DISCUSSION PAPER

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URBANIZATION PATTERNS AND INDUSTRIAL LOCATION IN SÃO PAULO STATE, BRAZIL: AN ATLAS

by

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The views presented here are those of the authors, and should not be interpreted as reflecting those of the World Bank.
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ABSTRACT

This document is a collection of the maps developed by the National Spatial Policies in Brazil research project and the Cartography Division over an 18-month period. Nineteen computer generated maps illustrating population growth and industrial development trends in Sao Paulo are included in this atlas. Compilation of these maps into one document facilitates comparisons of the spatial development of the State in different time periods. This provides a catalog of the maps available for use in subsequent papers and conferences. The atlas also introduces potential users of computer generated mapping to this new technique at the World Bank, and reviews the steps necessary for the user and the Cartography Division to develop these maps.
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INTRODUCTION

The maps presented in this atlas focus on population growth and manufacturing employment growth from Brazil census data, areas of particular interest to this research project. The maps preserve spatial detail by presenting data for each of the 571 "municipios" in the State of Sao Paulo (roughly corresponding to counties in the U.S.) or each of the 71 cities or urban agglomerations in the State. This adds another dimension to more traditional methods of analyzing these trends such as presentation of regional averages in tabular form. The advantage of using computer generated maps over the more traditional cartographic techniques was the speed and flexibility of mapping many different data sets over the many administrative units once the location of the 571 municipios had been encoded. The primary disadvantage of using computer generated maps was the time necessary to identify the locations of the individual municipios and encode this information.

The first map in this atlas portrays the regions and major cities of Sao Paulo State, thus providing a reference for the following computer maps. Figures 2 and 3 (note that figure numbers are not shown on the maps) illustrate the development of the road network in Sao Paulo State and the regions of Brazil.

Figures 4 through 10 show total population data for all 571 municipios of the State. One problem in generating these maps was that new
municipios had been created out of existing municipios between 1950 and 1980. Each of these maps present data for municipios based on 1950 boundaries to maintain consistency.

Figures 11 through 20 present information only for those cities and urban agglomerations that had over 20,000 urban population in 1970. The urban agglomerations (areas of continuous urbanization), including Metropolitan Sao Paulo, have been defined in the State. Data are aggregated for each agglomeration so that one total value for population or manufacturing is shown across all the municipios in a single agglomeration. The maps that present growth rates for both city population and manufacturing employment are based on 1950 municipio boundaries so as to control for boundary changes.

Figures 21 and 22 show the location of the 581 firms in the 1980 Sao Paulo Industrial Location Survey. These firms are mapped across all of the 571 municipios.

Using the Computer to Display Spatial Data

Maps have long been an effective way to illustrate spatial relationship between and within wide varieties of variables. It is only recently that, with the assistance of computers, researchers are able to make more extensive use of this potential analytical tool. Often, a number of analytical maps can be created for a region in a relatively short time and at a lesser cost than if done by traditional cartographic means.
Since computers only operate on information expressed in numerical form, the spatial attributes of geographic features (administrative boundaries, roads, rivers, cities...) must be rendered in numerical form. This is done by first assuming that the area to be mapped lies within some coordinate system, such as an x, y cartesian coordinate system, and then assigning numerical values to points associated with the geographic features. An administrative boundary or a river, for example, would be represented within the computer as a sequence of points defined by their x and y coordinate positions (for example point 1: \( x = 325, y = 289 \); point 2: \( x = 329, y = 276 \); and so on). This information is usually entered into the computer from a digitizer. A map is placed on this table-like machine, and then by positioning a cursor at a particular point, an electronic signal determines its x and y coordinates. Display devices, usually television-like screens or plotters connected to the computer, can produce an image of the geographic features by moving through the sequence of coordinate points with the pen "down" to draw a line, or with the pen "up" to move to a new feature. As administrative areas are defined by their boundaries, statistical data such as industrial or demographic information can be attributed to each of the areas. This information is also stored in numerical form on a computer file and is usually input into the system from a keyboard or from an existing computer tape.

Once the locational data (administrative boundaries) and the statistical data to be mapped are on the computer, software packages are then used to manipulate the information and generate maps. The maps are
generally of two types: the "shaded" or choropleth maps, and the "relief" or raised choropleth maps. The choropleth maps in this report were generated by a program called CALFORM. The program functions by an operator issuing it a series of commands telling it how to handle the data and how to place the various components such as legend, scale, and title on the map. The map user decides on the number of classes into which computer must group the data and can also specify the particular class intervals to be used. The selection of class intervals is an important step since an inappropriate selection may conceal an important spatial relationship in the data. The user also has control over the types of shading patterns to be used on the map. Wise selections of patterns can enhance the appearance of the maps as well as emphasize certain spatial characteristics of a region. This series of maps for Sao Paulo was output on the Cartography Division's large drum plotter, and each required about 50 minutes of plotting time. Both the computational and plotting times for a map are dependent upon the number of areas to be plotted, the density of the shading patterns, and the amount of additional information to be added to the map.

To initiate a computer mapping project for an area, one should have clearly defined objectives for the analytic use of the maps. The user must consider the scale at which the investigation is to occur, the appropriateness of various levels of administrative units to the investigation, and the reliability of the source data. Good source maps must be acquired in order to digitize the locational data into a Geographic
Base File. The digitizing process is often a time-consuming task, especially if the region is comprised of a large number of administrative areas. Time series data pose an additional complication to the mapping process if the administrative boundaries change over time. For Sao Paulo State, there were 530 municipios in 1950 and 571 municipios in 1980. This meant that a large number of additional boundaries had to be added to the 1950 Geographic Base File (GBF) and a number of others had to be changed in order to create the 1980 GBF.

The maps included in this atlas are designed to aid in identifying spatial development trends. The Cartography Division of the Bank has a number of different types of software packages to assist in the making of maps -- from area calculation programs to sophisticated, interactive, high resolution mapping packages. The Division is beginning to implement more powerful analytical capabilities which can assist complex locational analysis and resource management studies throughout the World Bank.
REGIONS AND HIGHWAYS MAPS

Figures 1-3
BRAZIL
State of São Paulo

DEVELOPMENT OF THE ROAD NETWORK
1955 - 1982

- DIVIDED HIGHWAYS
- PAVED ROADS
- SELECTED CITIES
- BUILT-UP AREAS
- GREATER SÃO PAULO AREA
- RIVERS
- STATE BOUNDARIES
- INTERNATIONAL BOUNDARIES

This map has been prepared by the World Bank and its contributors for the convenience of the reader and the extent to which it is attached. The boundaries, used on this map do not imply, on the part of the World Bank, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries.

Map's details include cities, roads, and geographical markers.
TOTAL POPULATION DENSITY FOR ALL
571 MUNICIPIOS

Figures 4 - 7
GROWTH RATES OF TOTAL POPULATION

Figures 8 - 10
BRAZIL
State of São Paulo
Average Annual Growth Rates Of Total Population
1970 to 1980

CITY POPULATION
-5.0 - 50.0
4.0 - 6.0
2.0 - 4.0
0.0 - 2.0
-50.0 - 0.0

URBAN POPULATION OF CITIES OVER 20,000

Figures 11 - 12
CITY POPULATION GROWTH RATES

Figures 13 - 15
Brazil
State of São Paulo
Average Annual Population Growth Rates
Cities Over 20,000
1970 to 1980

GROWTH RATES IN PERCENT
- 8.0 - 30.0
- 6.0 - 8.0
- 4.0 - 6.0
- 2.0 - 4.0
- 0.1 - 2.0
- 0.0 - 0.09

Source: INE, Demographic Censuses, 1970, 1980
MANUFACTURING IN CITIES OVER 20,000

Figures 16 - 20
BRASIL
State of São Paulo
Industry As A Percentage Of Total Nonagricultural Employment
Cities Over 20,000
1970

PERCENT OF TOTAL
NONAGRICULTURAL EMPLOYMENT

- 20. - 35.
- 10. - 20.
- .1 - 10.
- .1

SOURCE: IBGE, DEMOGRAPHIC CENSUS, 1970
LOCATION OF FIRMS IN 1980 SAO PAULO INDUSTRIAL SURVEY

Figures 21 - 22.
Brazil
State of São Paulo
São Paulo Industrial Survey
Number of Firms Surveyed
BRASIL
State of São Paulo
São Paulo Industrial Survey
Planned Operating Employment of Firms Surveyed

NUMBER OF EMPLOYEES
5000 - 10000
1000 - 5000
500 - 1000
100 - 500
50 - 100
0 - 50

SOURCES: WORLD BANK-FASE 1980, SAO PAULO INDUSTRIAL SURVEY

N
KILOMETERS 0 50 100 200
MILES 0 50 100

BRAZIL
São Paulo