence on the drivers of growth in cities.

TABLE 14

Demand side proximate determinants – income growth 1970-2000

Variables	1970	1991
Intercept	0.155 (11.37)	0.1548 (4.23)
Income per capita	-0.2897 (15.27)	-0.3661 (7.15)
Income market potential	0.0016 (2.83)	0.0018 (2.06)
Transportation cost	-0.0036 (4.82)	-0.0015 (1.57)
Piped water	0.0041 (0.98)	0.0036 (2.32)
Light bulb	-0.0024 (0.43)	0.0001 (0.32)
Years of schooling	0.0061 (4.77)	0.0037 (1.88)
Adj. R	0.68	0.33
Number of observations	123	123

T-values in parentheses.

6 CONCLUSIONS

In this paper, we have explored patterns of population and income growth across urban agglomerations in Brazil. In general, the Brazilian urban system follows a dynamic trajectory that has also been found in other countries. Urban growth happens throughout the urban system, but with regional differences in magnitudes. In particular, cities in the Central-West and North have recently grown faster than the already established urban agglomerations in the traditional industrial regions of the south. Per capita incomes tend to be larger in bigger cities, a pattern that has not changed over the three decades since 1970. However, there is some indication of income convergence with smaller, lower income cities experiencing relatively faster income growth.

Different size agglomerations also vary in terms of the mix of economic activity taking place. Small urban areas are dominated by “ubiquitous” sectors such as non-tradables and lower level services. Some small and medium size agglomerations also host industries that depend on the natural resource base. Medium size cities are

typically more specialized in a few industries such as textiles and pulp and paper products. Large agglomerations are much more diversified with a mix of higher technology manufacturing and specialized business services. These require increased labor skills and yield higher profits which translates into higher wages, which in turn attract qualified workers. Within these larger agglomerations, we have also documented a decentralization trend in the manufacturing sector. As land prices and congestion in the center increase, production enterprises move out. Rather than moving into smaller towns, where wages are low, they locate in the periphery of large cities to continue to reap agglomeration benefits, such as proximity to buyers, suppliers and specialized services.

The purpose of this paper has been to provide descriptive evidence of urban growth patterns in Brazil, rather than to conduct a rigorous analysis of the drivers of growth. Among the stylized facts that emerge, one is that city growth tends to have considerable inertia. Large cities tend to stay large and, despite some indication of income convergence, larger places also provide the highest incomes to its residents – although some of these higher wages may be subsumed by increased cost of living in large agglomerations. Secondly, a closer understanding of urban dynamics will need to consider region and city specific conditions (see also Pereira and Lemos 2003). While overall trends are useful, success of some cities or the failure of others may well be due to a combination of initial conditions, historical coincidence and natural advantage, such as location on the coast (Furtado 1959). These combine to trigger a process of cumulative causation that enables the current hierarchies to persist. How much these trends can be influenced by public policy is the topic of continuing work.

ANNEX 1

DATA SOURCES AND DEFINITIONS

There is no official definition of “city” or “agglomeration” in Brazil. The lowest administrative level consists of more than 5000 municípios. However, these vary greatly in size and many functional economic and population agglomerations consist of a number of municípios. In this paper, we therefore follow the example of a study of Brazilian urban dynamics by Ipea, IBGE and Unicamp (2002). It defined agglomerations based on their place in the urban hierarchy from “World Cities” (Sao Paulo and Rio de Janeiro) to subregional centers. For each agglomeration, this study identified the municípios that were a functional part of the urban area. The municípios belonging to each agglomeration were then further classified into eight categories according to how tightly they are integrated in the agglomeration, from “maximum” to “very weak”. The main criteria used in these classifications were centrality, function as a center of decision making, degree of urbanization, complexity and diversification of the urban areas, and diversification of services. These were measured by a range of census and other variables such as employed population in urban activities, urbanization rate, and population density. We modified this classification slightly by also including smaller municípios to existing agglomerations if their population exceeded 75,000 population and more than 75 percent of its residents lived in urban areas in 1991, or if they were completely enclosed by an agglomeration.

The agglomeration definitions developed by Ipea, IBGE and Unicamp (2002) are based on município boundaries valid at the time of the Brazilian Population Census of 1991 and the Population Count of 1996, while our study captures dynamics from 1970 to 2000. During this time, many new municípios were created by splitting or re-arranging existing ones. In fact, the number of municípios increased from 3951 to 5501 during these three decades. To create a consistent panel of agglomerations for the 1970 to 2000 period, we therefore used the Minimum Comparable Area (MCA) concept as implemented by Ipea researchers. MCAs group municípios in each of the four census years so that their boundaries do not change during the study period. All data have then been aggregated to match these MCAs. The resulting data set represents 123 urban agglomerations that consist of a total of 447 MCAs.

The sources for the majority of data employed in this paper are the Brazilian Bureau of Statistics (IBGE) Population and Housing Censuses of 1970, 1980, 1991 and 2000. We used the full Brazilian census counts to get information about total population and housing conditions (urbanization rate). Other data were collected only for a sample of households. We used this census sample information for income, industrial composition, education, piped water provision, and electricity availability. The sample sizes varied across census years (1970: 25 percent; 1980: 25; 1991: 12.5; 2000: 5), but all are representative at the município level, and thus are also reliable at the MCA level employed in this study. Table 15 reports the main variables, their source and the years available.

TABLE 15

Variable definitions and data sources

Data	Source	Years
Population	Population censuses	1970, 1980, 1991, 2000
Urbanization rate	Population censuses	1970, 1980, 1991, 2000
Income per capita (monthly deflated to 2000 values)	Population censuses (sample)	1970, 1980, 1991, 2000
Industrial composition (percentage of labor force employed in an economic activity sector)	Population censuses (sample)	1970, 1980, 1991, 2000
Years of schooling (average)	Population censuses (sample)	1970, 1980, 1991, 2000
Percent of households with access to piped water provision	Population censuses (sample)	1970, 1980, 1991, 2000
Percent of households with access to electricity	Population censuses (sample)	1970, 1980, 1991, 2000

Income vs. wages.

As discussed in the text, per capita income is not the preferred proxy for productivity growth as it includes not only real wage income, but also transfer payments and dividends or capital gains that were not necessarily generated locally. However, we used income because consistent wage data are available only for 1991 and 2000, and the overall quality of income data is better than the wage information. Overall, we do not believe that the use of income data significantly affects our analysis, since the correlation of income and wage data, both in terms of levels and growth rates, is very high for the two years in which both are available (Table 1).

TABLE 16

Correlation coefficients – wages versus income

	Wage 1991	Wage 2000	Income 1991	Income 2000	Wage growth	Income growth
Wage 1991	1.000					
Wage 2000	0.953	1.000				
Income 1991	0.993	0.948	1.000			
Income 2000	0.948	0.989	0.958	1.000		
Wage growth	-0.238	0.051	-0.227	0.032	1.000	
Income growth	-0.419	-0.147	-0.412	-0.148	0.937	1.000

ANNEX 2

INDUSTRIAL COMPOSITION OF THE 3 FASTEST GROWING CITIES IN THE WEST-CENTRAL (EXCL. BRASÍLIA)*

2-digit industry classification	2000	
	Employment share of the 3 cites in West-Central	Ratio relative to the national average, % (a)
Agriculture and forestry	6.56	132.02
Fishing	0.09	36.29
Mining	0.23	80.90
Food and beverage manufacturing	2.70	119.10
Tobacco product manufacturing	0.02	23.18
Textile product manufacturing	4.24	125.71
Leather processing and products manufacturing	0.46	46.21
Wood products manufacturing	0.54	123.33
Pulp, paper and paper products manufacturing	0.10	28.22
Publishing, printing and reproduction of recordings	0.73	81.47
Coal products, petroleum refining and alcohol production	0.06	54.91
Chemical products manufacturing	0.54	56.12
Rubber and plastics product manufacturing	0.19	27.14
Metal product manufacturing	1.80	61.81
Machinery and equipment manufacturing	0.35	43.81
Electrical and electronic machinery, equipment manufacturing	0.11	22.78
Transportation equipment manufacturing	0.22	20.69
Furniture and miscellaneous manufacturing	1.30	86.67
Finance service	1.62	78.99
Transportation, warehouse and communication service	6.01	86.57
Commerce	23.63	110.36
Construction	9.11	104.90
Domestic service	9.48	104.32
Public service	7.47	122.18
Education service	6.68	99.65
Health service	4.35	90.02
Other service	5.28	105.68
Other industry	6.16	90.35
(High tech industry)	0.61	74.66

* The 3 fastest growing cities in the West-Central region are Campo Grande, Cuiabá and Goiânia.

REFERENCES

- Barro, R.J. and Sala-i-Martin, X. (1995). *Economic Growth*. New York: McGraw-Hill.
- Black, D. and V. Henderson (2003), Urban Evolution in the USA, *Journal of Economic Geography*, 3, 343-372.
- Blanchard, O.J. and L.F. Katz (1992), Regional Evolutions. *Brookings Papers on Economic Activity*, 0, 1:1-61.
- Eaton, J. and Z. Eckstein, (1997). Cities and growth: Theory and evidence from France and Japan, *Regional Science and Urban Economics*, Elsevier, vol. 27(4-5), pages 443-474.
- Ellison, G. and E. Glaeser (1997), Geographic concentration in US manufacturing industries: a dartboard approach, *Journal of Political Economy*, 105:5, 889-927.
- Furtado, C. (1959), *Formação Econômica do Brasil*, São Paulo: Companhia Editora Nacional.
- Harris Dobkins, L. and Y. Ioannides (2001), Spatial interactions among U.S. cities: 1900-1990, *Regional Science and Urban Economics*, 3, 6:701-731.
- Henderson, J. V. and H.G. Wang (2005), Urbanization and City Growth: the Role of Institutions, Brown University, mimeo.
- Henderson, J.V. and C.C. Au (2004), How Migration Restrictions Limit Agglomeration and Productivity in China, *Journal of Economic Development*, forthcoming.
- Henderson, J.V., T. Lee, and Y.-J. Lee (2001) Scale Externalities in a Developing Country, *Journal of Urban Economics*, 49, 479-504.
- Henderson, V., Kuncoro, A., and M. Turner (1995), Industrial development in cities. *Journal of Political Economy*, 103, 1067-1090.
- IPEA, IBGE, and UNICAMP (2002), Configuração Atual e Tendências da Rede Urbana, Serie Configuração Atual e Tendências da Rede Urbana, Instituto de Pesquisa Econômica Aplicada, Instituto Brasileiro de Geografia e Estatística, Universidade Estadual de Campinas, Brasília.
- Kolko, J. (1999), Can I get some service here: Information technology, service industries, and the future of cities, Harvard University mimeo.
- Krugman, P. (1991), *Geography and Trade*, Cambridge, Mass.: MIT Press.
- Lemos, M., Moro, S., Biazzi, E., Crocco, M. (2003). A Dinâmica urbana das Regiões Metropolitanas Brasileiras. *Economia Aplicada*, 7, 1:213-244.
- DeMello L.R. (2002), Public finance, government spending and economic growth: the case of local governments in Brazil, *Applied Economics*, 34, 1871-1883.
- Motta, D., Muelle, C., Torres, M. (1997). A Dimensão Urbana do Desenvolvimento Econômico-Espacial Brasileiro. *Institute of Applied Economic Research (IPEA) Working Paper* No. 530, IPEA, Brasília.
- Pereira, F., Lemos, M. (2003). Cidades Médias Brasileiras: Características e Dinâmicas Urbano-Industriais. *Pesquisa e Planejamento Econômico*, 33, 1:127-165.
- Timmins, C (2005), Estimating Spatial Differences in the Brazilian Cost-of-Living With Household Location Choices, Forthcoming in *Journal of Development Economics*.

PUBLISHING DEPARTMENT

Coordination

Cláudio Passos de Oliveira

Supervision

Everson da Silva Moura

Reginaldo da Silva Domingos

Typesetting

Bernar José Vieira

Cristiano Ferreira de Araújo

Daniella Silva Nogueira

Danilo Leite de Macedo Tavares

Diego André Souza Santos

Jeovah Herculano Szervinsk Junior

Leonardo Hideki Higa

Cover design

Luís Cláudio Cardoso da Silva

Graphic design

Renato Rodrigues Buenos

*The manuscripts in languages other than Portuguese
published herein have not been proofread.*

Ipea Bookstore

SBS – Quadra 1 – Bloco J – Ed. BNDES, Térreo

70076-900 – Brasília – DF

Brazil

Tel.: + 55 (61) 3315 5336

E-mail: livraria@ipea.gov.br

Ipea's mission

Enhance public policies that are essential to Brazilian development by producing and disseminating knowledge and by advising the state in its strategic decisions.



ipea Institute for Applied
Economic Research

Secretariat of
Strategic Affairs

