AGGLOMERATION ECONOMIES AND INDUSTRIAL LOCATION IN SAO PAULO STATE, BRAZIL

by

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ABSTRACT

This study examines economic forces contributing toward the current shifts in manufacturing production away from Metropolitan Sao Paulo in Sao Paulo state. Locational pressures on manufacturing plants are explored in terms of the trade-off between productivity advantages due to agglomeration economies in the metropolitan center and labor cost advantages due to lower wages in outlying areas.

Spatial variations in productivity are examined using data for new manufacturing plants in Sao Paulo state. The analysis suggests that Metropolitan Sao Paulo has substantial agglomeration economies which enhance plant productivity. But, analysis of spatial variations in wages in Sao Paulo state shows that wages are substantially lower outside the metropolitan region, and result in substantially lower labor costs for plants in outlying regions. Comparison of the productivity advantages of central areas with the labor cost advantages of outlying areas shows that manufacturing firms in general face an even locational trade-off. The trend of industrial decentralization is consistent with this estimated trade-off.

Because industrial decentralization is under way in Sao Paulo state without direct public intervention and, as much as this study could determine, without major distortions to market signals, no further policy intervention is recommended. Procedures for further encouraging the efficient decentralization of industry, nonetheless, are identified.

Thesis Supervisor: Dr. William C. Wheaton
Title: Associate Professor of Economics and Urban Studies and Planning

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To my parents

Kenneth and Lynn Hansen

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Chapter 1

INTRODUCTION AND SUMMARY

The emergence of rapidly growing metropolitan centers of unprecedented size has alarmed decision-makers in developing countries and has prompted public intervention into the spatial dimensions of national economic development. Decision makers are concerned about the managability of large urban areas, the difficulty of providing adequate public services, transportation congestion, severe pollution, and inequity. Many governments have begun to experiment with various policies to decentralize economic activities away from large metropolitan centers. In many cases, decision-makers justify decentralization policies by arguing that large cities are economically inefficient. However, the validity of this argument has not been demonstrated, and one cannot help but question the desirability of decentralization policies from the standpoint of economic efficiency. [Mera, 1973].

So far economists have been unable to offer a conclusive empirical judgement about the net costs and benefits to society of centralized economic development. On the cost side, it is difficult to measure the negative economic effects of concentration accurately. These include the costs of investment opportunities foregone elsewhere in a country, the adverse effects of a highly centralized transport system which denies efficient access to many parts of the periphery, and the external diseconomies of pollution and congestion in the center. On the benefit side, it has proven difficult to measure the benefits of concentration, which relate to the positive effects of external agglomeration economies on the productivity of individual firms and industries. In view of the limited information, the prospect of reaching a definitive conclusion soon on the costs and benefits of concentration appears dim [Renaud 1981; Scott 1982].

While it is useful to explore more deeply into whether or not urban decentralization can be justified from the standpoint of economic efficiency, it is important to realize that, in many contries, decentralization policies are very likely to be pursued in any event in response to a host of issues that are supported by a broad range of interests. Therefore, the kind of research especially needed is that which helps governments formulate decentralization policies that are least damaging to other objectives that they may have.

The centerpiece of spatial strategies used to promote decentralization is frequently an industrial location policy. Industrial location policy, particularly targeted at the manufacturing industry, is often relied upon because manufacturing firms in many sectors are relatively footloose and are thus responsive to location policy instruments. Also, manufacturing firms tend to have larger multiplier effects on local and regional economies than firms in other sectors such as the service sector. However, few industrial location policies and instruments have been effective in fostering decentralization, even in the case of developed countries. [1] Good design of these policies is limited by our knowledge of the factors influencing industrial location behavior. Surprisingly little empirical evidence exists to confirm or reject the long-standing theories on the

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1 For example, see Townroe [1979].

determinants of industrial location choice. Also, not much empirical research has focused on identifying the specific forces which contribute to the heavy concentration of industrial activites in primate cities. Nor has there been much assessment of the propensity for particular types of industries to decentralize from large metropolitan centers in developing countries. [2] Hence there is considerable room for useful empirical analysis of industrial location behavior which could contribute to more effective design of industrial location policies. Such considerations motivate this study.

This dissertation attempts to fill some of the gaps in our knowledge about industrial location behavior in developing countries by focusing on the effect of external economies of agglomeration on plant location choice. External economics of agglomeration, or more simply, agglomeration economies, are the advantages that arise from the close proximity of the plant to other activities. In theory, agglomeration economies are considered to be an important determinant of industrial location. Even so, the influence of agglomeration economies on plant location is a topic that has been seriously neglected by researchers -- principally because agglomeration economies are hard to quantify. In much of the literature, they are treated as a "catch-all" concept and no sharp tools for analysis or measurement of their effect have been developed. But, although they are hard to measure, their importance and magnitude should not be underestimated. Agglomeration economies offer firms both static and dynamic advantages. In the static sense, due to the size and diversity of factor and product markets of big cities, firms in big cities can hire specialized labor on demand, purchase specialized inputs and

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2 Reif [1981] is a notable exception.

services quickly, subcontract work, hold low inventories, and, in general, reap the productivity gains of other nearby producers through reduced prices. In terms of dynamic advantages, the big city is the locus of ideas and communication about technological improvements in the industry; firms in the city can tap these economies and benefit because they are able to adapt quickly to technological changes.

Although manufacturing firms may be more able to reap these advantages in big city locations due to these advantages, such activities are also likely to face higher factor input prices there. The trade-off between a big city's productivity advantages and its factor cost disadvantages vis-a-vis other locations is a key determinant of where new manufacturing plants are likely to locate. There is good reason to suspect -- especially in developing countries where the differences between the big city location and the hinterland locations are pronounced -- that the agglomeration economies of the big city must more than compensate for its higher costs of land, labor, or other factors of production. Alternatively, where some degree of industrial decentralization is occurring, we expect that, at least for certain firms, the production advantages of outlying areas outweigh central agglomeration economies.

The importance of this trade-off on plant location decisions is likely to depend on the type or sector of manufacturing activity. Different industries receive differential benefits from agglomeration economies and thus will differ in their need to locate in or near large cities. The spatial distribution of manufacturing industry can be better understood by evaluating the importance of agglomeration economies to different manufacturing sectors. The product cycle model offers one point of view which suggests an explanation for sectoral differences in the degree of spatial concentration of industry in terms of agglomeration economies. This model, when applied in a regional (as opposed to international) context, predicts the location of firms in an urban hierarchy based on a firm's sensitivity to agglomeration economies and factor costs. This sensitivity is viewed as primarily a function of the degree of product and process standardization of the firm or industry. Manufacturing activities producing new products and using a new production technology are usually highly oriented towards agglomeration economies, and thus toward the larger cities, in order to minimize marketing and production uncertainties. Manufacturing activities producing more standardized products using more routinized production techniques are usually less dependent on agglomeration economies and more sensitive to factor costs such as wages and the cost of land, which are typically lower in smaller towns and provincial areas. Such considerations underlie much of the analysis in this study.

This dissertation comprehensively examines the influence of agglomeration economies on industrial location in of Sao Paulo state, Brazil. The study attempts to shed light on the questions of whether Grande Sao Paulo (GSP) is too big, how significant are the agglomeration economies of the metropolitan region, what is the trade-off between central productivity advantages and factor price advantages of outlying cities and areas, what types of industry are proper targets for a policy of decentralization and at what stage of their evolution, and what specific policy instruments can effectively stimulate industrial decentralization.

The state of Sao Paulo constitutes an especially appropriate region in which to analyze industrial decentralization in a developing country for several reasons. The state has an urban-industrial geography that is highly characteristic of many developing countries. Roughly the size of West Germany or Oregon, the state is dominated by a large metropolitan area, Grande Sao Paulo, but also has many secondary cities and a rural hinterland (see Map 1). The population of Grande Sao Paulo grew from 2.7 million in 1950 to 12.7 million in 1980, a rapid increase similar to that found in many other large cities in developing nations, and comparable to the further growth predicted for many cities. Grande Sao Paulo has also become the dominant manufacturing center in Brazil. By 1970, the state accounted for 36 percent of national domestic product, with only 19 percent of the national population. Grande Sao Paulo accounted for 70 percent of the product within the state of Sao Paulo and 74 percent of the state industrial employment. However, in recent years the centralization of both population and employment within the state has shown signs of a limited reversal. During the 1960s, manufacturing employment began to increase more rapidly in the secondary cities of the state than in the core metropolis. An identical trend for population followed in the nineteen seventies. Such a reversal in the tendency for industry to centralize in the metropolitan area is a rare occurance, and in this sense, Sao Paulo state provides a rich setting for analysis of the forces underlying industrial decentralization. Finally, there is little spatial policy intervention which directly affects industrial location in the state, especially in comparison with many other developing countries. [3] For this reason, the state is a context relatively

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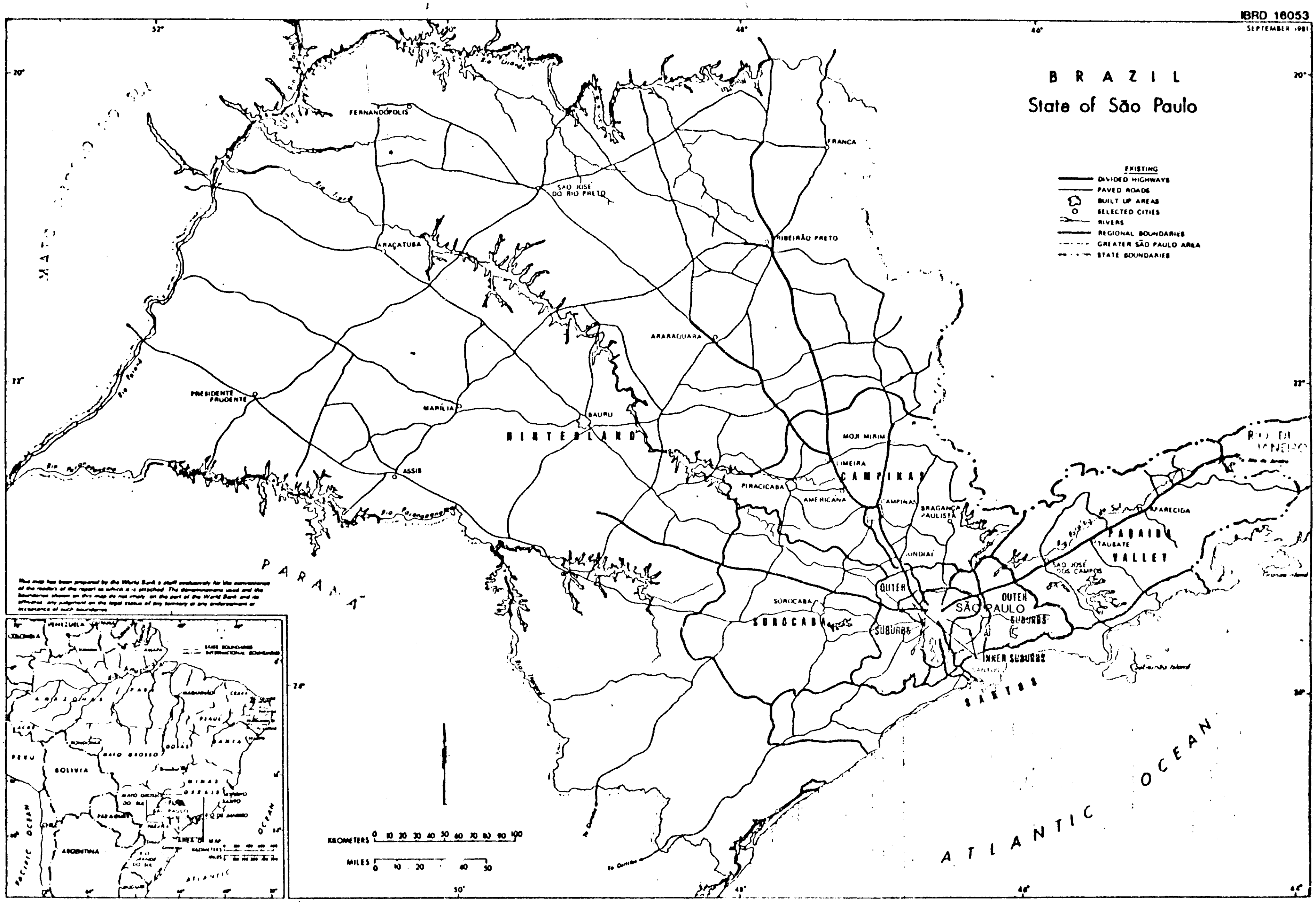
3 Types of direct government intervention are limited to a few tax and land grant incentives offered by several localities in the state and to a recent policy to restrict new heavy polluting industry from locating in the metropolitan region. This can be compared, for instance, with Korea, where over 100 pieces of legislation directly concern the location of industry [Lee, 1982].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EXISTING
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FRANCA
SAO JOSE DO RIO PRETO
RIBEIRÃO PRETO
ARAÇATUBA
ARARAQUARA
PRESIDENTE PRUDENTE
MARILIA
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JUNDIAI
APARECIDA
TAUBATE
PARAIBA VALLEY
SAO JOSE DOS CAMPOS
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unencumbered with non-market distortions for analysis of industrial location behavior. These factors and trends, which are discussed in far greater detail in subsequent chapters, make Sao Paulo state an extremely relevant region in which to study the current costs and potential for industrial decentralization in a developing nation.

The study is organized as follows. In Chapter 2, we begin to lay the conceptual groundwork for the case study of industrial concentration and decentralization in Sao Paulo state by discussing the economic rationale for industry to cluster and for the existence of cities. The elusive concept of agglomeration economies is reviewed and the product cycle model is outlined as the conceptual framework for analyzing the locational patterns and dynamics of industrial activity in Sao Paulo state. Drawing from the product cycle literature, regional applications of the model are reviewed, and three tests are identified for analyzing industrial location in Sao Paulo.

Chapter 3 begins the case study of industrial location in Sao Paulo state. The chapter traces Brazil's industrial geography from the colonial period to the tremendous concentration of industry in Sao Paulo City during the first half of the twentieth century, and finally to the onset of the trend of industrial decentralization from Grande Sao Paulo observed in recent years. At the turn of the century, the factors underlying the rapid growth of industry in Sao Paulo City had more to do with the impact of the coffee boom on regional income growth at the time and to capital mobility contraints that inhibited the flow of resources out of Sao Paulo state than to the importance of agglomeration economies. Nonetheless, because of the development of industry and the massive immigration of a talented labor force, by the 1920s, Grande Sao Paulo had developed substantial agglomeration economies that surely contributed to the increasing concentration of industry in the metropolitan area. Next, the recent trend of industrial decentralization from 1960 to 1975 is explored using trend and shift-share techniques to analyze industrial census data. The results of these analyses show that, during this period, sectoral patterns of industrial decentralization are consistent with the basic tenets of the product cycle model. That is, employment in the more innovative sectors remains highly concentrated in the metropolitan region while that of mature sectors is much less concentrated.

Chapter 4 explores several hypotheses about the industrial location behavior of new manufacturing plants using a sample of 356 firms that established plants in Sao Paulo state during 1977 to 1979. The overall hypothesis is that patterns of industrial location in the state depend on the trade-off between the productivity advantages in the metropolitan area due to agglomeration economies and the factor cost advantages of outlying locations. The analysis has four parts. First, spatial variations in the productivity of these new plants are examined to test whether or not plants in the metropolitan area have higher productivity than similar plants outside the metropolitan area. A production function approach is used to measure the extent to which agglomeration economies are present in Grande Sao Paulo. Second, factor price advantages in outlying areas are examined by analyzing spatial differentials in manufacturing wages in Sao Paulo state using 1980 social security data. Third, the trade-off between central productivity advantages and labor cost advantages of outlying areas is assessed by comparing the results of the productivity and wage analyses. Finally, I attempt to determine the extent to which information on this basic trade-off is used by industrialists in choosing whether or not to locate in Grande Sao

Paulo. To explore the relative importance of agglomeration economies and wage and land price differentials for new plant location in Sao Paulo state, a location choice model is developed and estimated using logit analysis for the subsample of the new plants that was used in the productivity analysis.

The results of the analyses in Chapter 4 indicate that there is a fairly even trade-off between central productivity advantages and the labor cost advantages in outlying areas, but that industrialists tend to give more weight to the advantages in the center in deciding where to locate their plants. Specifically, the productivity analysis demonstrates that firms closest to the center of the metropolitan region have higher productivity due to its substantial agglomeration economies. However, despite these central productivity advantages, the recent trend toward industrial decentralization away from Grande Sao Paulo is explained by the fact that wages are significantly higher in Grande Sao Paulo and decline with distance from the center of the metropolitan region. The results of the industrial location choice analysis suggest that industrialists are less concerned with wage differentials (and land price differentials) between the metropolitan region and outlying areas than about productivity differentials. There are sectoral differences in what factors influence location choice. When industries are broadly classified in two groups representing different product cycle stages -- innovative and mature -- agglomeration economies constitute the dominant locational factor, but, as expected, the mature sectors are more sensitive to labor cost differentials than are innovative sectors.

The final chapter summarizes the results of the analyses and outlines the major policy implications of the findings both in terms of the issue of the desirability of industrial decentralization policy and in terms of what specific policy instruments would effectively promote decentralization. Since this study does not analyze the negative externalities of further industrial centralization in the metropolitan area, no judgment about the net cost-benefit of decentralized development is offered. However, the productivity advantages of Grande Sao Paulo imply that a loss in production efficiency is associated with decentralized development in Sao Paulo state. This evidence suggests that policies advocating the decentralization of industry must come to terms with the possibility of sizable efficiency losses. In addition, because certain manufacturing activities are highly dependent on agglomeration economies (for instance, innovative, new technology industries), any policies which prohibit the location of new manufacturing activities within Grande Sao Paulo should be avoided. However, policy instruments are identified that promote the decentralization of manufacturing activities with the greatest propensity to operate efficiently in outlying areas, notably subsidiary and foreign owned plants and "mature" manufacturing sector activities. Finally, public efforts to disseminate information about the advantages of locations outside the metropolitan area are seen as useful and inexpensive procedures to foster industrial decentralization.

Chapter 2

INDUSTRIAL CONCENTRATION AND AGGLOMERATION ECONOMIES

Why Do Cities Exist?

Understanding the emergence of large urban industrial areas is an endeavor that has fascinated economists, geographers and others for decades. Historians, cultural anthropologists and sociologists have offered explanations for the existence of cities, for instance, in terms of the city as an administrative center for controlling a territory, as a walled protection against outside aggregation, as a fount of culture, and in terms of the social need of man to live close to other members of the same breed (see, for example, Redfield and Singer [1954]). On the other hand, most economists and geographers argue that the dominant reasons for the existence of cities are economic -- that the development of cities depends on resource endowments, transportation economies and external economies of scale (agglomeration economies).

The logical underpinnings for this economic perspective can be seen by examining the conditions which would ensure the non-existence of cities. In this direction, Losch [1959] posits two such conditions. He argues that if resources were evenly distributed over space and if there were constant returns to scale, then cities would not exist and population would be evenly distributed because each household could produce all it needed at a minimal scale of production. As soon as either of these conditions is relaxed, however, a justification for the existence of cities emerges.

Differing resource endowments over space imply that specific locations have a comparative advantage over other locations in the production of certain commodities. It pays for each of these locations to specialize in producing those goods in which it has a comparative advantage, and to engage in trade rather than to strive for self-sufficiency. Since the gains from trade will be greatest if transportation costs are minimized, a location with transportation advantages will be the preferred production site and will give rise to growth of a city. The development of many cities which are based on proximity to mineral resources, fertile agricultural land, deep water ports, amenity resources (for example, climate) etc., is consistent with a situation of unequally distributed resources. The growth of many cities throughout the world provides supportive evidence for this emphasis on natural resource endowment and staple exports (see Perloff and Wingo [1961]; North [1961]).

The special advantages of a location close to natural resources have been mainly dealt in the rubric of transportation economies (see, for example, Weber [1929]; Losch [1954]; Isard [1956]). Transportation economies, however, also refer to the reduction of transport costs possible when firms cluster together along transport routes (for example, Fales and Moses [1977]). Nevertheless, for purposes of discussion here, transportation advantages can be treated as equivalent to resource advantages.

Relaxation of the second (Losch) condition -- allowing for both internal and external economies of scale -- provides another justification for the existence of cities. Internal economies of scale motivate firms to locate in cities because the size of the market enables firms to expand their output and reduce average unit production costs. Firms also will locate in cities because they can tap external economies that result from the pecuniary and non-pecuniary benefits of interdependencies between local producers.

These external economies (or agglomeration economies) are those production advantages which owe to sheer size and diversity of economic activity within a city or, more narrowly, to the size of a specific industry within a city. Thus, cities exist because firms are attracted by their productivity advantages. Moreover, it can be argued that cities become larger since these productivity advantages increase (at least up to some point) with size of the city or industry. In this sense, forces are at work making some cities larger -- usually those cities with an initial production advantage of some kind -- and strengthening their competitive position vis-a-vis other locations.

Most economists have argued that resource endowments and transportation economies constitute the primary explanation for the concentration of industrial activities in cities, although the importance of agglomeration economies is frequently mentioned. In terms of the volume of theoretical and empirical work, considerably greater attention has been given to resource endowments and transportation economies, partially because of their tractability. Over the years, however, the relative importance of transportation costs on industrial location has declined because of improvements in the efficiency of transportation systems. The advances in highway networks and in the trucking industry over the last several decades have increased the efficiency in goods transportation throughout the world. This point, however, should not be extended too far because, for many industries, transportation economies remain the most critical location factor.

In terms of explaining why industries cluster in cities, the declining importance of transport factors suggests that agglomeration economies have been given less attention as a locational factor than they merit. The shortage of attention is partly due to the relative difficulty of analysis. Agglomeration economies have been notoriously difficult to measure, and, in much of the literature, are still treated as a "catch-all" concept.

The following sections are devoted to defining the concept of agglomeration economies, and also to reviewing one of the most elaborate theories on agglomeration economies and industrial location: the product cycle model.

Defining Agglomeration Economies

The concept of agglomeration economies traces back to Weber's classical theory of the location of industry [1929]. In classical location theory, agglomeration economies along with transportation and labor costs constitute the three basic locational forces which influence the location of a firm under conditions of perfect competition. Weber defined an agglomerative factor as one which reduces the costs of production when that production is concentrated at one place. Agglomerative factors include economies of scale within a plant as well as external economies which result from the spatial clustering of plants, such as the specialized division of labor between plants, the development of industry-specific maintenance and repair facilities, the emergence of specialized input and output markets, and the reduction of social overhead costs. In Weber's framework, these agglomerative factors would play an important role in plant location if such savings resulting from agglomeration economies offset those increased transport costs of inputs and outputs and labor costs that might be associated with locating in an industrial cluster.

In probing deeper into the nature of agglomeration economies and extending Weber's original concept, Hoover [1937], like Marshall [1920] before him, distinguishes between internal and external economies. Internal economies of scale are those economies that can be obtained by increasing the scale of operations. External economies of scale, according to Hoover, can be broken down into two distinct external effects on production costs: localization economies and urbanization economies. Localization economies refer to the productivity advantages for a firm of a given industry that derive from the number and functions of firms of that industry present in a particular area. Urbanization economies relate to the positive effects on a firm's production costs associated with the level of overall economic activity in an area. Other definitions of agglomeration economies have emerged, such as those by Scitovsky [1954] and Richardson [1973].[1] Hoover's categorization has been most widely used in the literature and is more useful for analyzing the location of manufacturing industry. The different agglomeration economies of Hoover are considered in more detail below.

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1 Scitovsky [1954] characterized external economies as either technical or pecuniary. Technical economies refer to benefits to producers that enter through the production function as, for example, in the case where one firm's labor training programs create a supply of skilled labor that can be tapped by other firms. Pecuniary economies involve benefits that enter through a firm's profit function; for instance, when a firm benefits from reduced input prices of a supplying industry or firm. Scitovsky's two categories are neither mutually exclusive nor discriminating enough to capture all the facets of external economies. Many externalities can be seen to confer both technical and pecuniary advantages and, except in externalities which concern marketing and other aspects of revenue maximization, the distinction between external economies that enter through the production or the profit functions has limited value.

Richardson [1973] classifies agglomeration economies into household, business, and social economies. He suggests that household and business economies should be distinguished to reflect that the forces inducing the spatial concentration of population may be quite different from those bringing about the concentration of firms. This distinction simply shows that agglomeration economies have multiple roles and that their benefits differ for different sections of society. His classification of agglomeration economies is not useful for our purposes since we are focusing only on the benefits enjoyed by business firms.

Localization economies are those external economies that accrue to firms in a single industry in a single area. Localization economies derive from: (i) the economies of intra-industry specialization when the size of the industry is large enough to permit greater specialization among firms in their detailed functions; (ii) economies associated with the development of common pools of highly specialized factors of production which are shared by many firms in the industry (for example, labor market economies, specialized marketing and storage services); (iii) scale economies in provision of transportation systems, public utilities, and other industrial infrastructure tailored to the needs of a particular industry; and (iv) the ease of communication among firms within the industry to accelerate the speed of adoption of innovations and of response to changing market conditions. As the cluster of firms in a particular industry grows in an area, highly specialized activities can be established which achieve internal economies of scale since, by operating on a scale large enough to serve many firms, they are able to lower average costs. In addition, an industry cluster increases the amount of inventories readily available to any one firm. This "massing of reserves", to use a term coined by Hoover [1948], lowers the amount of inventories each firm must carry on its own and gives firms greater flexibility to respond quickly to changing market conditions, an advantage not available to isolated firms. Finally, industry clustering also results in a reduction in transport inputs associated with the import of raw materials and other factor inputs into an area or the distribution of final products from an area.

Urbanization economies are also external economies but, unlike localization economies, they offer advantages to firms in all industries. For any firm, urbanization economies typically derive from: access to a large and diverse labor force; the availability of capital via specialized financial and banking services; the presence of local supply industries as well as large wholesaling facilities; the market potential due to the size of population, industry and income; high levels of efficiency and quality of public services; the presence of specialized business services (legal, accounting, computing, R & D and advertising); and the relative concentration of higher order facilities such as universities, government offices, cultural activities, hotels and conference complexes, which can provide indirect economies to production activities. Hence, urbanization economies for a firm are not internal to its industry, but are the result of the general level of economic activity in an urban area as might be measured by total local employment or population.

The distinction between these external economies is not extremely precise. In empirical studies, localization and urbanization economies are commonly highly correlated; increasing returns to industry size (localization economies) and increasing returns to urban size (urbanization economies) are often treated as overlapping or synonomous variables.

Similarly, the distinction between external and internal economies of scale is not watertight. The difference between localization economies and internal economies of scale sometimes becomes blurred over time as large firms internalize those very processes which smaller firms within that industry had previously supplied [Townroe and Roberts, 1980]. In this connection, it has frequently been argued that it is the new, small firms that may be especially dependent upon localization economies in the first few years of their

While the nature of internal economies of scale has been given considerable attention in the "mainstream" of the theory of production, the same cannot be said of the external economies. [2] Throughout much of the literature, and there are a few notable exceptions, the attempt to pin down external (or agglomeration economies) either conceptually or empirically have been less than successful. The most well-worn approach to understanding agglomeration economies are two-fold. One approach is more deductive and quantitative and stems from input-output theory. This approach focuses on analysis of reductions of transport, production, and communication costs obtained from the proximity of "related" firms in an area. Of principal concern are those economies achieved through the overlap of geographical proximity and functional linkage. These can occur at the level of either industries, firms, or production units. The literature on functional linkage between industries is vast, encompassing most work on input-output systems. The efforts to identify geographically discrete complexes of industrial activity within input-output systems are relatively few; examples are Isard et. al. [1959]; Richter [1969]; Streit [1969]; Lever [1972; 1975]; and Tybert and Mattila [1977]. Although several studies fail to that functionally-linked activities are located nearby one another [for example, Hoare, 1975], many of these analyses do suggest that strong inter-industry relationships increase the potential for functionally-linked industries to benefit from agglomeration economies. [3]

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2 One exception is a theoretical analysis by Chipman [1970].

3 In Chapter 4 we will examine the extent to which industry is functionally linked to nearby industry benefits in terms of productivity advantages within Brazilian data. An index is developed that reflects the extent to which a plant in a local economy is surrounded by other plants that are related through input-output linkages (forward and backward linkages).

The flow of goods, information, and resources between branch plants of a multiplant firm is an "intra-firm" linkage that has locational implication. Generally, branch plants are expected to have fewer local linkages, and also depend less on agglomeration economies than single plant firms. There is some support for these notions in the literature, although it is not overwhelming [Taylor, 1975]. The productivity advantages of branch plants in Sao Paulo state are tested in Chapter 4.

The second effect relates to external economies of scale in the strict Marshallian sense, which insists on the basic notion of decreases in costs due to growth of aggregate production. The richness and complexity of these external economies have been elaborated at great length in and emerged as a major theme from the New York Metropolitan Region Study (for example, Hoover and Vernon [1959]; Lichtenberg [1960]).

Some elements of this theme are contained in the following quotation from Max Hall [1959]:

> "The external economy may derive from an electrician or a sewing-machine repairman or a free-lance photographer responding to the call of a firm that does not need him full-time. It may derive from a manufacturing establishment doing specialised contract work such as embroidery, typesetting, photo-engraving, or the making of unique electronic components. It may come from a supplier of buttons, fabrics, thread, or paper, able to make fast delivery so that the manufacturer does not have to keep large numbers of things in stock. It may grow out of a testing laboratory, a technical library, a convenient cluster of hotels to accommodate visiting buyers, or a freight forwarder pooling the small shipments of small firms in carload lots. It may be based on the presence of manufacturing space in small, variable, rentable pieces. It may even grow out of a revolving supply of specialised labor such as garment workers accustomed to seasonal cycles, printers, staff writers, editors, or electronic engineers. Such a supply enables a firm to pick up employees quickly and let them go with equal suddenness, and makes in

unnecessary to maintain a stable force of workers for an unstable demand."

The dependence of specific industries and certain types of industrial activities on external economies was the common denominator in explaining the economic structure of the New York Metropolitan Region and accounting for its particular mix of industries (see, especially, Lichtenberg [1960] and Vernon [1960]).

Industrial Agglomeration in the Product Cycle

The analyses composing the New York Metropolitan Region study gave shape to a theory that has emerged as one of the most elaborate paradigms attempting to explain industrial agglomeration and industrial decentralization: the product cycle model. The concepts developed in the New York Metropolitan Region study built on earlier notions of Kuznets [1939], Aldelfer and Michl [1942], and Burns [1934], and were precursors to the well-known application of the "product cycle" in international trade [Vernon, 1966; Hirsch, 1967]. Many of the elements of the "international" product cycle model -- which has finally re-emerged under that name in the urban and regional economics literature (for example, Thompson [1969]; Norton and Rees [1979]; Hekman [1980a; 1980b]) -- in fact, derive from the classic New York Metropolitan Region study. Essentially, in the regional context, the product cycle framework stresses the changing relative importance of different factor inputs for industries at various stages of an industry's life cycle, and relates the demand for these factors to their relative availability within the urban hierarchy. Large urban areas, for instance, have a particular advantage for production activities in which continual innovation or a constant flow of new information plays an important role. More mature production activities using standardized production methods and machinery, on the other hand, are less dependent on continuing innovation and can filter down the urban hierarchy to take advantage of lower wages elsewhere. Larger cities provide a conducive environment for the more complex processes of production at the early stages of the product cycle, and spin off the routinized, more standardized elements of production into smaller centers.

This "filtering down" process of industrial location, on which Lichtenberg [1960], Thompson [1968], and Cromley and Leinbach [1980] have written, is viewed largely as a consequence of technological change within an industry over time. Lichtenberg uses the evolution of radio manufacturing to illustrate the process.

> "In the 1920's, when radio manufacturing was in its infancy, the New York Metropolitan Region was the nation's major production center. This rapidly and radically changing industry, faced with an uncertain demand for its products, was dominated by small plants using little capital equipment. Like the producers in our external-economy category, radio producers were dependent on pools of skilled labor, on rented quarters, on a variety of suppliers, and on research facilities provided by others. The Region was well suited to nurture this industry since it had earlier cradled the electrical industry, beginning with the work of Thomas Edison. And the electrical industry in turn had grown up there because of the Region's unusual facilities for experimentation and technical development, its large market, and its pools of funds looking for investment.
>
> In the late 1920's, the radio industry began to mature. And the Region's share of national radio production began to decline. As technology setled down, producers found it profitable to standardize production. Large plants were built to house the specialized machinery needed to turn out huge numbers of identical radios at costs per unit far lower than those a small producer could meet. With the shift to standardized production, the use of unskilled workers engaged in simple,

> repetitive processes became a possibility. Though labor costs in this industry were a smaller proportion of total costs than materials, the differences in the wages of unskilled labor between the Region and small towns or rural areas were one important locational consideration to the producers." [Lichtenberg, 1960, pp. 117-118].

As the product cycle concept was subsequently generalized and refined [Vernon, 1966; Hirsch, 1967], an innovation is seen to pass through three basic stages before becoming obsolete: (1) innovation; (2) growth; and (3) maturity.

The first stage is an innovation stage where a new product is first developed, a production process for the product is developed, and the product's characteristics are refined in response to early market signals. This stage is characterized by an uncertain market, short production runs, an unsettled and rapidly changing technology, high managerial and skilled labor orientation, high production costs, and high reliance on subcontractors and suppliers. These characteristics typically motivate new industries to locate in large cities for several reasons. The instability of demand and frequent changes in technology or the cost or availability of production factors put a premium on contacts and adaptability. Access to common services and inventories outside the firm, to sources of finance, and to complementary producers is vital to new industries. In short, new industries in the innovation stage are oriented to, if not highly dependent on, external economies.

When and if the product appears to have found a market niche, effort is turned to expanding productive capacity and to maintaining their market share (resisting invasion). The growth phase occurs as demand becomes more predictable, which enables production processes and product lines to become more fixed. Investment per worker can be augmented, since the market and production processes have become stable and predictable enough to justify extended runs of identical items. Also, the various management functions over time become professionalized, specialized and distinct, and this greater stability permits production to become more routinized, and allows some of the services and steps which earlier were done outside the firm to be internalized. Therefore, in this growth stage, the firm becomes a more self-contained system, internalizing many of the functions for which it had previously depended on externally. Consequently, the firm at this stage generally becomes less reliant on the external economies available primarily in the large urban center, and is therefore more footloose. Maintaining market share becomes an important concern of product leaders during the late portion of the first stage and part of the second stage, as product followers attempt to capture some of the market by imitating or improving upon the originator's product and processes. In addition to product differentiation, the threat of an imitator may be met by relocating or setting up a branch plant near to the imitation's plant, thereby obviating whatever locational advantages might exist for the imitator [Ellinger, 1977].

In the mature stage, the product becomes standardized and operations are routinized. The technical, scientific, and much of the managerial talent previously important are replaced with specialized machinery and semi-skilled and unskilled labor. In this third phase, efforts are made by all firms to maintain market share by reducing costs and, to the extent possible, by differentiating products with cosmetic and intangible characteristics through advertising and minor design changes. Because internal economies of scale are exhausted during the growth phase, producers attempt to minimize costs by shifting operations to lower cost locations. Some firms are able to survive through merger to acquire a comparative technological advantage and to achieve better spatial coverage of the market than other firms.

The product cycle model emphasizes the importance of external economies for: (i) small single plant firms; (ii) firms with rapid product turnover; and, more generally, (iii) new industries. Factors of critical importance to these activities are face-to-face communication economies, ready availability of a wide variety of goods and services, availability of technical labor, and a large market. For these activities, the fluidity of their situation, the lack of standardization of procedures, and the need for personalized contacts are forces pulling them toward large urban areas. The scarcity of entrepreneurs and managers in outlying areas add to the pull of large cities.

The dependence of small firms on large city external economies was a central finding of the New York Metropolitan Region study. The "incubator" hypothesis posits that "....small manufacturing establishments will find it advantageous to locate initially at high density central locations within the metropolis. This advantage is due to any number of factors including ready access to rentable production space, raw materials, labor, and other services." [Hoover and Vernon, 1959]. Strong support for this hypothesis was provided in the New York Metropolitan Region study. For instance, over 60 percent of firms with 60 or fewer employees was concentrated in the core area. However, results have been largely inconclusive or negative in tests of the notion for other cities [Struyk and James, 1975; Cameron 1973], although a test of the hypothesis for New York in a later period reconfirmed the earlier positive finding [Struyk and James, 1975].

Manufacturing firms with rapid product turnover are also highly dependent on external economies. High fashion women's clothing, toys, and brochure printing are typical activities with high product turnover. A high degree of uncertainty is common to these activities. Vernon [1960] states that "....uncertainty about the product and uncertainty about the demand for it, exists in every line of manufacture that has swiftly changing styles. ... From one month to the next, a producer sometimes has no way of knowing what he may be expected to produce, what materials or processes may be involved, and what volume may be demanded." (p. 101). Shops and plants with high product turnover also tend to be extremely clustered in large cities, due to their need to share certain common facilities, to top these facilities at top speed, and to have face-to-face contact with suppliers and buyers in many facets of their production and marketing dealings. These tendencies of industries with high product turnover are elaborated in great length in the New York Metropolitan Region study [Hoover and Vernon, 1959; Lichtenberg, 1960; Helfgott, 1959; Gustafson, 1959], as well as elsewhere [for example, Finger, 1975; Steed, 1978]. [4]

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[4] Also, Webber [1972] has made some progess towards a more rigorous mathematical statement on the impact of uncertainty on industrial location. He adapted a bid-rent function to show the trade-off between decreasing land costs and increasing uncertainty (i.e., decreasing expected returns) as a firm moves away from the center of the market. Those firms for which uncertainty rises most rapidly with distance from the center of the market face the steepest bid-rent curves. In this bid-rent framework, firms characterised by steeper bid-rent curves, reflecting greater sensitivity to uncertainty in either demand or production or both, tend to locate nearer the center of the market than firms with less steep bid-rent curves. An approach somewhat parallel to this is used to examine productivity in relation to distance from the center of metropolitan Sao Paulo in Chapter 4.

The locational implications of the product cycle hypothesis for _new industries_ have already been referred to in the case of the radio industry. A similar pattern has been observed for consumer electronic industries as a whole. The New York Metropolitan Region played a major role in the early development of these industries by providing a supportive economic environment for these small and innovative producers. When television, hi-fi and electronic components settled down to large scale production, they grew more rapidly elsewhere -- especially in smaller cities and towns in the Midwest and elsewhere, where labor costs were lower than that of the New York Metropolitan Region [Hund, 1959]. Since then, New York has continued to make important contributions in new product development in electronics, while manufacturing has become concentrated in the Midwest, the West, and Japan.

Several other studies have analyzed the locational tendencies of industries as they move through the product cycle. Hekman [1980a], for instance, in a longitudinal case study of the textile industry, explains the shift of the industry from the United States Northeast to the South in a product cycle framework. He argues that attributing the initial concentration of textile mills in Southeastern New England can be attributed to the build-up of an agglomeration of high technology industries that were attracted to each other, and to a local resource pool of skilled mechanics and entrepreneurs. Prior to 1880, during the industry's period of rapid innovation of machinery and machine tool design, plants clustered in Eastern Massachusetts and Rhode Island "...because of localization economies resulting from close proximity to the source of technological change in the industry" [Hekman, 1980a, p. 697]. After 1880, the shift in growth of the textile industry to the Southeast is linked to standardization of the production process that encouraged the substitution of unskilled labor for skilled labor and technological inputs.

A second study by Hekman [1980b] focusses on the location of employment in the computer industry. He notes that while some activities of the computer industry have matured somewhat (particularly the manufacture of peripheral components such as terminals, printer, and circuit boards) and are located away from the primary centers of the industry, much of the industry's design and manufacturing activities remains fairly concentrated in the primary centers. As long as new computer models and generations of models are introduced quite regularly, companies do not want to separate design and manufacturing operations, because the manufacturing facilities must be readapted each time and because there is much testing and learning in the process. On the other hand, Hekman points out that almost two-thirds of all employment in the industry is concentrated in branch plants, suggesting that the industry has reached a fairly mature stage of development. The study does little more than speculate on the reasons underlying the locational patterns of the computer industry.

Studies by Lichtenberg [1960] and Norton and Rees [1979] also analyze regional shifts in industrial growth in the United States using the product cycle model. They are discussed in more detail below.

In view of the preceding description of the product cycle model, the question of what constitutes a satisfactory test of the hypothesis is now addressed. Most tests of the product cycle model have been conducted with respect to the model's locational and trade implications in the international context [for example, Hirsch, 1967; Hufbauer, 1969; Wells, 1972]. However, several attempts have been made to test the product cycle hypothesis in the interregional context. These tests are essentially of two types.

The most direct test involves tracing the locational tendencies of a specific industry as it evolves through the product cycle. Historical analysis of this type has confirmed the basic locational predictions of the product cycle model in case studies of a handful of industries in the United States, including women's and children's apparel [Helfgast, 1959]; printing and publishing [Gustafson, 1959]; electronics [Hund, 1959]; textiles [Hekman, 1980a]; and computers [Hekman, 1980b].

A second test involves analysis of the growth of employment and value added in industry in general, classifying specific manufacturing industries by product cycle stage variables and dominant locational characteristic. Essentially, inferences are made regarding the validity of product cycle hypotheses on the basis of industry mix effects, and the impact of competition on industrial growth in different locations. In studies that have pursued this approach, fast growth "new" industries are found predominantly in metropolitan areas with external economies, such as New York [Lichtenberg, 1960], while the peripheral areas appear consistently to offer more competitive production locations for more standardized production activities [Norton and Rees, 1980].

The longitudinal case studies of an industry evolving over the product cycle appear to provide the most straightforward support for the product cycle model. Hund's study of the electronic industry and Hekman's study of the textile industry are excellent examples. However, although this approach is a useful test of the product cycle model hypothesis, the approach is not able to consider the broad spectrum of total manufacturing industry. Partly for this reason, more general approaches have also been pursued.

The second type of test is less direct than the first approach, and typically involves a broader analysis of industrial growth. Two studies are representative of this second approach.

Lichtenberg's [1959] somewhat eclectic examination of the location of manufacturing industries inside and outside the New York Metropolitan Region is essentially s shift-share analysis in which the impact of industry mix and competition on manufacturing growth are isolated. He demonstrates that the New York Metropolitan Region had a fast growing mix of industries, relative to that of the rest of the nation, between 1929 and 1954. Also, controlling for the impact of industry mix, a long-run tendency for industries to grow faster outside than inside the New York area is detected; in other words, the New York Metropolitan Region exhibited a fundamental competitive weakness with respect to other regions. These shift-share results are not very different from other studies addressing interregional industrial performance in the United States (for example, Borts and Stein [1960]). However, Lichtenberg closely examines the industries that contributed most to the fast-growing industry mix and the forces that underlie much of the competitive decline of the New York Metropolitan Region for many industries. He found that the industries that were highly concentrated in the region and also grew fast in the nation were industries predominantly oriented toward external economies, such as printing and apparel and "new" industries from among the electrical and electronic industries and the "miscellaneous" categories of industry. Lichtenberg attributes the competitive weaknesses of the New York Metropolitan Region to high production costs within the region, especially wages, a continuous process of standardization of productive processes in most industries, and the growth in the speed and availability of truck transportation. Although this type of analysis is not as precise as an industry case study for testing the product cycle model, Lichtenberg's argument is convincing, and obviously supports the basic tenets of the product cycle model.

A second, more recent study also uses shift-share analysis to explain regional shifts in American manufacturing growth in terms of the product cycle model [Norton and Rees, 1979]. Norton and Rees find that the traditional Manufacturing Belt (New England, Mid-Atlantic, and East-North-Central regions) is continuing to experience a decline in its share of the nation's high technology/high growth industry and in its capacity to spawn innovation. The authors suggest that the high technology growth centers in manufacturing have become more prevalent in the "peripheral" states, especially in the Southwest. They argue that, over time, the decentralization of mature industries from the Manufacturing Belt to the states of the Southeast and Southwest has gradually fostered an economic environment that is conducive to the spawning of innovation and new growth industries, particularly through agglomeration economies and the growth of regional markets.

While this analysis broadly confirms a product cycle/filter down process of industrial location in the United States that has been widely suspected, for example, along the lines presented quite succinctly in Hekman's case study of the textile industry, the analysis has two major shortcomings. First, the evidence demonstrating that innovative high growth industries are becoming more prevalent in the "periphery" is at best suggestive. While the shift-share results for value added during the 1972-1976 period [5] demonstrate that the "periphery", taken as a whole, enjoyed a positive industry mix (dominance of industries growing faster than the national average), with a concomitant negative mix for the core, the opposite is true in the employment data. The authors fail to account convincingly for this discrepancy. Second, the logic of the use of the product cycle model to explain the relocation of industrial seed bed functions within a national economy is questionable. The product cycle predicts, as Norton and Rees rightly acknowledge, that plants are able to vacate the core seed bed when their reliance on external economies is reduced or eliminated and when there is a threat to market share due to competition. Once dependence on external economies is eliminated via standardization of processes and product design, the plant or industry is free to migrate to a location which cannot provide them. Norton and Rees imply that the relocation to the periphery of plants no longer dependent on external economies necessarily will generate external economies and thus create an industrial seed bed in the periphery. This argument is obviously internally inconsistent. If, on the other hand, the analysis had been done within an urban hierarchy framework rather than in terms of major regions of the United States, the argument might have been more convincing and consistent with the product cycle model.

The product cycle tests of regional shifts in industrial growth conducted by Lichtenberg and Norton and Rees essentially involved identification of which industries were responsible for the observed industry

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5 The 1972-76 period may be a poor period to use, given the tremendous jolt given to the system by the increase in oil prices and the strong regional implications of these price changes.

mix and competitive effects. In both studies, the industries underlying the positive industry mix effects could be identified as early stage product cycle industries, and those underlying the positive competitive effect were predominantly the more mature stage industries. The classification of industries according to product cycle stage presents perhaps the most difficult and crucial aspect of these analyses. Lichtenberg classified industries by dominant locational factor, identified as transport-sensitive, labor-sensitive, external economies-oriented, inertial, or unclassified. He explicitly states that, statistically, he is unable to isolate industries in their "cradle" stages; however, many "miscellaneous" industries and some electrical and electronic industries (which he was unable to classify by dominant locational characteristic) are identified in his analysis as "new" industries. He also treats external economies-oriented industries as early stage industries, in spite of their mature product processes, because they are high product turnover industries (for example, apparel and printing). Norton and Rees construct a much less detailed classification of industries in the product cycle. Using measures of technological intensity (for example, innovations per net sales, expenditures on Research and Development per net sales), high growth-high technology industries are classified as early stage industries, while low growth-low technology industries are classified as mature industries. These two studies represent the only attempts made to classify industries in the product cycle. In the next chapter, drawing from these studies, Brazilian industries are broadly classified by product cycle stage.

With such a classification, a simple test of the product cycle model is possible within an urban hierarchical context, such as a large metropolitan area and outlying secondary towns and hinterland. The product cycle hypothesis can be tested by measuring the extent to which employment in "new" industries is located in the large metropolitan area. If employment in new industries is significantly more concentrated in the central areas than that of mature industries, then the findings would support the product cycle model.

An alternative test of the product cycle model in the inter- (or intra-) regional context to be presented here comes from the literature on the product cycle in the international context. Many of these studies argue that new products are often developed, produced, and marketed initially in the United States, mainly in terms of the demand uncertainties faced by firms in innovating new products [Hirsch, 1967; Wells, 1972]. [6] That is, the large American market has a high income elasticity of demand and is exceptionally receptive to novel products. But this only explains why a new product is marketed, not why it is produced in the United States. Klein [1973] develops a theory to explain new product production in the United States in terms of supply uncertainties faced by innovative firms. Klein contends that new products are produced in the United States because of the "learning advantages" of American firms (due to high levels of scientific and engineering resources), which serve to minimize production uncertainties. The production function analysis below looks at productivity differences within an industry, which can be thought of as tracing out the locus of learning advantages emphasized by Klein. This procedure is discussed below.

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6 Vernon [1980] has recently suggested that the product cycle model in the international context has lost much of its initial explanatory power because of the advances in communications internationally and growing dominance of multi-product, multinational corporations which have the effect of short-circuiting product cycle stages.

In his dynamic model of comparative advantage, Klein [1973] characterizes the decision of whether to locate production in the United States or abroad within a production function framework. The production function is composed of two terms. One term represents the firm's technical knowledge or "learning advantage", which can be realized only by producing in the United States, and results from "the high marginal products of learning resources (scientists and engineers) in U.S. firms relative to other countries" (p. 176).[7] The second portion of the production function is simply the firm's own constant returns to scale technology for capital and labor inputs, which Klein depicts as the static production function.

Where to base production depends essentially on the trade-off between the learning advantage of a United States location and the static advantages of a foreign location. Initially, an innovative firm produces in the United States to exploit its learning advantage. Eventually, however, as the production technology becomes more standardized, the advantage of producing in the foreign country will outweigh cost reductions obtained by remaining in the United States to exploit the learning advantage.

In view of the earlier discussion of the product cycle model in an interregional context, it is not difficult to see how Klein's model could be reinterpreted in that context. The learning advantage can be realized by having a production site in a large metropolitan area, while static advantages may be exploited by locating the plant in a town or rural area. In producing a commodity Z, the large metropolitan area is assumed to have a learning

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[7] This term is essentially equivalent to a Hicks-neutral external shift factor whose components are usually scale and technology factors.

advantage, while smaller towns and rural areas have a static advantage. If the learning advantage dominates the static advantage, the metropolitan area will have the comparative advantage in Z . However, if the metropolitan area's learning advantage declines over time, as either opportunities for additional learning are exhausted or as non-metropolitan areas learn about Z's production process, comparative advantage in Z may shift to non-metropolitan areas. In the context of a large metropolitan area and its hinterland, it is possible to test whether the comparative advantage in producing any commodity Z lies in central or outlying areas using a production function framework.

Summary

This chapter has reviewed several important concepts that explain industrial concentration in cities. Whereas transportation costs may explain industrial concentration to some extent, this discussion emphasizes the importance of agglomeration economies on industrial location. The product cycle model is described as a particularly useful construct for explaining industrial location processes. The model provides a basis to distinguish between the types of manufacturing activities that are drawn to large urban areas to tap agglomeration economies, versus those that filter down through the urban hierarchy in search of a more competitive production location. Several tests of the product cycle hypothesis are reviewed and three principal kinds are identified: (i) an industry-specific case study; (ii) an analysis of the location of total industrial activity classified by different stages of the product cycle; and (iii) a production function analysis of the productivity and competitiveness of different industries with different emphases on agglomeration economies in different areas.

The next two chapters explore the influence of agglomeration economies on the processes of industrial centralization and decentralization in Sao Paulo state.

Chapter 3

INDUSTRIAL AGGLOMERATION IN SAO PAULO

Midway through the nineteenth century, the city of Sao Paulo was a small and sleepy provincial capital in comparison with its future rival, Rio de Janeiro, then the nation's capital and leading city. In 1907, the city of Rio de Janeiro produced 33 percent of national output, while the entire state of Sao Paulo produced only 17 percent. During World War I, Sao Paulo City overtook Rio, steadily increasing its share to over half of total national output by the 1950s. In 1970, Sao Paulo state, with about 19 percent of Brazil's population and three percent of its land area, accounted for 56 percent of national domestic output. Metropolitan Sao Paulo, henceforth referred to as Grande Sao Paulo (GSP), accounted for 70 percent of state product and 74 percent of state industrial employment.

The remarkable industrial growth of Sao Paulo City poses a number of questions such as: Why did industrial development occur in Sao Paulo City? How did Sao Paulo City overtake Rio's lead as the dominant city and manufacturing center in Brazil? Why do manufacturing activities continue to be attracted to Grande Sao Paulo? The following sections examine these questions and, in addition, explore the recent trends of industrial decentralization in Sao Paulo. The first section outlines the early evolution of Brazil's industrial geography. In sections 2 and 3, the product cycle model is examined as a framework for explaining, firstly, the tremendous centralization of industrial activity in Sao Paulo at the turn of the twentieth century, and secondly, the decentralization of manufacturing industry in Sao Paulo from 1960 to 1975.

The Early Evolution of Brazil's Industrial Geography

The evolution of Brazil's industrial geography is briefly reviewed in order to provide background for understanding the build-up of industrial agglomeration in Sao Paulo at the turn of the twentieth century.

Brazil's early economic history is characterized by a series of "boom and bust" cycles associated with sugar (1550-1700), gold and diamonds (1690-1800), and coffee (1840-1930). Because of this relationship between economic growth and staple commodities and mineral resources, natural resource endowments and staple export theory go a long way towards providing a general framework to explain Brazil's early economic geography. The staple export model essentially depicts "a good deepwater port as the nucleus of an agricultural hinterland well adapted for the production of a staple commodity in demand on the world market." [Perloff and Wingo, 1961, p. 193].

During the sixteenth and seventeenth centuries, a number of settlements developed along Brazil's coastline, mainly in the Northeast region. The economies of the settlements were based on sugar cultivation and processing, with the output destined for Portugal and elsewhere in Europe. Sugar was exported in exchange for a variety of consumption and investment items. Since these coastal settlements had very few economic linkages between them, economic growth in each region was primarily related to the economic development within that region alone. Most economic activities were organized to serve external needs. Other economic activities that arose were essentially ancilliary to the production of the principal export commodities or related to basic needs of the local population (for example, food processing, spinning and weaving, and brick and furniture making [Dickenson, 1978]).

The relative endowments of any of these coastal regions in terms of soil fertility, ease of communication within a region, and the quality of the deepwater port were the factors that essentially explained the relative growth of these regions. Initially, Salvador, the colonial capital, and to a lesser extent Recife and Belem, were the largest settlements. Later on during the colonial period, Rio de Janeiro emerged as the second largest center, after Salvador.

As competition from the Caribbean reduced the importance of sugar in Brazil, mining for gold in Minas Gerias emerged as an important industrial activity. Also, in the frenzy for gold, rich iron ore deposits were discovered which led to establishment of a rudimentary iron foundry industry.

Initially, the new mining activities had links with Salvador which, for instance, became the site of one of the first gold smelting houses in Brazil. But eventually Rio became the major entrepot for these activitues, due to its proximity to the mining centers in Minas Gerias.

A shift in the locus of industrial activity from the Northeast towards Rio and the Southeast became increasingly pronounced with the advent of the coffee boom. Introduced into the Amazon Basin in the early eighteenth century, coffee cultivation shifted to the lowlands around Rio de Janeiro around 1770. From about 1820 to 1850, as Brazil increased its share of world coffee output from one-fifth to over one-half, Rio flourished. Consequently, the lead possessed by Salvador in terms of the concentration of economic activity quickly dissolved in the face of extremely fast-growing regional markets in Rio de Janeiro.

Later, coffee boom periods coincided with expansion of the agricultural frontier to the Paraiba Valley between Rio and Sao Paulo and subsequently to the highlands northwest of Sao Paulo. Brazil's share of world coffee production approached 60 percent in the 1880s and reached 75 percent after the turn of the century. This growth in Brazil's share of world coffee output took place in the context of a tremendous expansion in world demand for coffee -- an expansion due to the newly acquired taste for the brew by the rapidly growing and increasingly affluent masses in Europe and the United States.

Just as in the nineteenth century Rio's rise to pre-eminence in Brazil's urban-industrial hierarchy finds explanation in the early coffee boom period (1840-1860), Sao Paulo's tremendous growth in the subsequent period was driven by the shifting location of coffee during the second phase of the coffee boom (1860-1930). Both circumstances suggest that the strength of the agricultural hinterland of an urban center relative to that of competing regional economies determined the place at which the concentration of economic activity would be greatest. This pattern is reflected in the shift in the concentration of cotton textile mills from the Northeast to Rio de Janeiro, and to the Southeast more generally, at a time of transition in the relative strengths of their agricultural hinterlands [Stein, 1959]. 1

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1 In 1866, six of Brazil's nine cotton mills were located in the Northeast; by 1875, 16 of 30 were in the Southeast. In 1885, 33 of 48 mills were in the Southeast, with the greatest concentration of spindles and looms existing in the city and suburbs of Rio de Janeiro [Stein, 1959].

Similarly, the relative strength and dynamism of Sao Paulo's agricultural hinterland in comparison to the waning strength of Rio's hinterland is an important argument in the explanation of Sao Paulo's usurpation of Rio's position in the urban-industrial hierarchy in the twentieth century. However, the relative strength of the agricultural hinterlands does not provide a complete explanation. Part of the explanation relates to imperfections in capital flows between regions while another part of the explanation concerns the difference between Rio and Sao Paulo in the build-up of external economies. Both of these issues are discussed in the next section.

Nonetheless, this brief review does indicate, in a preliminary way, the importance of staple export theory in explaining the early evolution of Brazil's industrial geography, and sets the stage for discussion of the tremendous concentration of industrial activity in Sao Paulo in the twentieth century.

Industrial Agglomeration and the Product Cycle

In Brazil, at the turn of the twentieth century, Rio de Janeiro was the overwhelming recipient and seedbed of industrial activity. Rio's population (811,000) was over three times that of Sao Paulo city (240,000) in 1900. Moreover, at the time, Rio was the largest port, the largest commercial and manufacturing center, and the hub of the rudimentary national railroad network. However, Sao Paulo city in 1900, despite its smaller size, was the more dynamic center, propelled by rapid expansion in coffee production in its hinterland. The population of Sao Paulo city quadrupled from 1890 to 1900. Sao Paulo's share of national industrial output increased from 17 percent in

1907 to 32 percent in 1920, while that of Rio (including all of its surrounding state, Guanabara) fell from 40 to 28 percent.

The product cycle framework stipulates that the location of new industries and the build-up of industrial agglomeration depend on the relative abundance of: (i) specialized goods and services; (ii) technicians, managers and other skilled workers; and (iii) low-cost face-to-face communication.

Sao Paulo's ability to provide specialized goods (both imported and domestic) and services grew rapidly in the twentieth century. The early evidence shows that Santos (Sao Paulo's port) had an increasing role as the port of entry for imports. During 1913 to 1921, for example, on average 39 percent of Brazil's textile machinery imports entered into Santos while in some years the proportion was over 50 percent. Sao Paulo (via Santos) became the primary destination of a multitude of imported goods.

On the other hand, there was rapid expansion in domestic production. Early in the nineteenth century, industry in Sao Paulo City largely consisted of adjunctive maintenance shops and parts suppliers for the more lucrative business of importing. The proportion of goods produced locally for the Sao Paulo market, however, increased between 1910 and 1928 from about half to perhaps three-quarters of the total [Dean, 1969, p. 135]. The number of industrial establishments in Sao Paulo City jumped from about 52 firms in 1895 to 326 firms employing 24,000 industrial workers in 1907 [Bandeira, 1908] to 4,514 firms employing 84,000 workers in 1920 [Censo Industrial].

Dean finds that one fundamental difference between the importers of Rio and Sao Paulo was that during periods of importing difficulty, the Sao Paulo importers reoriented by financing and embarking on industrial ventures, while "those of Rio sold out their industrial interests and retreated to their original occupation, that of mere wholesalers." [Dean, 1969, p. 29]. The reason why entrepreneurs in the two cities responded differently to changes in economic conditions is not entirely clear but undoubtly has great bearing on how growth in Sao Paulo City got underway and on why Sao Paulo City outpaced Rio. Some part of the explanation probably relates to differences in the characteristics of foreign immigrants, such as entrepreneurial talent and social mobility, as is described below. Another factor concerns differences in the availability of capital in Sao Paulo and Rio, and to the constraints on the mobility of capital between the two regions [Katzman, 1976].

During the First World War, Rio was more vulnerable than Sao Paulo to the interruption of trade, due to its greater dependency on imports. Sao Paulo, with a greater industrial excess capacity at the start of the war, was able to expand into Rio's market. Dean remarks that "during the years before 1906 Sao Paulo was a market at the disposal of Rio, that between 1906 and 1914 Sao Paulo became independent and that after 1914 Sao Paulo began to invade the market of the capital" [Dean, 1969, p. 97]. The interruption of trade during the war years also induced great diversification in the manufacture of new products in Sao Paulo, particularly in metalworking to produce parts and entire machines of cast iron for agriculture and industry. Although many shops went out of business after the war, not all disappeared [Simonsen, 1939]. By 1920, Sao Paulo had dethroned Rio as Brazil's most important industrial center. By the 1940s, Sao Paulo state represented the largest industrial agglomeration in all of Latin America. Clearly, Sao Paulo City was a fertile seedbed for industrial activity in terms of the specialized goods and services available there.

Turning to the agglomeration of technical and entrepreneurial talent in Sao Paulo City, over the course of the first decades of the twentieth century Sao Paulo City came to have the largest and most diversified labor pool in the country. The tremendous expansion and sophistication of Sao Paulo's labor market can be largely attributed to foreign immigration. Foreign immigration to Sao Paulo, initially destined for the rich agricultural frontier in the Western part of the state and, after 1895, shifting increasingly to the state capital, virtually transformed the prominantly agrarian town into an immigrant-oriented early industrial city by the 1920s -- with almost two-thirds of the 580,000 residents or their offspring foreign-born [Merrick and Graham, 1979].

Rio de Janeiro was the destination of the "Portuguese wave" of immigration to Brazil prior to 1885. At the time of the 1872 census, Rio registered the highest relative concentration of foreign immigrants. However, by 1920 the population of the state of Sao Paulo had the highest foreign-born percentage, having captured the lion's share of the new "Italian wave" of immigration at the turn of the century. Over the period 1872-1929, the state of Sao Paulo attracted some 57 percent of the total Brazilian immigration of over 3.5 million. Immigrants brought with them knowledge and skills that were extremely valuable to the industrial growth of the country. In the early twentieth century, the foreign-born registered about double the literacy rate of the native-born [Merrick and Graham, 1979].

Much of the labor force in the provincial capital was composed of immigrants who either had originally come to tend coffee trees and left the coffee plantation for the city, or had been contracted in Italian cities to come to work in Sao Paulo factories. The latter were immigrants with industrial experience who formed a cadre of semi- and skilled labor primarily for textile mills. In addition, an immigrant bourgeoise, which arrived in Sao Paulo with some financial resources or human capital (technical education or experience in trade or manufacture), constituted a significant entrepreneurial force behind Sao Paulo's industrialization. Dean [1969] sketched out the colorful background and rise to industrial pre-eminence of many immigrant entrepreneurs who launched industrial ventures and pioneered new products in Sao Paulo.

Immigrant entrepreneurs initially established trading business and industries in activities with which they were already familiar. The large immigrant population constituted a ready-made market for the businessman who knew how to cater to European tastes. Factories were established to manufacture such products, including felt hats, poster, olive oil, beer, wine, ornamental marble, and furniture. The first Italian millionaire in Sao Paulo, Gioranni Briccola, derived his fortune initially in banking, but other early immigrants made fortunes in textiles, flour mills, sugar mills, silk weaving mills, shoe-making and other light industry [Dean, 1969, p. 52].

Unquestionably, immigration to Sao Paulo played a major role in the formation and take-off of the largest and most diversified industrial labor force in Brazil. By 1919, 29 percent of industrial workers in Brazil were situated in Sao Paulo state. Although evidence is fragmentary, it is highly likely that Sao Paulo possessed the country's most sophisticated skill pool of entrepreneurs, tool-workers, machine builders, managers and other specialized labor that is so important in early stages of product and process development.

It is very difficult to find direct evidence of the existence of communication economies within Sao Paulo City at the turn of the century. It appears that in any case, Rio probably possessed a relative advantage in terms of low cost face-to-face communications, due to its greater size and because it was the national capital. In fact, Rio's overall agglomeration economies were undoubtedly more highly developed initially. Nonetheless, Sao Paulo City, on the basis of the growth of its market area, the local availability of capital generated by coffee and the inflows of skilled labor from abroad, was able to build up its agglomeration economies to match and eventually surpass those of Rio. Among these, face-to-face communication is extremely important in the generation of industrial activity and in explaining at one level why spatial concentration occurs. Certainly, in early twentieth century Brazil, and perhaps more broadly generalizable to developing countries as a whole, information transfers and contracts are often more personal and unstandardized than in more developed countries where trade journals, government documents and other media of information prevail. Contracts, terms of payment and delivery, product specification and other means of contract and agreement are often far less standardized in developing countries, where word of mouth, personal agreement and other informal and unstandardized contracts are common. Social contact often requires discussion and negotiation over tea and cafezinho, with the appropriate courtesies, expressions of mutual respect, and so on, before the discussion can gradually enter into matters of substance. These customs and conditions provide an indication of why communication economies are important.

In conclusion, the development of conditions conducive to rapid industrial growth and fostering geographical concentration of industry in Sao Paulo appears to conform reasonably well with basic elements of the product cycle model. Sao Paulo became a center with highly specialized goods and services, with a large and diversified pool of labor and entrepreneurial talent, and very likely in possession of substantial communication economies. Together, these agglomeration economies created an industrial seedbed effect which made Sao Paulo an attractive location in which to establish industrial enterprise. What is not explained well by the product cycle model, however, is why at the turn of the century Rio de Janeiro, with its far greater agglomeration economies, did not keep its initial advantage as the prime location for industrial innovation and growth in Brazil. The answer lies outside the product cycle framework and relates more to the geographic shift of coffee production and to inefficient capital markets [Katzman, 1977]. As coffee production shifted southwest to Sao Paulo, Sao Paulo City became the entrepot with the largest coffee-producing hinterland, and with its direct links to the sea (Santos), Rio was by-passed by this shift. It is important to remember that coffee, in contrast to other exportable staples such as wheat, is a very high value cash crop, is enormously profitable, and generates very high incomes and capital surpluses. Consequently, with the growth of its hinterland, Sao Paulo spawned an increasing share of the traditional industries which were closely linked to agricultural raw materials and rural mass markets. The prosperity of the coffee region produced a surplus for re-investment in education, public works, and industrial machinery. Because financial intermediation was poorly developed in Brazil [Katzman, 1977], capital tended to accumulate within the state rather than flowing to Rio, which had more highly developed external economies. Consequently, due to the growth of its market area and supply of capital, and the eventual build-up of its own external economies -- supplies of specialized goods and services, technical workforce, and communication economies -- Sao

Paulo surpassed Rio as Brazil's largest and most dynamic center of industrial activity.

Industrial Decentralization in the Product Cycle

Thus far, the analysis indicates a tremendous polarization of economic activity in Sao Paulo state and particularly in Grande Sao Paulo. In recent years, however, there is evidence of a decentralization of manufacturing industry within the state, since areas outside the metropolitan core are capturing increasing shares of manufacturing employment. In one sense, this evidence contributes new empirical content to the long-standing debate in the growth pole literature concerning the continued divergence (or eventual convergence) of the core and periphery, at least in an inter-regional context [Myrdal, 1957; Hirschman, 1958; Williamson, 1965; Mera, 1978; Stohr and Todtling, 1977]. A full evaluation of the causes of decentralization of manufacturing employment is not attempted in this section; rather, the analysis concentrates on intersectoral differences in the observed decentralization of manufacturing industry in Sao Paulo state. Specifically, this section examines which industries have the greatest propensity to decentralize from the center to the periphery, that is, from Grande Sao Paulo to the rest of Sao Paulo state. As indicated earlier, the product cycle framework suggests that it is the mature industries which filter down the urban hierarchy. Peripheral regions are seen as more efficient locations of industrial activities in which production has become routine and no longer requires the expertise and other agglomeration economies prevalent in the industrial core.

While more rigorous tests of this hypothesis are conducted in Chapter 4 using a production function approach with recent plant data, this section explores, using secondary data, the extent to which the locational tendencies of manufacturing sectors during 1960-1975 concur with the product cycle model. Two analyses are presented: an analysis of the level and rate of change of decentralization by sector; and a shift-share analysis of manufacturing employment and value added in Grande Sao Paulo and the rest of the state for 1960-1975.

Before turning to these analyses, two preliminary steps are needed. First, evidence must be reviewed on the general trend of decentralization of manufacturing activities within Sao Paulo state in the past two decades. Second, manufacturing industries in Sao Paulo must be broadly classified by their stage of evolution in the product cycle.

<u>The Turning Point in Industrial Centralization: 1960</u>. The trend toward industrial concentration in Sao Paulo city and its suburbs -- which together make up Grande Sao Paulo (GSP) -- during the first half of the twentieth century is reflected in Grande Sao Paulo's rising share of state manufacturing employment. It increased from 60.5 percent in 1940 to 62 percent in 1950 and reached 70.7 percent in 1960. However, 1960 was the peak of the trend toward manufacturing concentration in the state. Already during the 1950s, three industrial countermagnets to the metropolitan region were emerging: the port of Santos (72 km. from Sao Paulo); Sao Jose dos Campos (93 km. to the northeast), and Campinas (89 km. to the northwest). Growth in manufacturing employment in these three cities, although from smaller bases, was 50 percent higher than in GSP. During the 1960s, rapid industrial growth extended to all the major cities within 150 km. of Sao Paulo. Manufacturing

employment grew at an average rate of six percent among the major cities of this "ring", versus a 4.4 percent rate of growth in GSP. Beyond the ring region, manufacturing employment in the major cities of the "interior" averaged only 3.8 percent per year during the 1960s, but jumped to 9.5 percent per year during the first half of the 1970s. Grande Sao Paulo's share of state manufacturing employment thus dropped from its peak of 70.7 percent in 1960 to 70 percent in 1970, and to 67.9 percent in 1975.

Several factors appear to underlie the shift in rapid manufacturing growth to cities outside Grande Sao Paulo.

On the one hand, the areas outside GSP became more hospitable to industry. During the 1950s, road transportation virtually replaced rail as the principal means of goods transportation. By the late 1950s, the highway network had expanded significantly throughout the state, providing direct links between cities, and thus ending Sao Paulo's monopoly on nodal positions in the transport network. Similar advances in the electricity grid and in water supply in outlying regions of the state equipped many cities and towns with an infrastructural base adequate to attract industry. In addition, local demand was building in the interior of the state. Although the rural population of the state declined in absolute terms during the 1950s and 1960s, the state's urban population outside GSP increased by over four million over the two decades. By 1970, nine cities outside the metropolitan region had a population exceeding 100,000.

On the other hand, the rising diseconomies of urbanization arising from the size of the urban area undoubtedly account for some part of the decentralization of manufacturing. By 1960, Grande Sao Paulo had a population of 4.8 million; in 1970, the population was 8.1 million. High land and wage costs in the metropolitan core raised the cost of manufacturing there. The agglomeration economies of the metropolitan area continued to justify the presence of some sectors (as is demonstrated in Chapter 4). But, more traditional sectors -- those less able to exploit agglomeration economies and more sensitive to wage and other factor cost differentials -- were pushed out of the city.

Classification of Manufacturing Industries According to the Product Cycle. Two approaches are used to broadly classify industries in the product cycle. One method of estimating the maturity of an industry is based on how long the sector has existed in Brazil. The age of an industry is approximated by when the sector first "appears" in census data for Sao Paulo state. In this method, manufacturing sectors that registered a strong presence by 1930 are classified as mature sectors; sectors that appear in the 1940s and experience rapid growth in the 1940s and 1950s, yet slow down during the 1960s, are classified as intermediate stage sectors; and, finally, industries that "appeared" in census data in the 1950s or 1960s and have registered above average growth rates are typed as innovative sectors. The first approach is complemented and corraborated by a second method in which sectors are classified by skill intensity, Research and Development (R&D) intensity, and other factors useful in discriminating between early-stage, innovative industries and mature industries. For this second approach, the procedure for classifying industries relies on a simple rank ordering of sectors from highest to lowest measures for these variables. Sectors falling in the top one-third of a composite score for these product cycle variables are classed as innovative industries, the middle third are called intermediate sectors, and the bottom third are classified as mature sectors. Reconciliation between the two approaches is achieved simply by shifting border line sectors as classified in the first approach either upward or downward one product cycle stage based upon how the industry is classified by the second method.

Two tables show when different sectors first emerged and began to grow in Sao Paulo. Table 3.1 presents the sectoral composition of manufacturing employment and value added from 1940 to 1975. Average annual growth rates in manufacturing value added and employment are presented in Table 3.2.

As shown in Table 3.1, the traditional consumer goods sectors -- including textiles and food, which were firmly established in the early 1900s in Sao Paulo -- continued to dominate other industrial activities in the 1940s and 1950s, both in terms of employment and value added. The relative importance of these sectors declined, however, as some intermediate sectors expanded in the 1940s, and as capital goods sectors came into existence in the 1940s and 1950s and grew rapidly in the 1950s and 1960s.

The rubber and paper industries appear to have emerged by 1940 and experienced rapid growth during the 1940s. The share of state value added and employment held by these two sectors reached a peak during the 1960s and subsequently declined. Similarly, value added growth rates of these industries were above average during 1950 to 1960 and remained below average thereafter. This evidence suggests that while rubber and paper were innovative and high-growth sectors during the 1940s and 1950s, they cannot be so classified in the 1960s and 1970s.

Although the sectoral detail is obscured in the 1940 census, one suspects that the arrival of the electrical goods and transport machinery

Table 3.1

Sectoral Composition of Manufacturing Value Added and Employment in Sao Paulo State 1940–1975

	SECTORAL COMPOSITION OF VALUE ADDED					SECTORAL COMPOSITION OF EMPLOYMENT				
	1940	1950	1960	1970	1975	1940	1950	1960	1970	1975
Traditional consumer goods	56.1	54.0	38.4	33.8	26.5	62.0	58.6	47.3	37.5	37.3
Textiles	27.8	22.2	12.3	9.9	6.2	32.7	31.9	19.9	14.4	9.8
Clothing	5.2	4.2	3.5	3.3	3.3	6.3	5.2	5.4	6.1	7.1
Food	14.5	14.7	12.0	10.2	7.7	15.2	10.9	10.2	9.1	7.8
Beverages	6.0	3.7	2.4	1.7	1.2	2.3	2.1	1.9	1.5	0.9
Tobacco	–	1.2	0.9	0.8	0.6	–	0.7	0.4	0.1	0.2
Printing & publishing	1.3	3.4	2.7	3.3	3.2	3.6	2.8	3.1	3.2	3.0
Furniture	–	2.2	2.3	2.0	1.9	–	2.9	3.6	3.4	3.3
Miscellaneous	1.3	2.4	2.3	2.6	2.4	1.9	2.1	2.8	3.1	5.2
Intermediate goods	29.5	37.3	39.1	39.5	43.5	31.9	34.7	34.8	38.1	34.8
Non-metallic minerals	5.8	7.5	6.0	5.0	5.0	7.5	9.7	8.2	7.4	6.6
Metallurgy	6.4	9.6	9.2	10.5	12.6	7.4	9.6	10.5	11.6	13.8
Lumber & wood	4.0	2.3	1.2	0.8	1.0	6.5	2.7	1.9	1.3	1.5
Paper	1.4	2.6	3.2	2.9	2.8	1.8	2.6	2.7	3.0	2.6
Rubber	0.5	3.3	4.6	2.8	2.4	0.9	1.4	1.9	1.8	1.8
Leather	1.2	0.9	0.6	0.3	0.3	1.1	1.0	0.8	0.6	0.5
Chemicals	10.2	11.1	10.0	9.3	12.4	6.7	7.7	5.4	4.5	3.6
Pharmaceuticals	*	*	2.3	3.9	3.0	*	*	1.8	1.5	1.0
Perfume & soap	*	*	1.2	2.8	1.5	*	*	0.7	0.7	0.6
Plastics	*	*	0.8	2.2	2.5	*	*	0.9	2.3	2.8
Capital Goods	10.5	7.5	22.5	26.7	28.3	4.8	6.7	18.0	24.4	27.9
Machinery	10.5	3.0	4.9	8.3	12.6	4.8	3.0	5.4	8.5	13.1
Electrical	+	2.6	5.8	7.3	7.4	+	2.1	5.4	6.7	7.0
Transport equipment	+	1.9	11.8	11.1	8.3	+	1.6	7.2	9.2	7.8
Total						307,962	529,554	825,061	1,235,943	1,815,065

* included in chemicals in 1940 and 1950;
\+ included in machinery in 1940.

Source: IBGE, Censo Industrial, 1940, 1960, 1970, 1975.

Table 3.2

Average Annual Growth of Manufacturing Value Added
and Employment in Sao Paulo State, 1950-1975

	Value Added			Employment		
	1950-60	1960-70	1970-75	1950-60	1960-70	1970-75
NonMetallic Minerals	6.2	9.9	12.9	7.7	3.5	4.5
Metallurgy	8.2	12.4	18.3	5.4	5.6	10.9
Machinery	13.9	17.2	23.4	10.4	9.2	16.7
Electrical	27.7	12.5	13.5	14.4	6.5	8.1
Transport	30.4	10.8	6.8	20.2	7.0	3.7
Wood	1.7	8.0	17.7	0.1	1.3	9.7
Furniture	9.5	9.5	12.3	6.0	4.1	6.2
Paper	11.2	9.6	13.3	5.4	5.6	4.6
Rubber	12.6	9.1	9.8	7.7	4.7	6.6
Leather	4.5	2.6	11.6	2.0	0.5	5.4
Chemicals a/	11.5	10.6	20.7	6.8	2.4	2.7
Pharmaceuticals	-	17.4	7.2	-	2.4	-0.7
Perfume	-	15.3	10.4	-	5.1	2.7
Plastics	-	22.9	17.7	-	15.4	11.4
Textiles	2.5	9.1	3.7	0.5	1.3	-0.9
Clothing	6.8	9.3	13.8	4.6	5.8	10.4
Food	6.6	10.2	7.3	3.1	3.4	4.1
Beverages	4.1	5.4	7.4	2.9	1.8	-4.1
Tobacco	5.9	10.3	5.1	-0.4	-0.5	-0.7
Printing	6.2	13.4	13.4	3.5	4.9	5.5
Miscellaneous	8.3	14.0	24.7	5.1	5.5	19.2
TOTAL MANUFACTURING:	8.8	11.4	13.8	3.7	4.5	7.1

Source: IBGE, Censo Industrial, 1950, 1960, 1970, 1975.

a/ Pharmaceuticals, perfume, and plastics sectors are reported as subsectors of the chemical sector in 1950.

sectors occurred in Sao Paulo during that period. In fact, all of the capital goods industries prove to be dynamic during the 1940s, 1950s, and 1960s. (See Table 3.2). The transport machinery sector exploded during the 1950s in Sao Paulo with the growth of Ford, GM, Mercedes Benz, Volkswagen, and others. Its average annual rate of growth in value added topped 30 percent during the 1950s. The electrical goods sector began to develop in the 1930s as production of radios, refrigerators and electric motors developed, although, due to dependence on imported components, the sector was largely restricted to that of assembly. The electrical industry grew rapidly in the 1940s, 1950s, and 1960s. In the overall pattern of the electrical industry, foreign companies have played a large role, at least in part because of the nature of the technology involved, which Brazil has imported from developed country producers [Newfarmer, 1977].

Prior to 1940, the machinery sector was geared towards light engineering. In the post-war period, the industry expanded to produce more heavy and more complex machinery, and substituted domestic equipment for imported. In general, the machinery sector experienced very rapid growth in terms of both value added and employment since 1950.

The chemicals industry is a collection of both traditional and high technology activities. In 1920, the industry in Brazil consisted largely of explosives, match production, and the processing of vegetable and animal oil, with other chemicals imported. By 1940, production of coal and oil derivatives, artificial fibers, paint, and household chemicals emerged. During the 1960s, petrochemicals, fertilizers, paints and dyestuffs were the fastest growing subsectors. On average, the sector has maintained a relatively constant share of state manufacturing value added, at roughly 10 percent. Because of the wide range of manufacturing activities subsumed in the industry, it is difficult to classify. But its continued dynamism is reflected in above average growth rates in value added growth in the 1950s and early 1970s.

The pharmaceutical industry developed initially in the 1920s to package imported drugs, and later compounds were imported for drug-making within Brazil. Sixty percent of raw materials are still imported, and the industry is heavily concentrated in foreign pharmaceutical companies [Evans, 1976].

Pharmaceuticals showed a high growth rate in value added in the 1960s. The plastics industry emerged in the 1950s, primarily in Sao Paulo. It experienced the most rapid increase in employment of any Brazilian industry between 1960 and 1970, and continued to expand rapidly in the early 1970s.

Another sector that deserves some mention along with the more innovative sectors is the miscellaneous sector. Often the more recent and innovative manufacturing activities not easily classified elsewhere (such as optical and photographic equipment and medical instruments) are lumped into the miscellaneous sector. This sector experienced above average growth in both value added and employment in the 1960s and the early 1970s.

Two other sectors, clothing and metallurgy, that are generally regarded as mature industries, exhibited some dynamism in recent years, clothing especially in terms of employment growth. There may have been new process innovations stimulating growth in metallurgy. While the clothing sector has a simple and highly standardized production process, innovation and rapid product turnover are characteristic of this sector. For this reason, the clothing sector may be more dependent on agglomeration economies than expected. In the New York Metropolitan Region Study, most subsectors of the clothing industry were classified as highly oriented towards external economies, reflecting the rapid product turnover, unpredictability of demand, and need to have instant face-to-face communication with suppliers and comparison shoppers [Lichtenberg, 1960]. Nonetheless, the clothing and metallurgy industries in Sao Paulo are not classified here as innovative sectors.

Turning to the other approach to classify sectors in the product cycle, innovative, early-stage industries are characterized as skilled labor-intensive, as Research and Development (R&D) intensive, and as having relatively low capital intensity. Analysis of these factors provides additional perspective to aid in classifying Brazilian two-digit manufacturing sectors according to different stages of the product cycle, again subject to the problems of classification at such a high level of aggregation.

Sectoral Differences in the Use of Skilled Labor. Several measures of labor skill intensity can be used to identify the skill composition of the labor force by industry. First, sectoral differences in average wages should reflect differences in skill levels, given conditions of perfect competition in product and factor markets as well as labor mobility among industries. Table 3.3 gives a ranking of sectors by average wages in 1979.

Second, the proportion of professional and technical workers to total employment is used to measure labor skill intensity. Brazilian data on this measure were not available. However, in general, skill intensity by sector and, more specifically, the proportion of professional and technical workers to total employment, has been shown not to very greatly across different countries [Teitel, 1976]. Following Teitel, Brazilian industries are ranked

Table 3.3

Ranking of Manufacturing Industries by Indicators of Skill and R&D Intensity

	Rank According To:			
	Proportion of Professional & Technical Workers (a)	Average Wages (b) 1970	Average Wages (b) 1979	R&D Intensity (c)
Chemicals	1	2	4	4
Perfume	2	6	1	5
Pharmaceuticals	3	1	6	6
Plastics	4	12	14	7
Electrical Equipment	5	7	2	2
Printing	6	4	8	n.a.
Machinery	7	5	3	3
Metallurgy	8	9	9	9
Transport	9	3	7	1
Rubber	10	8	5	n.a.
Paper	11	10	10	10
NonMetallic Minerals	12	16	11	8
Tobacco	13	n.a.	13	n.a.
Food	14	15	12	14
Beverages	15	11	16	n.a.
Textiles	16	13	15	11
Wood	17	17	17	12
Furniture	18	14	18	13
Leather	19	n.a.	19	n.a.
Clothing	20	18	20	n.a.

a/ From Teitel [1976].

b/ Average wages from special tabulations of the 1970 Brazilian Demographic Census and from Brazilian social security data files (RAIS) for 1979.

c/ From National Science Board [1977].

according to the average proportion of professional and technical workers in total employment across 17 industrialized and semi-industrialized countries (see Table 3.3).

Third, the proportion of managerial and administrative workers provides another dimension of the labor skills composition in manufacturing. This measure probably does not reflect the extent of innovativeness in a sector quite as well as the proportion of professional and technical workers. In fact, creative entrepreneurs are likely to be the most important element in innovation, and such individuals should be included as innovation workers [Sveikauskas, 1979]. However, it is difficult to distinguish creative entrepreneurs from the available data.

Sectoral Differences in R&D Intensity. Another way to measure the innovativeness of an industry is on the basis of its R&D intensity. While it has been demonstrated that firms spending the most money on R&D are not necessarily the most innovative [Mansfield, 1971], there is a strong statistical association between R&D intensity (defined as R&D finds as a proportion of sales) and technological intensity (innovations per net sales is used as a proxy) among U.S. manufacturing sectors ($r = 0.88$; $p < 0.01$) [National Science Board, 1977]. In the absence of Brazilian data on these measures, U.S. data are used to rank Brazilian manufacturing sectors according to R&D intensity (see Table 3.3). The danger in relying heavily on this U.S.-derived measure of R&D intensity to classify the innovativeness of Brazilian industries lies in the fact that many sectors in Brazil are transferring technology, rather than investing in-house in product and process development.

Sectoral Differences in Capital Intensity. Product cycle stage classification of sectors on the basis of capital intensity is also not without risk. While it is true that, within a sector, the innovative, early stage manufacturing activities are likely to be less capital intensive than the mature and standardized manufacturing activities, it is difficult to make cross-sectoral comparison. Some innovative activities in the chemical sector, for example, are bound to be much more capital intensive than a mature textile industry. Nonetheless, some estimates of capital intensity that attempt to classify industry are presented: the capacity of installed equipment per employee in 1970, and electricity consumed per employee in 1970.

The results of pair-wise comparison of the rankings of the indicators of "innovativeness" by sector, using the Spearman rank correlation coefficients, are shown in Table 3.4. The relationship between the proportion of professional and technical workers to total employment and average wages for manufacturing sectors in Sao Paulo in 1979 was found to be significant ($r = 0.83$; $p < 0.01$). The relationship also exists when less reliable average wage data (census) are used for 1960 ($r = 0.70$, $p < 0.01$) and for 1970 ($r = 0.81$, $p < 0.01$).

The relationships between the proportion of managerial and administrative workers with average wages and with the proportion of professional and technical workers are weaker ($r = 0.42$, $p < 0.032$ and $r = 0.44$, $p < 0.027$, respectively). The stronger indicators of skill-intensity of labor, average wages and proportion of professional and technical workers, have significant association with R&D intensity. As expected, the indicators of capital intensity do not have strong relationships with the other measures of sectoral "innovativeness".

Drawing together these two approaches for classifying industries in the product cycle, it is possible to distinguish in general terms over the

Table 3.4

Statistical Comparison of the Ranking of Manufacturing Industries According to Indicators of Skilled-Labor Intensity, R&D Intensity and Capital Intensity (Spearman Rank Order Correlation Coefficients)

	Skilled Labor Intensity		R&D Intensity	Capital Intensity	
	Proportion of Professional and Technical Workers	Proportion of Managerial and Administrative Workers		Electricity Consumed per Worker-1970 (KWH/L)	Capacity of Installed Equipment per Worker-1970
Average Wages, 1979	+0.83*	+0.42*	+0.59*	+0.25	+0.26
Proportion of Professional and Technical Workers	-	+0.44*	+0.61*	+0.22	+0.15
Proportion of Managerial and Administrative Workers, 1970	-	-	+0.15	+0.20	+0.21
R&D Intensity	-	-	-	+0.13	+0.12
KWH/L, 1970	-	-	-	-	+0.89*

Sources: Table 3.3; IBGE, Censo Industrial, 1970.

* Statistically significant at the 0.05 probability level.

past twenty years whether a manufacturing sector is in the early or late phase of its evolution.

Further tests distinguishing between innovative and mature activities within a single manufacturing sector are possible within plant data and are presented in chapter 4. Table 3.5 indicates how sectors are classified in the product cycle for 1960, 1970, and 1975.

The classification rules we have relied upon here relate to the age and growth rate of individual sectors and to various measures of sectoral "innovativeness". Obviously the procedures and data used to classify manufacturing sectors by product cycle stage are far from perfect. But perfection in this task was not sought and was probably not attainable. On the one hand, the level of industry aggregation, at 2-digit SIC, is too gross to permit much precision. Moreover, the field is not exacting. A variety of different classification rules, all equally plausible, could have been devised to classify industry in the product cycle, that would have led to slightly different results. In this study, we required a rough, order of magnitude, classification of sectors in the product cycle that would enable us to test the locational tendencies of individual industries.

Sectoral Distribution of Manufacturing Employment in Sao Paulo State

This classification is used to analyse the sectoral distribution of manufacturing employment within Sao Paulo state. Analysis of the levels as well as the trends of decentralization of employment for each sector provides a basis to examine the product cycle hypothesis. It is expected that the more mature sectors will exhibit a stronger decentralization tendency than innovative sectors.

Table 3.5

Classification of Manufacturing Sectors in the Product Cycle, 1960, 1970, and 1975

1960	1970	1975
	Innovative	
Machinery	Machinery	Machinery
Electrical	Electrical	Electrical
Pharmaceuticals	Pharmaceuticals	Pharmaceuticals
Perfume	Perfume	Perfume
Plastics	Plastics	Plastics
Miscellaneous	Miscellaneous	Miscellaneous
Transport	Transport	
Chemicals		
	Intermediate	
NonMetallic Minerals	Chemicals	Transport
Metallurgy	NonMetallic Minerals	Chemicals
Rubber	Metallurgy	NonMetallic Minerals
Paper	Rubber	Metallurgy
Printing	Paper	Rubber
	Printing	Paper
		Printing
	Mature	
Textiles	Textiles	Textiles
Clothing	Clothing	Clothing
Food	Food	Food
Beverages	Beverages	Beverages
Tobacco	Tobacco	Tobacco
Leather	Leather	Leather
Wood	Wood	Wood
Furniture	Furniture	Furniture

The sectoral distribution of manufacturing employment in Sao Paulo state from 1960 to 1975 is shown in Table 3.6.

When manufacturing sectors are broadly divided into groups according to product cycle steps, the innovative sectors exhibit on average a greater tendency to locate within Grande Sao Paulo than the mature sectors. Throughout the time period, employment in the mature sectors is considerably more decentralized than that of the innovative and intermediate sectors. In 1960 and 1970, the share of mature sectors employment that is outside GSP is over twice that of innovative sector employment.

Table 3.7 illustrates the relative concentration of employment in GSP by sector. The pattern in the table shows most sectors lining up along a diagonal. The most notable deviation for the pattern, tobacco, is explained by the fact that virtually all tobacco production in Sao Paulo is held by one company with plants in Sao Paulo city. The relatively high concentration within mature sectors of clothing sector employment in GSP accords with the high product turnover associated with many clothing manufacturing activities, as previously discussed. This explanation may also apply to the furniture sector.

In terms of the trends of employment decentralization, recall that during the period 1960 to 1975, GSP's share of total state manufacturing employment declined from 71 to 66 percent. All three of these broad sector groups exhibit a general trend of decentralization during this period, although the innovative sectors as a group became slightly more centralized during the 1960s. A substantial drop in the GSP share of innovative sector employment occurred from 1970 to 1975; however, over three-fourths of those jobs were still in GSP in 1975. GSP's share of employment in the mature

Table 3.6

Employment in Grande Sao Paulo as a Percentage of Total State Employment by Sector, 1960, 1970 and 1975

	1960	1970	1975
Innovative Sectors	82	83	76
Machinery	68	72	68
Electrical	90	89	84
Pharmaceuticals	97	95	90
Perfume	73	75	81
Plastics	97	92	88
Miscellaneous	88	87	75
Transport 1/	88	86	--
Chemicals 1/	72	--	--
Intermediate Sectors	76	72	72
NonMetallic Minerals	57	55	52
Metallurgy	88	83	80
Rubber	88	79	75
Paper	73	79	75
Printing	86	84	80
Chemicals 1/	--	59	64
Transport 1/	--	--	78
Mature Sectors	59	58	55
Textiles	62	62	57
Clothing	76	69	69
Food	41	40	43
Beverages	51	34	26
Tobacco	99	99	95
Leather	44	38	35
Wood	49	50	46
Furniture	73	69	65
ALL MANUFACTURING SECTORS	71	70	66

Source: IBGE, Censo Industrial, 1960, 1970, 1975.

1/ The transport sector is considered as an innovative sector in 1960 and 1970 but becomes an intermediate sector in 1975. The chemicals sector is an innovative sector in 1960 and an intermediate sector thereafter.

Table 3.7

Employment in Grande Sao Paulo as a Percentage of Total State Employment by Sector: Average Percentage During 1960-1975

	Percentage of State Employment in GSP		
	81-100%	61-80%	0-60%
Innovative Sectors			
	Electrical Pharmaceutical Plastics Miscellaneous Transport	Machinery Perfume	
Intermediate Sectors			
	Metallurgy Printing	Rubber Paper Chemicals NonMetallic Minerals	
Mature Sectors			
	Tobacco	Clothing Furniture	Textiles Food Beverages Leather Wood

Source: Table 3.6.

sectors has remained substantially lower than that of the innovative (and intermediate) sectors. In 1960, the share was 59 percent, and declined to 55 percent by 1975.

Looking at individual sectors, the mature sectors that experienced the greatest decentralization, relative to their initial levels in 1960, were beverages, rubber, miscellaneous, transport, plastics, and leather, in that order. This trend might be reflective of the extent to which these industries have become increasingly standardized and competitive.

In sum, employment in what is broadly classified as the more innovation-oriented manufacturing sectors is, as expected, notably centralized in Grande Sao Paulo, while employment in the more mature sectors is considerably more decentralized.

Shift-Share Analysis of Manufacturing Growth in Sao Paulo State

Another way to test the product cycle hypothesis -- that the mature, slower-growth manufacturing sectors are decentralizing from Grande Sao Paulo while the faster-growth innovative manufacturing sectors are not -- is shift-share analysis. Using the shift-share technique, the changes in employment (or value added) for a given area over a given time period are attributed to three influences. These influences, as applied to Sao Paulo state, are: (i) the aggregate growth of the state economy; (ii) the particular industrial structure or mix of the subregion (in this case, GSP and the rest of the state are the subregions); and (iii) a differential shift which indicates changes in the relative locational advantage of the subregion for economic growth. The particular version of shift-share utilized to examine 1960-1975 changes in employment and value added in Sao Paulo state follows Stevens and Moore [1980]. The procedures for calculating the shift-share measures are presented in the Appendix to Chapter 3 (p. 79).

While this technique has been the subject of considerable controversy concerning the levels of disaggregation used in the analysis and in the selection of the base year, most researchers accept the technique as being of value in identifying the impact of differences in industrial structure on the spatial pattern of manufacturing change [for example, Keeble, 1976].

Using the shift-share technique to examine the product cycle hypothesis involves analysis at a 2-digit level of industrial aggregation and the associated risks of oversimplification. Also, since the technique essentially entails detailed sectoral breakdowns of industrial growth rates, it is necessary to assume, in the context of the product cycle hypothesis, that innovative sectors are relatively fast-growing, while mature sectors are relatively slow-growing. Table 3.2 reveals that this assumption holds reasonably well overall in terms of value added growth and, to a lesser extent, for employment growth. Chemicals, pharmaceuticals, perfume and transport have lower than average employment growth rates in 1970-1975. However, since the number of exceptions is relatively small in other periods and for value added growth, this problem is not likely to have a serious impact on the analysis.

For the results of the shift-share analysis to provide support for the product cycle hypothesis, GSP and the rest of the state are expected to have opposite signs for both the differential shift effects and industry mix. GSP is expected to have a negative sign for the differential shift effect, while that for the rest of the state is expected to be positive. This would indicate that, on average, all industries in the rest of the state outside GSP are growing faster than their statewide counterparts, and vice-versa for industries within GSP. It would also indicate that industrial decentralization is occurring. Furthermore, the relative abundance of growth and innovation generating industries within GSP is expected to be reflected in a positive industrial mix effect. On the other hand, the rest of the state is expected to specialize in the slower-growth mature industries and therefore exhibit a negative mix effect.

The results of the shift-share analysis of employment and value added changes in the state over the two periods 1960-1970 and 1970-1975 are summarized in Table 3.8. The results are expressed in terms of the percentage of total employment or value added change attributed to state growth, industry mix, and differential shift effects.

Looking first at the components of employment growth, the results generally accord with expectations. During both periods in Grande Sao Paulo, most of the employment gains can be attributed to the state growth (i.e., subregional growth is proportional to total state employment growth), 6 or 7 percent was due to industrial mix effects, and negative differential shifts (the degree to which GSP industries grew slower than their state counterparts) had a dampening influence on employment growth.

The results show an opposite pattern for the rest of Sao Paulo state. The proportion of employment growth attributable to state growth is much less than in GSP, the industry mix has a dampening influence on growth, and the different shift contributes significantly to employment growth.

Employment growth in GSP is attributed to a favorable industrial mix, indicating that during both periods the metropolitan area does specialize in

Table 3.8

Manufacturing Employment and Value Added Change Within Sao Paulo State
Growth, Industry Mix, and Regional Shifts Effects, 1960-1975

	Percentage of Employment Change Attributed To:				Percentage of Value Added Change Attributed to:			
	Employment Change 1/	State Growth	Industry Mix	Differential Shift	Value Added Change (Millions of 1970 $Cr)	State Growth	Industry Mix	Differential Shift
Grande Sao Paulo								
1960-75	321,485	103.9	7.4	-11.3	12,392	113.1	-6.5	-7.2
1970-75	301,116	110.9	6.0	-16.9	17,998	116.7	1.3	-17.9
Rest of Sao Paulo State 2/								
1960-70	126,758	90.2	-18.8	28.7	4,548	63.8	16.0	19.7
1970-75	153.328	78.6	-11.8	33.2	9,138	67.3	-2.6	35.3

1/ New industrial sector created in 1975 called "support services" not included in this table. Therefore, employment change is slightly understated.

2/ Missing data for cities below 20,000 population in Western Sao Paulo (beyond the Campinas and Sorocaba Regions).

Sources: (1) IBGE 1970 Industrial Census - Sao Paulo.
(2) IBGE 1975 Industrial Census - Sao Paulo.
(3) SEP (1978) Plano Regional do Macro-Eixo Paulista, Anexo 3.
(4) EMPLASA, Subsidies for an Industrial Development Policy, Locational Aspects - Sao Paulo.

faster-growth industries than that of the state as a whole. Conversely, the negative industrial mix in the rest of the state found during both periods indicates that the industrial mix is more heavily weighted to the slower-growing sectors.

The negative differential shift effects found in Grande Sao Paulo in both periods indicate that, given the overall level of state growth and GSP's favorable industry mix, growth is less than what is expected on the basis of average industry growth statewide. The opposite differential shift effects for GSP and the rest of the state suggest a loss of competitive or locational advantage in the core, and a corresponding gain in the periphery. The increasing relative locational disadvantage for investment in GSP is a reflection of many things, including the rising rent and land values combined with traffic congestion and external diseconomies in GSP on the one hand, and on the other hand, in the rest of the state improved industrial infrastructure, more diversified labor markets, and so on.

The shift-share results for value added change are generally similar to those for employment change. The rest of the state is capturing a progressively larger share of value growth, although GSP continues to generate the larger absolute increment. A major difference between the value added and employment results, however, relates to the industry mix effects during 1960 to 1970. Value added growth in GSP is pulled down by a slow-growing industrial mix, while the reverse is true in the rest of the state. It would appear that the differences are largely due to the varying degrees of capital intensity of the growing sectors inside and outside Grande Sao Paulo. During the 1960s, the sectors with the faster employment growth in GSP appear to have been slower-growth sectors in value added terms. In the rest of the state, the reverse is apparent to an even greater extent.

To find a higher degree of capital intensity in manufacturing activities outside GSP is not inconsistent with the product cycle framework. Innovative and early stage growth industries are not expected to be as capital intensive as stagnating or declining industries. It is not until the mature phase, or approaching it, that the technological and marketing uncertainties settle down and an industry can commit to a given production process and major capital investment. Thus, production which has been decentralized via product cycle mechanisms would be expected to be relatively capital intensive.

The differential shift component of value added change, reflecting changing locational advantage, closely parallels the trends in employment change. Positive differential shift is contributing to hinterland growth.

Summary

The industrial geography of pre-twentieth century Brazil can be characterized as an economic archepelago. In each isolated economic region, the level of urbanization and industrial activity of the region's leading city, usually a deepwater port, was determined largely by the region's natural resource endowment and world demand for the region's primary staple export.

When Brazil began to experience rapid industrialization after the turn of the twentieth century, Sao Paulo, at the vortex of the coffee boom, was the reigning economic region. Although Rio de Janeiro had been the leading economic region through the first two-thirds of the nineteenth century and had the most conducive economic environment for nuturing new industrial activity, Sao Paulo became the preferred location by industry.

Why? First, the coffee economy in Sao Paulo generated very rapid growth in regional income, especially in comparison to that of Rio's then unhealthy hinterland. Second, the country's fragmented economy and rudimentary banking system constrained the interregional flow of capital. Private capital was primarily reinvested in Sao Paulo. Sao Paulo state had a high degree of fiscal autonomy, and was able to reinvest the lion's share of its revenues locally, sending little on to Rio.

These conditions permitted the build-up of an industrial agglomeration in Sao Paulo City. Similarly, the infusion of entrepreneurial talent from abroad, rapid growth in local demand, and periods of import shortfalls (for example, World War I) stimulated this process. Soon, Sao Paulo City too developed considerable external economies which ultimately guaranteed its rise to urban and industrial pre-eminence in Brazil.

Since 1960, a decentralization of manufacturing employment in Sao Paulo was reflected in the rapid growth of manufacturing employment in secondary towns in the state, particularly in the "ring" region surrounding Grande Sao Paulo. The sectoral patterns of manufacturing decentralization roughly correspond to the filter-down process of the product cycle model. Employment in the more innovative sectors remains, by and large, highly centralized in the metropolitan region, while that of the mature sectors is much less centralized.

The product cycle model predicts such a pattern because of the need of the innovative sectors for agglomeration economies found predominantly in the metropolitan core and because of the pull of locations outside the metropolitan area with lower prices for the factor inputs used by the more mature sectors. While this chapter has explored these notions using secondary date, the next chapter uses plant data to assess the relative importance of agglomeration economies for different manufacturing activities in Sao Paulo.

Appendix to Chapter 3

SHIFT-SHARE EQUATIONS

Using shift-share techniques, employment (or value added) changes over time can be disaggregated into three components. Following Stevens and Moore [1980], we can define these components within the context of Sao Paulo State as:

State Share: $SS_i \equiv e_i^{t-1}(E^t/E^{t-1})$

Industry Mix: $IM_i \equiv e_i^{t-1}(E_i^t/E_i^{t-1} - E^t/E^{t-1})$

Sub-regional Shift: $RS_i \equiv e_i^{t-1}(e_i^t/e_i^{t-1} - E_i^t/E_i^{t-1})$

where e_i and E_i are subregional (GSP or rest of the state) and state employment (or value added) in industry i; e and E are subregional and state total employment in all industries; and t-1 and t are the beginning and end of the analysis period, respectively. And, by definition,

$$e_i^t \equiv SS_i + IM_i + RS_i \quad .$$

Since in our analysis we wish to decompose the change in employment rather than attempt to forecast future employment, the state share is redefined as

$$SS_i \equiv e_i^{t-1}[(E^t/E^{t-1}) - 1]$$

so that

$$e_i^t - e_i^{t-1} = SS_i + IM_i + RS_i \quad .$$

This equation disaggregates change in the subregion's employment in industry i into changes caused by total state growth, by industry i growing faster or slower than the average for total industry in the state, and by shifts of employment into and out of the region under study.

Chapter 4

AN EMPIRICAL ANALYSIS OF THE PRODUCTIVITY, WAGES, AND LOCATION OF NEW MANUFACTURING PLANTS IN SAO PAULO STATE

The historical evidence showed a strong tendency for Brazilian industry to cluster within Sao Paulo City and its metropolitan area during the first half of the twentieth century. However, lately, this centralization trend has shown signs of a limited tendency toward reversal. Among developing countries today, such a reversal in the tendency for industry to centralize in one or a few major urban centers is an extremely rare occurance. In this light an exploration of forces and circumstances causing industrial decentralization in Sao Paulo state is of considerable interest, particularly because of widespread efforts to accelerate the process of decentralization in many developing countries.

What factors underlie this limited decentralization of manufacturing industry in Sao Paulo state? One plausible hypothesis is that Grande Sao Paulo, with nearly 13 million inhabitants, is simply becoming too big to be an efficient location for manufacturing resources. It is possible that Grande Sao Paulo no longer has the productivity advantages it once did because its agglomeration economies have petered out as it has grown so large. The buildup of negative externalities such as pollution and congestion within GSP may have detracted significantly from its desirability as a location for manufacturing because firms have to pay higher wages to compensate workers for the urban disamenities and higher commuting costs in GSP.

Another hypothesis is that industrial decentralization has occurred because many of the constraints on industrial location outside the metropolitan area have been removed, making those areas more competitive. As highways, electric power, water, telephones and other industrial infrastructure networks have expanded in the rest of the state, it has become increasingly possible for industry to locate there.

Undoubtedly there is some truth in both of these explanations. The trend of industrial decentralization probably relates to the trade-off between the productivity advantages due to agglomeration economies in the metropolitan area and the labor and land cost advantages in outlying areas. I suspect that, at least until 1960, the bulk of new industrial employment was concentrated in GSP because central productivity advantages outweighed the advantages of outlying areas. But after 1960, it would appear that the balance is no longer overwhelmingly tipped in favor of GSP. In recent years, wage and land price differentials between GSP and the rest of the state may have widened, thereby increasing the competitiveness of production sites outside the metropolitan area.

The hypotheses underlying this trade-off are testable ones. Ideally, I would like to examine how the relative productivity and cost advantages of central and outlying areas of Sao Paulo state have changed over time. However, since data constraints preclude a test of these dynamic hypotheses, these hypotheses are examined in static terms: does Grande Sao Paulo (still) have agglomeration economies; do outlying areas have factor cost advantages; and how do productivity advantages of GSP compare with other cost advantages of outlying areas.

This chapter focuses on analysis of these hypotheses. The main question is whether the observed decentralization trend, limited as it is, can be explained by the competitiveness of production sites outside the metropolitan region. To establish the existence and importance of productivity and wage differentials over space, the extent of these differentials is estimated. In the first section of the chapter, a production function framework is developed to estimate spatial variation in the productivity of manufacturing activities using data from a sample of new plants thoughout Sao Paulo state. In a second section, differentials in manufacturing wages are estimated. Finally, the locational trade-offs between GSP and outlying areas are analyzed in depth using a model of industrial location choice. The choice for the typical firm -- locating in GSP or in the outlying areas -- is modeled in terms of the relative importance of the factors of productivity, wage, and land price differentials. The importance of agglomeration economies vis-a-vis other factor cost advantages for different manufacturing industries at various stages of the product life cycle is evaluated using this location choice model.

The first section examines spatial variation in manufacturing productivity in Sao Paulo state and is prefaced with a review of the attempts to measure agglomeration economies.

4.1 Spatial Variation in Manufacturing Productivity in Sao Paulo State

The concentration of industrial activity in a large city or metropolitan region of a developing country is frequently attributed to higher levels of productivity resulting from agglomeration economies [Alonso 1971; Mera 1973]. However, very little empirical evidence exists to substantiate this proposition. Only a few empirical studies have examined differences in industrial productivity between regions or related to city size in developed or developing countries.

Recently, various methodologies have been advanced to examine inter-urban and inter-regional differences in industrial productivity and to measure agglomeration economies. Unfortunately, several conceptual and empirical problems beset this work, and therefore limit the strength of the findings.

Two basic approaches have been pursued by researchers trying to measure increasing returns to scale in urban areas. First, agglomeration effects have been explored by examining the relationship between per capita incomes and city size. The reason for suspecting a positive relationship is that higher incomes should reflect higher productivity and, in turn, that higher productivity indicates higher agglomeration economies. Fuchs [1967], Mera [1970], and Hoch [1972] find empirical support for agglomeration economies in this fashion. The problem with this approach, however, as indicated by Hoch [1972], Tolley [1974], Richardson [1978b] and others, is that higher incomes could be compensating payment for the negative externalities of urban life and that it is difficult to isolate the productivity effects from the urban disamenity effects which both produce higher incomes.

A more direct way of measuring the influence of agglomeration economies (or city size) on industrial productivity is a production function approach. Several cross-sectional production function estimations of city size and productivity have been done. Of these, the most conclusive are three studies of U.S. cities showing that urban size, at least up to a certain level, has a positive influence on industrial productivity [Sveikauskas 1975;

Segal 1976; Moomaw 1981]. In addition, several attempts have been made to measure explicitly the existence of agglomeration economies in manufacturing industry in the United States [Shefer 1973; Kawashima 1975; Carlino 1979; Henderson 1982], in the United Kingdom [Townroe and Roberts 1980], and in Brazil [Rocca 1970; Boisier 1978; Hay 1979; Henderson 1982]. In spite of the formidable measurement problems encountered by these studies, on balance, they appear to confirm the existence of agglomeration economies.

Notable among this last group of studies are ones by Shefer, Carlino, and Henderson because of the sophistication of their approaches. Shefer used a variant of the generalized constant elasticity of scale (CES) production function suggested initially by Dhrymes [1965] to estimate agglomeration economies at the two-digit SIC manufacturing industry level. In this variant of the CES production function, a homogeneity parameter that reflects total returns to scale, that is, internal and external economies, can be estimated. [1] Shefer estimated homogeneity parameters for manufacturing industry in U.S. standard metropolitan statistical areas (SMSAs) for 1958 and 1963 and

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[1] Dhrymes [1965] demonstrates that a generalization of the CES production function approach which assumes homogeneity and imperfect competition in both the product and capital markets can be written as:

$$w = a\ Q^b\ L^c$$

where w is the wage rate, Q is output, and L is labor input. Dhrymes shows that the homogeneity parameter can be written as:

$$h = \frac{1 + c}{1 - b} \quad .$$

found that agglomeration economies existed in most two-digit manufacturing industries.[2]

Carlino extended Shefer's work by analyzing the composition of the estimated homogeneity parameter in terms of the types of agglomeration economies effects. The relationship between estimated homogeneity parameters and measures of internal economies of scale, localization economies, urbanization economies, and urbanization diseconomies was analyzed using multiple regression. He found that urbanization economies and diseconomies effects were strongest.

These two studies represent a substantial advancement in the measurement of agglomeration economies. However, their use of the Dhrymes CES production function variant (adopted principally so as to circumvent the lack of capital data) presents a serious problem when it is applied in examining productivity and city size. The estimates of the parameters are based on three variables: wage rate, value added, and labor input. The wage rate and value added per worker, however, are both endogenously determined. Since this simultaneity is not recognized explicitly in either of the studies that use the Dhrymes CES production function framework, and since both value added per worker and the wage rate are probably positively correlated with city size and other measures of agglomeration economies, the estimation very likely yields biased estimates of the homogeneity parameter.

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2 Shefer claims to be measuring "localization economies". But, since he uses total industrial output per SMSA as a proxy for this effect, he is measuring some kind of agglomeration economies effect that falls somewhere in between industry-specific localization economies and the more general urbanization economies.

Henderson [1982], in a recent study and with capital stock data, tried to correct this weakness of the Shefer and Carlino work. He employed a Cobb-Douglas production function extending the framework of Moomaw [1981] and also specified a more elaborate functional form production function using a two-stage least squares estimation procedure. Henderson concluded that localization economies were much more important than urbanization economies for manufacturing industry using both U.S. and Brazilian data. A weakness of Henderson's analysis, unfortunately, relates to the difficulties inherent in distinguishing between actual industrial clustering advantages and other advantages. In particular, Henderson is unable to demonstrate conclusively the extent to which localization economies per se, as opposed to proximity to natural resources, account for the high number of cities that are specialized in one manufacturing industry.

In addition, a shortcoming common to these three attempts to measure agglomeration economies is the failure to control adequately for internal economies of scale effects. Each study uses average establishment size in an urban area to control for internal economies. However, such data on average establishment size in a given area are unreliable for the estimation of economies of scale because they are unduly influenced by the number of very small plants and contain no information on the level of scale economies at which most of the production was conducted. Consequently, it is difficult to distinguish between internal and external economies of scale. Rocca [1970] deals with this problem by stratifying each industry sample by size of establishment. Other than Rocca, Shefer [1973] is the only one to explicitly acknowledge the problem: "economies of scale which are internal to the firm, were not neutralized, that is, we have not accounted for the size distribution of firms in each industry; thus it is conceivable that a portion of the localization economies should be attributed to [internal] economies of scale" (p. 63).

This study attempts to correct for deficiencies of previous studies by using data on new plants (or establishments). First, by using plant data, internal economies of scale can be controlled for, making it possible to measure accurately external economies of scale. Second, the use of data on new plants avoids simultaneity problems, similar to those encountered by Henderson [1982] because the existing distribution of industry can be regarded as exogenously given for the purposes of this study. Third, the study avoids the endogeneity problem encountered by Shefer and Carlino using the Dhymes CES production function approach since capital data are included. Furthermore, in this analysis land assets are included with plant and equipment as the capital stock. Defining capital in this way constitutes an important advantage over prior work, because land plays an important role in the urban economy and omission of this portion of capital introduces a potentially important bias. Finally, previous studies of manufacturing productivity have focused on productivity differentials between regions or related to city size. This study examines actual <u>spatial</u> differences in the productivity of manufacturing activities within the context of a large region of a developing country -- Sao Paulo state. The central question explored in this section is whether Grande Sao Paulo has productivity advantages when compared to other locations within the state. And if so, how is this higher productivity related to agglomeration economies.

The Analytical Framework for the Productivity Analysis

A production function approach is used here to measure plant productivity in Sao Paulo state. The Cobb-Douglas production function is assumed [3]:

$$V = a K^{b} L^{c} \qquad (1)$$

which relates value added, V, to the amount of capital, K, and labor, L, employed and to the amount of all other factors linked to the total of value added, represented by parameter a. Parameter a is commonly referred to as a technology or Hicks-neutral shift factor that is neutral with respect to capital and labor inputs, that is, "leaves the marginal rates of substitution unchanged....simply increasing or decreasing the output attainable from a given input" [Solow 1957]. Hicks-neutral productivity, named for John R. Hicks [1932], is the "residual" output growth attributable to factors other than capital and labor inputs.

Dividing by L on both sides of equation (1) and multiplying the right-hand-side by L^{b}/L^{b} leads to the following:

$$V/L = a \, (K/L)^{b} \, L^{b+c-1.0} \qquad (2)$$

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3 Since data on factor prices are not available for all of the sample, it was not possible to attempt an estimation of more complex forms such as the translogarithmic (translog) functions. The preferred form of the production function would be the translog production function in which external economies would augment capital, labor, and land at differential rates. However, in the present data wages of employees is not available, precluding calculation of labor and capital factor shares and thus preventing the estimation of translog production functions.

in which (b+c-1.0) expresses internal plant economies of scale. The inclusion of capital intensity as an independent variable implies that equation (2) is analyzing total factor productivity even though labor productivity is the left-hand-side variable.

Two additional variables are added to the basic productivity equation in order to control for plant differences in the skill composition of their labor force and in the number of years of operation of the plant. The variable, ADMIN, is the percentage of white-collar employees to the total labor force of a plant and is included as an indicator of high level skills. A dummy variable for the number of years the plant has been in operation, YROP, is also included to allow for a break-in period during which plants gradually reach their maximum level of productivity. The sample of plants, as described below, are new plants that have been in operation for only one to four years; YROP simply takes on these values.[4] Finally, the variable of prime interest in this study is distance from the center of the metropolitan region (DSP). Distance is measured in kilometer road distance from the plant to the central square of Sao Paulo City. Inclusion of this distance variable

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4 The fact that these are new plants raises the problem that one may be measuring variation in plant start-up times rather than in bona fide Hicks-neutral productivity. By controlling for the number of years the plant has been in operation (at the new site), however, it can be expected that much of the variation in start-up periods can be eliminated. Also, some recent evidence suggests that plant start-up time is not very long even in developing countries. Cohen [1975] has estimated from monthly data of firms in developing countries that the majority of new firms reach maximum levels of output within a year. The problem is further reduced because some 85 percent of plants in the sample are simply transferring operations from one location to another or establishing a branch plant, and therefore are more likely to achieve fully effective operation faster than new single plant enterprises.

is similar to estimation of a productivity gradient which indicates the influence on plant productivity of accessibility to the city center.

Rewriting equation (2) to include these variables and taking logarithms (except for the YROP dummy variable) gives the following estimating equation:

$$\text{Ln}(V/L) = \text{Ln } a + b \text{ Ln}(K/L) + (b+c-1.0) \text{ Ln }(L) + d \text{ Ln}(\text{ADMIN}) + e\,(\text{YROP}) + f \text{ Ln }(\text{DSP}) + \text{random term} \quad (3)$$

The parameter d reflects the impact of high-level labor on productivity, and e reflects the greater productivity of more established plants. Parameter f, which is expected to be negative, shows the decline in Hicks-neutral productivity as a function of increased distance to the center of Sao Paulo City.

The Data for the Productivity Analysis

This analysis of productivity uses a sample of 356 new industrial plants in Sao Paulo state. These plants were part of the sample included in the 1980 Sao Paulo Industrial Location Survey conducted jointly by the World Bank and the Institute of Planning and Economics (FIPE) at the University of Sao Paulo. In the survey, a total of 581 plants were selected as a stratified random sample from a universe of 1961 manufacturing companies which opened new production plants in new locations in Sao Paulo state during 1977 to 1979. These plants include new single establishment firms (births), new branch plants, and plants that have relocated. The sample gave greater weight to larger plants and to plants locating outside Grande Sao Paulo. [5] Capital assets are given by the firm manager's best guess of the plant's current (1980) net worth. Labor is the total number of employees. ADMIN is the ratio of administrative employees to the total number of employees. Next, value added data were obtained from the state of Sao Paulo value added records for 1980. Since it was not possible to obtain value added data for all plants, in this analysis, a subsample of 356 plants for which the value added data are available and reliable is used; data were checked for obvious coding errors. The plants in the 581 sample for which value added data was not obtained presumably had gone out of business. Since there was no systematic spatial pattern observed among the plants which were excluded, we presume that the subsample was not biased.

The Results of the Productivity Analysis

Table 4.1 presents basic results for equation (3). Each column in Table 4.1 is a separate estimation. Column (1) is the basic form. In this equation, the coefficient for capital intensity is 0.31, somewhat higher than Rocca's [1970] previous estimates of this coefficient from Brazilian value added data. [6] The existence of internal (plant level) economies of scale is

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5 Townroe [1980] describes the survey and sampling procedure more fully.

6 Another equation was estimated in order to consider the potential bias associated with measuring capital stock in terms of the value of plant and equipment and omitting land value. Results then indicate the value of accessibility (the coefficient of Ln (DSP)) is -0.152 instead of -0.129 in Column (1). Omission of land from the value of capital assets, the general procedure followed in prior studies of urban manufacturing productivity overstates the value of accessibility by about 18 percent.

Table 4.1

The Relationship Between Distance to Sao Paulo City and Hicks-Neutral Productivity in New Manufacturing Plants in Sao Paulo State

Equation -->	(1)	(2)	(3)	(4)	(5)	(6)
Variable						
Constant	9.13	9.21	9.26	9.17	8.87	10.32
Ln (K/L)	.3083 (6.18)*	.2728 (5.25)*	.2676 (5.14)*	.2784 (5.63)*	.3387 (4.69)*	.2849 (3.95)*
Ln (L)	.1102 (1.93)*	.1149 (1.97)*	.1136 (1.95)*		.0981 (1.34)	.1077 (1.12)
Ln (ADMIN)	.2007 (2.47)*	.1243 (1.44)	.1189 (1.39)	.2067 (2.64)*	.2427 (2.36)*	.1221 (0.90)
Ln (DSP)	-.1292 (-3.04)*	-.1135 (-2.63)*	-.1130 (-2.63)*	-.1164 (-2.79)*	-.1373 (-1.37)	-.3341 (-2.19)*
Years in Operation	.1570 (3.06)*	.1660 (3.22)*	.1650 (3.21)*	.1555 (3.10)*	.1558 (2.48)*	.1645 (1.82)*
Ln (Company Size)				.1698 (4.28)*		
Industry Dummies		Included				
Industry Dummies x Ln (K/L)			Included			
n	356	356	356	356	223 (GSP)	133 (Non GSP)
Adj. R^2	.176	.188	.191	.209	.154	.171
Standard error of estimate	1.062	1.054	1.052	1.041	1.046	1.010

Source: Regressions based on equation (3).
t ratios in parentheses.

* indicates significantly greater than zero at the 95 percent level; for DSP, a negative one-tail test.

indicated in this equation by the positive and significant coefficient for Ln(L). Also, a high percentage of white collar workers in the plant work force is associated with higher levels of productivity, as is years of doing business, indicated by the large and significant coefficient for YROP.

Of main interest, the coefficient of distance to the center is negative and quite large; a one percent increase in distance from the center city is associated with a substantial 0.13 percent decline in Hicks-neutral productivity. The results indicate that -- after controlling for capital intensity, size of the plant, high skilled labor inputs, and the number of years that the plant has been in operation -- plants located closer to the center of Sao Paulo City do indeed have higher levels of productivity. Conversely, new plants located far from Sao Paulo City are apparently subject to substantial productivity disadvantages.

The explanatory power of the productivity regressions is quite low. There is a great deal of variability in these micro data which is not adequately explained by the variables at our command. That "pure" structural relationships (e.g., variables for K/L and L) cannot explain more than a fraction of the variation in multifactor productivity is troublesome, and raises the spector of problems of omitted variables. However, remember that our dependent variable is Ln (V/L) and not Ln (V) (value added). If we had estimated the absolute rather than the per worker form, we would have greatly raised R^2s. Part of the difficulty we encounter in explaining the variance in the dependent variable undoubtedly stems from the typically erratic annual variation in profits and taxes -- two components of value added. Also, the fact that "establishment" data is used -- data that, as mentioned above, have greater "noise" than more aggregated data -- contributes to low R^2s. These low R^2s can also be attributed to the fact that these regressions are estimated using a pooled industry sample; and the fits are typically better for individual industry regressions as shown below. Moreover, specific errors in data account for some of the unexplained variance. For instance, the capital data causes measurement problems in this study, as in most empirical studies of production. In this case, survey respondents were asked to estimate the net worth of their plant, equipment, land, and other assets. Undoubtedly, such "forced guessing" has contributed to random error. Nonetheless, the low explanatory power of these results are not an uncommon occurance in cross-sectional production function studies of establishment data (see Griliches and Ringstad, 1971).

Because some or all of the spatial variantion in plant productivity might be due to a relatively greater distribution of high productivity sectors in the metropolitan area, three kinds of industry dummies are included in the basic equation to control for sectoral differences. First, Hicks-neutral industry dummies, representing nine separate industries, are added to the basic equation. Second, industry dummies interacting with capital intensity to allow for sector differences in the capital share are included. Columns (2) and (3) indicate that inclusion of these dummies does not greatly alter the effect of distance. A one percent increase in distance is still associated with a 0.11 percent decline in overall productivity. These estimates imply that, even accounting for interindustry differences in these two ways, accessibility to Sao Paulo City has a substantial impact on the productivity of new plants. Third, in order to control for sectoral differences in the effect of accessibility to Sao Paulo City on plant productivity, industry dummies interacting with the distance variable are included in the equation. The results of this estimation are presented in Table 4.2. When sectoral differences in the distance effect are allowed,

Table 4.2

The Relationship Between Distance from the Center and Hicks-Neutral Productivity in Manufacturing in Sao Paulo State with Industry Dummies Interacting with the Distance Variable

Variable	Coefficient	(t-statistic)
Constant	9.36	
Ln (K/L)	.2724	(5.23)*
Ln (L)	.1175	(2.03)*
Ln (ADMIN)	.1484	(1.76)*
YROP	.1667	(3.26)*
Ln(DSP)	-.1660	(-3.20)*
Ln(DSP) x Metals	.0260	(0.52)
Ln(DSP) x Machinery	.1185	(2.26)*
Ln(DSP) x Electrical	.0987	(1.48)
Ln(DSP) x Transport	.0631	(0.82)
Ln(DSP) x Chemicals	.2206	(2.76)*
Ln(DSP) x Plastics	.1661	(2.63)*
Ln(DSP) x Textiles	.0629	(0.95)
Ln(DSP) x Clothing	-.0092	(-0.16)
Ln(DSP) x Food & Beverages	-.0041	(-0.06)
n	356	
Adj. R^2	.196	
Standard Error of Estimate	1.049	

Source: Regression based on equation (3) with industry dummies included. t-ratios in parentheses.

* indicates statistically significant at the 95 percent level.

the accessiblity effect for the base sector (in this case the diverse sector) is -.1660, a slightly more negative effect than in the basic equation for all industries. Other results are again essentially unchanged. For most industries, the coefficient for Ln (DSP) is not significantly different than that for the base sector. However, the accessibility effect is significantly lower than that of the base sector in three industries: machinery, chemicals and plastics at -.0475, +.0546, and +.0001 respectively. Central productivity advantages appear to be less for these three industries than for all other sectors. Further efforts to isolate the effect of distance to central areas for separate industries are reported below.

Accessibility to Sao Paulo City appears to affect the productivity of plants throughout Sao Paulo state; however, it is possible that this effect is not linear. A test is made in order to examine the hypothesis that the accessibility effect on productivity is different inside and outside the metropolitan area. Columns (5) and (6) of Table 4.1 examine the effect of distance within 223 plants in Grande Sao Paulo and 133 plants outside the metropolitan area. Distance has a negative effect both within and outside the metropolitan area. The magnitude of the effect within GSP is comparable to that in Column (1) although the coefficent falls short of significance. Outside the metropolitan area, the effect of accessiblity to the center has a much larger negative impact on plant productivity. Outside GSP, a one percent increase in distance to the center city is associated with a 0.33 percent decline in plant productivity. These results are fairly consistent with expectations since plants within the metropolitan area presumably have relatively ready access to many agglomeration economies while outside GSP, accessibility to the productivity advantages of the metropolitan area appears to decline more sharply. These results also indicate that internal economies of scale do not appear to exist for new plants inside or outside the metropolitan area. The coefficients for ADMIN suggest that the effect of highly skilled labor on productivity is substantial for new plants within the metropolitan area but is not significantly different from zero for new plants outside GSP.

Overall, this evidence suggests that accessibility to the center of the metropolitan area is positively associated with Hicks-neutral productivity for new manufacturing plants in Sao Paulo state. That is, after controlling for factor proportions, plant size, high skilled labor input, industrial sector, and years in operation, new plants closer to Sao Paulo City have a higher ratio of output per worker to inputs per worker.

It may well be that agglomeration economies are the most important factor underlying this accessibility effect. Other factors may also underlie the accessibility effect. Three potential factors are considered but, as shown below, do not undermine the importance of agglomeration economies.

First, if outlying plants ship most of their production to the center of Grande Sao Paulo, their lower Hicks-neutral productivity may reflect their higher transportation costs rather than any advantage in production efficiency. Within this data set, there is a subsample of 89 plants for which estimates of shipment transportation cost are available. A test of the importance of output shipment costs was made using this subsample. The coefficient for distance is virtually unaffected when output is alternatively defined as value added plus transport costs. This evidence suggests that the accessibility effect fundamentally does not reflect these shipment cost influences.

Second, the accessibility effect could possibly reflect spatial differences in labor quality. In the basic results, an attempt is made to control for high skilled labor inputs by including the ratio of administrative to total labor. However, labor input data are not adjusted for education. Therefore, productivity may be lower in outlying areas because of lower labor quality. This possibility has been checked by including a measure of average education in each industry for 50 subregions within Sao Paulo state. The variable is equal to: 3, if the average years of education is greater than 9; 2, if average years of education is between 6 and 9; 1, if average years of education is between 1 and 6; and 0, if less than one year of education. Average education does not have a significant effect, and other coefficients are virtually unchanged. Therefore, the hypothesis that the accessibility effect is due to labor quality differences can be rejected.

The third possible explanation for the accessibility effect is that some or all of the Hicks-neutral productivity advantages of plants in central areas is due to the existence of higher nominal wages in central areas than in outlying areas rather than to higher productivity <u>per se</u>. The analysis of spatial variation in wages in Sao Paulo state below does indicate that nominal wages are substantially higher in central areas. And, Hicks-neutral productivity is estimated here in terms of value added, which is composed of wages and salaries, interest, taxes, and profit. Therefore, one might suspect that some or all of the high accessibility coefficient is simply due to higher wages in central areas rather than higher levels of productivity <u>per se</u>. However, if product markets are reasonably efficient, that is, if output prices do not vary greatly within Sao Paulo state, this possibility can be discounted as follows. In order to be competitive, a firm that pays a high wage must either charge a high price for its output or reduce production costs such that the marginal revenue product of labor equals the marginal product of labor. If the firm faces a competitive market, then it is not possible to increase prices (except to the extent that the quality of products varies and product differentiation is possible). Therefore, high wages must be compensated for by cutting production costs. This can be accomplished in two ways: either by substituting capital and other inputs for labor or by exploiting agglomeration economies. Factor shares are controlled for in the production function framework; therefore, it would appear that the higher Hicks-neutral productivity in central areas is not a mirage of higher wages but rather is associated with the ability of plants there to exploit agglomeration economies.

As mentioned above, an effort was made to isolate the effect of distance for eight two-digit manufacturing sectors represented by plants in the sample. These industry results are now presented but it should be noted that in many sectors, the results are based on relatively small samples. Also, the present samples contain many different production processes within each broad industrial classification, and therefore cannot be expected to provide the same precision as studies that analyze detailed micro data describing identical production processes. Furthermore, when using data for individual plants, extreme values for different producing units do not cancel each other out within each observation as normally occurs in the more aggregated urban or regional area analyses when each datapoint averages the data from many different producing units. For these various reasons the industry results presented here are not especially precise and provide only a general indication of overall industry patterns.

Table 4.3 presents the estimates of the distance effect on productivity for individual industries. The coefficient for distance is negative for all of the eight industries. It is significant in two industries, transport and diverse, and is only slightly below significance in machinery. This is fairly strong evidence for agglomeration economies considering the limitations of the data. These limitations are shown by the fact that the well-established capital deepening effect is significant in only five of the eight industries examined. The plant size, white-collar percentage of the work force, and years in operation variables are less significant and more mixed in their effect in these industry results. Overall, the distance variable emerges fairly well from these industry results.

In order to analyze more extensively the productivity advantages in the metropolitan region, an effort is made to determine within the pooled industry data what specific agglomeration economies influences, in addition to that of distance to Sao Paulo City, have an effect on productivity. Three influences are examined: localization and urbanization economies; inter-industrial linkages; and intra-firm linkages.

The tests and results of these analyses are presented fully in Appendix A and are only briefly summarized here.

Inter-Industrial Linkages. The productivity advantages of central areas in Sao Paulo state may be in part due to the external economies that plants can achieve by locating in proximity to other producers that offer particularly important inter-industrial linkages. The influence of inter-industrial linkages on plant productivity in Sao Paulo state is examined using a fairly elaborate gravity model index of forward and backward linkages to

Table 4.3

The Effect of Distance to Sao Paulo City on Hicks-Neutral Productivity of New Manufacturing Plants in Sao Paulo State: Detailed Industry Results

Variables	Machinery	Electrical	Transport	Plastics	Textiles	Clothing	Food&Bev	Diverse
Constant	5.05	8.46	9.00	9.12	10.18	10.02	9.61	11.51
Ln (K/L)	.5951	.4227	.4461	.3910	.2481	.1068	.2219	.1915
	(5.30)*	(2.59)*	(2.52)*	(1.83)*	(1.08)	(0.96)	(0.98)	(1.92)*
Ln (L)	.1399	.0819	-.0511	-.1197	.3350	.2175	.1504	.0531
	(1.29)	(0.44)	(-0.29)	(-0.55)	(1.50)	(1.87)*	(0.57)	(0.38)
Ln (ADMIN)	.0156	.6150	-.2149	.3537	.4459	-.0703	-.0337	.2233
	(0.09)	(2.66)*	(-0.84)	(1.21)	(1.21)	(-0.51)	(-0.06)	(1.00)
Ln (DSP)	-.1499	-.0957	-.2961	-.0200	-.0266	-.0967	-.1741	-.2982
	(-1.54)	(-0.87)	(-2.16)*	(-0.13)	(-0.20)	(-1.35)	(-1.00)	(-2.93)*
Years in operation	.1604	.1684	-.2671	.1634	-.1757	.1677	.1685	.1172
	(1.42)	(1.52)	(-1.76)	(1.25)	(-1.07)	(1.45)	(0.75)	(0.89)
n	56	34	24	32	23	35	18	57
Adj. R^2	.396	.483	.297	.183	.172	.165	-.172	.119
Standard error of estimation	.782	.734	.674	.788	.777	.673	1.118	1.099

Source: Regressions based on equation (3).
t ratios in parentheses.

* Indicates significantly greater than zero at the 95 percent level.
(For DSP, a negative one-tailed test.)

production conducted in surrounding areas. However, despite their intricacy, these indices are fairly crude measures of inter-industry relationships within a local economy because they are constructed at the two-digit industrial sector level and use data from the national input-output table.

The measure of forward linkages showed some effect in the pooled data and this measure was found to be significant in only one industry in the detailed industry estimates. Overall, however, the results appear to indicate that inter-industrial linkages do not influence plant productivity within Sao Paulo state. The prevalence of GSP as a single major industrial complex suggests that Sao Paulo state is not a context in which strong inter-industrial effects can be expected in secondary centers. More substantial inter-industrial linkage effects could perhaps be detected in data for other countries as, for example, Korea, where development has relied more heavily on the formation of separate and distinct industrial complexes [Westphal, 1979].

Localization and Urbanization Economies. Behind the attempt to differentiate between localization and urbanization economies lies an important policy question. If productivity is enhanced by localization (own industry size) economies, then urban area specialization in particular traded goods is to be encouraged. On the other hand, if urbanization (city size) economies predominate, then this specialization may not matter since it is the general level of economic activity rather than its specific nature that enhances productivity of the firm [Henderson, 1982]. Furthermore, in terms of our main hypothesis regarding the trade-off between productivity and wages, it is expected that variations in wages are explained more by urban size than by the size of an industry in an urban area. This, coupled with the predominance of localization economies, would suggest that a firm could operate most competitively by locating in secondary cities and towns specialized in its industry.

To measure the influence of localization and urbanization economies on productivity in Sao Paulo state, proxies for these effects -- own industry size (IND) for localization economies and city size (POP) for urbanization economies -- are added to the basic equation. The results indicate that only urbanization economies have a significant positive effect on productivity (see Table A.3). However, when distance is included neither localization nor urbanization economies influences are significant. Due to the high correlation between distance and city size (r = -0.74), it is extremely difficult to isolate the two effects. Overall, these patterns suggest that distance is the dominant effect in the total sample, and to the limited extent that the data can reveal, urbanization economies appear more important than localization economies for manufacturing plants in Sao Paulo state. [8]

Intra-Firm Linkages. The flow of information and inputs between plants of a multiplant firm is an intra-firm linkage that can convey productivity advantages and reduce the need to exploit external economies. Pred [1975] has argued that much spatial diffusion now takes place within the boundaries of organizations, particularly large firms. If information availability is an important consideration in production, producers in remote

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8 Henderson [1982] examined the effect of industry and city size in the entire southeast region of Brazil using census data. He reported strong evidence of localization economies and no evidence of urbanization economies. The analysis of these effects in Sao Paulo State clearly indicates that the major agglomeration economies are associated with distance from the core of the metropolitan Sao Paulo. It is not surprising that distance from Sao Paulo is the major effect within the immediate Sao Paulo area, but that industry size or city size is more important within a broader range and variety of cities.

areas are handicapped because they do not have access to the necessary information. If, however, the producing unit in question is a subsidiary plant, and particularly a subsidiary plant of a large enterprise, then such an information deficit is much less likely to be important. The required information can simply be transferred within company channels from colleagues based in more centrally located areas; managers in the outlying areas are therefore much less hampered by their location. Similar reasoning applies in the case of foreign owned firms.

Within the sample of plants, it is possible to isolate those plants which are subsidiaries either because they are direct subsidiaries to other (domestic) firms or because they are branch plants to their own firm. A subsidiary plant is expected to have greater advantages than other single plant firms in the same location. In addition, the effect of intra-firm linkages of Brazilian subsidiary plants can be compared with the possible advantages of intra-firm linkages for foreign owned firms.

The results indicate that subsidiary plants are, on the average, 52 percent more productive than non-subsidiary plants located the same distance away from Sao Paulo City (see Table A.5). Similarly, the effect of foreign control is significant and extremely strong; a completely foreign controlled plant is 154 percent more productive than a completely domestically owned plant. [9] Although some part of the high subsidiary effect arises from the

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[9] Recall, however, that Tyler [1978] found positive foreign effects in a pooled sample, but much less of a foreign impact in individual industries. Part of the explanation for this extremely high foreign effect may be simply due to the possibility that foreign firms pay higher wages than domestic firms. If so, these higher wages are reflected in the value added per worker variable and contribute to Hicks-neutral productivity.

fact that subsidiaries are likely to have foreign ownership (that is, the subsidiary effect drops from 52 to 37 percent when the foreign ownership is included), little of the overall strong effect of foreign control can be attributed to the subsidiary effect. Overall, intra-firm linkages within a foreign owned firm seems to be more effective in its influences on productivity than Brazilian intra-firm linkage effects.

In evaluating alternative procedures for decentralization policy, it is of interest to see if the productivity advantages of subsidiary and foreign-owned plants hold both within and outside Grande Sao Paulo. The subsidiary plant effect is very large within the metropolitan area and insignificant outside the metropolitan area. Subsidiaries are therefore particularly useful in bringing information to non-central locations within the metropolitan area, but do not effectively convey information to the hinterlands. This suggests that information carried with a firm is most helpful when the recipient plant has access to at least some other sources of information and is not unduly isolated.

The foreign ownership effect, on the other hand, is very large and significant both within and outside the metropolitan area. This result implies that a decentralization policy that promotes the location of foreign owned plants in outlying areas may be particularly effective.

By taking stock of the various types of agglomeration economies by individual industries, it is possible to test partially the product cycle hypothesis. Recall from Chapters 2 and 3, this hypothesis states that agglomeration economies are more important for innovative industries than for mature industries. In summary form, Table 4.4 reports the sensitivity of sectoral productivity to agglomeration economies with sectors classified by

Table 4.4

Summary of Statistically Significant Influences on New Plant Productivity in Sao Paulo State by Industry

	Accessibility	Inter-Industrial Linkages		External Economies		Intra-Firm Linkages	
	DSP	BL	FI	Localization	Urbanization	Subsidiary	Foreign
Innovative Sectors							
Machinery			X	X	X		
Electrical					X		X
Plastics							
Diverse	X				X	X	X
Intermediate Sectors							
Transportation	X	X	X			X	
Mature Sectors							
Textiles							
Clothing							
Food & Bev.						X	X

product cycle stages. The eight manufacturing sectors included in the productivity analysis are fairly evenly represented in at least two of the three broad product cycle groups as classified in Chapter 3. In general, these agglomeration economies measures -- assessibility to the center of Sao Paulo, inter-industrial linkages, external economies, and intra-firm linkages -- were most frequently important for innovative sectors as expected. However, the results were not entirely unambiguous especially since the distance effect, a measure of overall agglomeration economies, was significant in only one out of four innovative sectors. The results, therefore, provide only weak support for the product cycle hypothesis. More support is provided, however, in that all the industries for which external economies effects have statistically significant influences on productivity, are innovative sectors.

In sum, this analysis of the spatial variation in Hicks-neutral productivity of new plants in Sao Paulo state suggests that substantial agglomeration effects exist -- that agglomeration economies have not petered out. New plants located close to the center of the metropolitan region have significantly higher productivity than plants located in more remote areas. These results are extremely robust. These central productivity advantages are not due to transportation cost effects, nor differences in labor quality, nor due to sectoral differences. However, it was not possible within our data to find very strong links between these central productivity advantages and other explicit measures of agglomeration economies -- that is, localization and urbanization economies or forward and backward linkages. Inter-firm linkages between plants in multi-plant firms, on the other hand, were shown to greatly enhance plant productivity. In particular, the results indicated that foreign owned plants are much more productive than domestically owned plants even in remote areas which suggests that a decentralization policy that promotes the location of foreign plants in outlying areas may be very effective. Whereas this section has established that plants in central areas have substantial productivity advantages, an important question must be addressed. Why, then, do any plants locate outside the metropolitan region? The next section considers the hypothesized labor cost advantages of outlying areas.

4.2 Spatial Variations in Manufacturing Wages in Sao Paulo

The preceding analysis has established that the central area of Grande Sao Paulo has substantial productivity advantages for new manufacturing plants. Whether new industry will locate in central areas, however, also depends on the extent of any off-setting disadvantages in the central areas such as higher wages and higher land costs. Generally, industry can be expected to locate in central areas when productivity advantages decline rapidly with distance to the center and wage and land price differentials between regions do not offset these differentials. Conversely, the decentralization of industry is to be expected when there are limited central production advantages, but high wage and land cost differentials exist between the central and outlying areas.

This section examines the spatial variation of manufacturing wages in Sao Paulo state and tests the hypothesis that wages fall with increasing distance from Grande Sao Paulo. This analysis of wages sets the stage for the section in which the trade-off between productivity and wage advantages for new plant location is assessed empirically.

A Simple Model of Wage Differentials [10]

Although the existence of wage differentials across cities and regions has long been observed in cross section data, the question of whether or not these differentials are a long run phenomenon or a short run distortion or adjustment process has not been established in empirical analysis (for example, Fuchs [1967], Scully [1969], Goldfarb and Yezer [1976], Holland [1976]). Theoretically, the persistence of money or nominal wage differentials can be explained by the existence of production advantages for firms in areas with high nominal wages. This is the result of the interaction of both supply and demand factors. On the labor supply side, workers locating in large urban areas are likely to face high living costs and high commuting costs as well as other urban disamenities and therefore these workers will demand high money wages which shifts the aggregate labor supply curve in. On the labor demand side, firms are in a position to pay high money wages in locations where there are offsetting locational advantages such as agglomeration economies which raise the productivity of all factors. The earlier sections of this chapter have already addressed locational advantages in production that are likely to influence the firm's demand for labor. We have established in GSP the importance of these agglomeration economies.

These demand and supply side interactions explain why we expect a negative wage gradient within Sao Paulo state with wages highest in the center

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10 In the formulation of this model and analysis of the data, I benefitted greatly from suggestions by Andrew Hamer and William Dillinger and their work in progress: Hamer and Dillinger [1983].

of Sao Paulo City and declining with distance from there. [11] In order to estimate a wage gradient we specify and estimate several equations using wage data from Brazilian 1980 social security files for a sample of workers from all manufacturing industries as well as for a sample of workers from each two-digit manufacturing sector. With the main focus on determining wage differentials between the metropolitan area and the rest of the state, the variable of principle interest is distance from Sao Paulo City. In the equations, we obviously want to control for labor characteristics, plant characteristics, cost of living differences, and urban disamenities. [12]

Specification of the Wage Gradient Equations

An equilibrium reduced form model in which wages are expected to vary by worker characteristics, plant size, cost of living, and distance to Sao Paulo City, takes the following form:

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[11] The wage gradient concept was initially introduced on the basis of commuting costs in a monocentric city. Moses (1962) argued that wages will tend to be higher in the CBD (where employment densities are relatively higher than residential densities) because workers attracted from a distance will need compensation for the costs and disutilities of commuting. In examining the relationship between wages and city size, Fuchs (1967) indicates that the higher commuting costs found in larger cities explain part of the association between high wages and large cities. In the context of Sao Paulo state a negative wage gradient can generally be expected. But some bumps in what would otherwise be a monotonically decreasing gradient are also expected, reflecting the high wages in some of the large cities outside the metropolitan area.

[12] The simplicity of this model overlooks several complexities that could affect the slope and shape of the wage gradient -- such as unionization, government favoritism toward specific sectors, firms or locations, monopsony or oligopsony behavior in setting wage levels, inertia and lack of information for either workers or firms (e.g., see Goldfarb and Yezer [1976]).

$$\text{Ln (WAGE)} = a + b\ \text{SEMI} + c\ \text{SKILLED} + d\ \text{TECH} + e\ \text{SUP} + f\ \text{AGE} + g\ \text{SEX} + h\ \text{EXP} + i\ \text{Ln (PS)} + j\ \text{Ln (POP)} + k\ \text{Ln (DSP)} \quad (2.1)$$

where: WAGE = wages in cruzeiros per hour in December 31, 1980;

SEMI = semi skilled labor dummy, 0 or 1;

SKILLED = skilled labor dummy, 0 or 1;

TECH = technical labor dummy, 0 or 1;

SUP = administrative labor dummy, 0 or 1;

AGE = age of worker classes, 0,1,2,3, or 4;

SEX = dummy variable (male = 0, female = 1);

EXP = years of continuous employment at the firm, classed 0,1,2,3,4;

PS = plant size, number of workers;

POP = 1980 city (municipio) population; and

DSP = road distance in kilometers from Sao Paulo City.

A logarithmic relationship between wages and city size and distance to Sao Paulo City is assumed. Worker characteristic variables serve primarily as control variables. The wage gradient equation is estimated for all sectors and for each manufacturing sector.

The Data

Data used to estimate wage gradients are from the 1980 Brazil social security files (Relacao Anual de Informacoes Socias -- RAIS). The coverage of the files, as legally defined, includes all employees of private businesses. It excludes the self-employed, public sector employees, domestic workers, and other workers outside the formal sector. For purposes of this study the universe was confined to employees in the manufacturing sector in Sao Paulo state. The initial sample was a one percent random drawing of employee records in the city of Sao Paulo, and a ten percent sample of employee records in the rest of the state.[13]

The RAIS data provides the following worker characteristics which are expected to be related to level of earnings:

skill level: classified by manual, semi-skilled, skilled, technical, and administrative;

education: classified by illiterate, literate but primary school (4 years) incomplete, primary school complete, secondary school (5-8 years) partial or complete, higher education;

sex;

age: classified by 0-20 years, 21-30 years, 31-40 years, 41-50 years, 50 or more years; and

experience: classified according to length of continuous employment at the firm: less than 1 year, 1-2 years, 2-3 years, 3-4 years, 4 or more years.

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[13] Preliminary analysis of the data revealed some systematic errors in coding. RAIS measures wages according to various units (hourly, weekly, monthly), and codes the unit of measure used on each record. After adjusting wages to a common unit of measure (hourly), a small proportion of extreme outliers were evident, whose magnitude suggested an error in coding the unit of measure. Criteria for exclusion of outliers (based on standard deviations) were tested. It was found that the number of outliers ceased to decline beyond 2.5 standard deviations from the mean (within the range tested). Records with wages over 2.5 standard deviations from the mean, accounting for approximately two percent of the sample, were therefore excluded from the sample data.

Higher skill level, greater education, and longer experience at the plant indicate higher labor quality and are expected to be positive influences on nominal wages. Age is also expected to have a positive impact on wages (to the extent that it represents length of experience in the occupation). Other things being equal, it is expected that males would be paid more than females due to well known discrimination in urban labor markets. In the equations, all variables except skill level are specified as continuous variables in estimation of the wage gradients.

Data on plant size are included in one set of equations. It is hypothesized that wages are positively correlated with plant size because large plants may have privileged access to capital, and greater susceptibility to minimum wage and similar legislation. [14]

Data on locational characteristics were used to control for cost of living differences. It is expected that living costs would increase significantly with city size. This is consistent with Thomas' [1982] findings that living costs, food costs in particular, in Grande Sao Paulo are roughly 60 percent higher than in other urban areas of the state, and twice as high as in rural areas. Hence, city size is used as a proxy for cost of living.

Results of Wage Gradient Estimations

Table 4.5 contains the results of estimating wage regressions for labor supply and demand within a pooled sample of 2008 workers from all 22 two-digit manufacturing sectors in Sao Paulo state. Three equations are

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[14] The correlation of plant size with wage levels is "an observed empirical regularity in desperate search of a theoretical explanation" (Goldfarb and Yezer, 1976, p.348). Also see Masters (1969) and Nelson (1973).

Table 4.5

Manufacturing Wages in Sao Paulo State in 1980

Results for Pooled Sample of Workers in all Manufacturing Sectors

	Dependent Variable	Constant	SEMI	SKILLED	TECH	SUP	AGE	SEX	EXP	Ln (PS)	Ln (DSP)	Ln (POP)	n	Adj. R^2	S.E.E.
(1)	log WAGE	4.45	.163	.436	1.007	1.674	.009	-.297	.032		-.226		2008	.405	.616
		(3.60)*	(3.97)*	(9.77)*	(17.96)*	(17.82)*	(5.80)*	(-8.50)*	(9.04)*		(-9.87)*				
(2)	log WAGE	2.69	.248	.505	1.116	1.762	.010	-.285	.031			.050	2021	.399	.637
		(14.59)*	(5.77)*	(10.83)*	(19.17)*	(20.09)*	(6.86)*	(-7.66)*	(9.03)*			(3.32)*			
(3)	log WAGE	3.59	.254	.498	1.030	1.753	.010	-.258	.023	.090	-.174		2021	.462	.602
		(25.36)*	(6.23)*	(11.29)*	(18.63)*	(21.11)*	(7.11)*	(-7.31)*	(6.83)*	(11.49)*	(-7.60)*				

Source: Regressions for (1) and (2) based on equation (2.1); regression for (2) based on equation (2.2).
*Indicates coefficient is significant at the 95 percent level.

estimated for this pooled data. The results of equation (3) show that semi-skilled workers offer their services for a wage about 29 percent ($e^{.25}-1$) higher than unskilled workers; skilled workers are about 65 percent more expensive than unskilled laborers; similarly, technical workers and administrative personnel demand wages roughly 180 and 477 percent higher than unskilled workers, respectively. Age and firm-specific experience have a positive influence on wages as expected. Other things equal, female laborers receive wage levels about 26 percent lower wages than males. The significant coefficient for Ln(POP) indicates that a one percent increase in city size is associated with .05 percent higher wages. The effect of prime interest, the coefficient of distance to Sao Paulo City, is negative and quite large; a one percent increase in distance from the center of the metropolitan region is associated with a 0.176 percent decline in wage levels.

Equation (3) is identical to equation (1) in Table 4.5 except that plant size is included. The estimated coefficients, for worker characteristics are essentially the same as those in equations (1) and (2). The results are consistent with the hypothesis that larger plants are associated with higher wage levels. Controlling for plant size, the effect of distance from Sao Paulo City is -0.17, or about 25 percent less than the coefficient when plant size is not included. Overall, this evidence suggest that, after controlling for worker characteristics and plant size, wages decline substantially with distance from the center of the metropolitan region.

Wage gradients are further examined in twenty individual industry regressions. Individual industry results are presented in Table 4.6. Again looking at the effect of primary interest, distance from Sao Paulo City, the

Table 4.6

Manufacturing Wages in Sao Paulo State in 1980: Individual Industry Results

Sector	CONSTANT	SEMI	SKILLED	TECH	SUP	AGE	SEX	EXP	Ln (PS)	Ln (DSP)	n	Adj. R^2	S.E.E.
Non Metallic Minerals	4.41	.733	.992	1.481	2.003	.006	-2.40	.018	.026	-.367	4027	.360	.806
	(34.72)*	(19.92)*	(23.01)*	(26.74)*	(26.01)*	(5.02)*	(-5.35)*	(6.03)	(3.56)*	(-16.55)*			
Metals	2.94	.209	.470	1.009	1.742	.012	-.197	.038	.088	-.034	4554	.584	.499
	(30.72)*	(9.14)*	(18.98)*	(35.16)*	(39.15)*	(14.43)*	(-7.41)*	(16.81)*	(20.23)*	(-2.19)*			
Machinery	3.72	.335	.563	1.126	1.974	.013	-.169	.025	.045	-.170	7662	.416	.596
	(48.31)*	(13.53)*	(22.64)*	(38.35)*	(45.72)*	(17.07)*	(-7.24)*	(13.71)*	(9.77)*	(-12.38)*			
Electrical	2.71	.351	.753	1.304	2.262	.006	-.072	.083	.043	-.017	2047	.260	1.152
	(7.51)*	(4.34)*	(9.34)*	(13.91)*	(16.86)*	(2.01)*	(-1.18)	(9.44)*	(1.93)*	(-.28)			
Transport	3.53	.196	.442	.879	1.722	.011	-.254	.035	.115	-.198	2430	.493	.532
	(19.66)*	(5.46)*	(11.40)*	(20.78)*	(24.56)*	(6.79)*	(-5.71)*	(11.91)*	(13.04)*	(-6.19)*			
Wood	3.42	.248	.474	.995	1.502	.006	-.154	.022	.071	-.125	1159	.530	.498
	(26.11)*	(7.88)*	(13.58)*	(19.59)*	(17.34)*	(4.65)*	(-4.38)*	(5.79)*	(11.13)*	(-5.21)*			
Furniture	2.69	.210	.356	.936	1.431	.009	-.131	.032	.152	-.054	754	.394	.540
	(14.16)*	(4.16)*	(6.42)*	(18.46)*	(12.28)*	(4.88)*	(-2.73)*	(5.28)*	(9.32)*	(1.71)*			
Paper	3.18	.161	.443	.939	1.654	.009	-.282	.021	.158	-.127	2116	.612	.430
	(26.04)*	(6.22)*	(14.70)*	(25.31)*	(24.26)*	(8.93)*	(-10.47)*	(8.97)*	(19.16)*	(-6.29)*			
Rubber	3.46	.216	.650	1.113	1.636	.014	-.215	.022	.115	-.179	808	.610	.455
	(26.21)*	(3.61)*	(10.46)*	(15.49)*	(15.74)*	(7.91)*	(-4.48)*	(4.45)*	(10.03)*	(-7.72)*			
Leather	2.75	.195	.335	1.288	1.265	.009	-.204	.021	.150	-.053	719	.545	.340
	(15.47)*	(4.18)*	(5.45)*	(13.89)*	(13.63)*	(6.49)*	(-6.92)*	(5.56)*	(14.77)*	(-2.02)			
Chemicals	4.27	.281	.533	.982	1.795	.007	-.319	.025	.052	-.226	3028	.583	.491
	(52.69)*	(11.42)*	(19.47)*	(32.23)*	(42.15)*	(7.02)*	(-12.76)*	(14.12)*	(8.54)*	(16.93)*			
Pharmaceuticals	4.27	.279	.602	.931	1.798	.012	-.197	.013	.082	-.276	816	.717	.381
	(16.15)*	(6.97)*	(14.12)*	(22.27)*	(28.54)*	(6.32)*	(-6.42)*	(2.71)*	(7.69)*	(-5.98)			
Perfume	3.34	.159	.375	.737	1.723	.010	-.110	.017	.150	-.121	444	.650	.390
	(6.77)*	(3.04)*	(6.97)*	(12.61)*	(18.01)*	(3.98)*	(-2.09)*	(4.08)*	(8.50)*	(-1.26)*			
Plastics	3.23	.010	.468	.859	1.773	.012	-.230	.056	.089	-.111	482	.380	.702
	(8.26)*	(1.02)	(4.99)*	(7.43)*	(10.40)*	(3.74)*	(-3.01)*	(3.74)*	(3.45)*	(-1.74)*			
Textiles	3.24	1.44	.590	1.127	1.745	.009	-.025	.012	.049	-.025	3990	.433	.469
	(34.47)*	(5.47)*	(19.19)*	(25.94)*	(23.92)*	(11.56)*	(-1.46)	(7.37)*	(8.96)*	(-1.46)			
Clothing	2.86	.283	.356	.851	1.628	.013	-.219	.026	.047	-.045	3811	.406	.415
	(37.50)*	(8.94)*	(10.77)*	(19.02)*	(23.77)*	(17.59)*	(-15.45)*	(10.51)*	(9.84)*	(-4.07)*			
Food	3.63	.040	.462	.874	1.593	.006	-.310	.014	.113	-.155	4548	.482	.526
	(49.71)*	(1.91)*	(20.06)*	(29.14)*	(38.44)*	(7.39)*	(-15.11)*	(9.61)*	(20.14)*	(-13.69)*			
Beverages	2.96	.224	.457	.870	1.356	.006	-.361	.020	.122	-.047	747	.432	.499
	(16.68)*	(4.50)*	(8.43)*	(12.41)*	(10.84)*	(3.09)*	(-5.16)*	(5.20)*	(8.01)*	(-1.54)			
Printing	3.28	.141	.332	.594	1.336	.007	-.121	.041	.029	-.055	206	.454	.517
	(8.71)*	(.90)	(2.35)*	(3.91)*	(7.13)*	(2.02)*	(-1.54)	(5.27)*	(1.03)	(-.98)			
Diverse	3.66	.243	.408	.867	1.835	.006	-.310	.036	.138	-.196	938	.560	.535
	(20.45)*	(5.45)*	(7.93)*	(12.20)*	(18.46)*	(3.09)*	(-7.39)*	(8.04)*	(14.02)*	(-5.89)*			

Source: Regressions based on Equation (2.2)
*Indicates coefficient is significant at the 95 percent level.

coefficient is negative for all twenty industries and significant in thirteen. Relatively small sample sizes are found in four of the seven industries where the coefficient for Ln(DSP) is not significant. The magnitude of these wage gradients varies considerably from sector to sector; these differences will be explored below in relation to sectoral productivity gradients. Nevertheless, the evidence indicates that manufacturing wages decline with distance from Sao Paulo City.

In this section, how much which wages decline with distance from Sao Paulo City has been measured. Within an equilibrium reduced form model, controlling for labor quality, industry chararacteristics including plant size and sector, and city size, wages are substantially higher in central areas than in outlying areas of Sao Paulo state. Using the results of this analysis with that of the productivity analysis, recent industrial location trends can be analyzed in terms of the trade-off between central productivity advantages and labor cost advantages of outlying areas.

4.3 The Trade-Off Between the Advantages and Disadvantages of a Central Location Within Sao Paulo State

If an industrialist has reasonably good information about alternative locations in which to establish a new plant, the preceeding analyses suggest that he should be attracted to central areas because of productivity advantages associated with agglomeration economies but that also he should be repulsed from central areas because of high labor costs. This section explores whether or not there is a trade-off between central productivity advantages and central labor and other cost disadvantages for new plants in Sao Paulo state. If productivity advantages are indeed offset by other costs disadvantages, then that trade-off would help to explain why all industry is not located in GSP: such a result would suggest that outlying areas provide competitive sites for production. On the other hand, if outlying areas are competitive locations, then why do the majority of new plants continue to locate in Grande Sao Paulo? One explanation is that plant managers are unaware of the competitiveness of production sites in outlying areas.

This section has two parts. First, the trade-off between productivity and wages is examined by comparing the results of the preceeding two sections. Then a model of industrial location is presented that estimates the influence of productivity, wage, and land price differentials on the choice of plant location in Sao Paulo state.

The Trade-Off Between Productivity and Wages

The most general way to measure the trade-off between productivity and wages is to compare the slope of the productivity and wage gradients over distance estimated for the pooled sample of all manufacturing sectors. Recall that the productivity gradient is the coefficient for distance from Sao Paulo City (Ln(DSP)) in the productivity analysis. The value of this coefficient ranges from about -0.11 to -0.17 depending upon the model specification (from Tables 4.1 and 4.2). The wage gradient is the coefficient for distance to Sao Paulo City (Ln(DSP)) in the wage analysis. It is -0.17 when plant size is controlled for and -0.23 when it is not (from Table 4.5). The roughly equal magnitude of these coefficients indicates that central productivity advantages are largely offset by central cost disadvantages as reflected in wage levels. This fairly even trade-off between productivity and wage gradients suggests that outlying areas offer competitive production sites.

Table 4.7 shows the productivity and wage gradients for individual manufacturing sectors as classified by product cycle stage (see Chapter 3). Table 4.7 also shows the Grande Sao Paulo share of new industrial jobs in the state as indicated in approved licenses for industrial investment issued by the state pollution central agency (CETESB) during 1977 to 1979. [15]

Direct comparison of the productivity and wage gradients in this way, however, offers only a crude picture of the forces influencing plant location in Sao Paulo state. To evaluate with greater precision the productivity-wage trade-off and its effect on plant location, we must also account for the relative importance of labor costs to total costs. For, though the productivity gradient fully reflects the decline in output per total inputs of distance from Sao Paulo City, the wage gradient does not reflect a directly comparable decline in production costs with distance. The rate at which an industry's production costs fall with distance depends not only on the wage gradient but on the share of labor in total costs. In other words, the rate at which costs decline over distance is equal to the wage gradient times the wage elasticity of costs, ceteris paribus.

Formally,

$$\frac{\partial C}{\partial DSP} = \frac{\partial w}{\partial DSP} \times \frac{\partial C}{\partial w}$$

where C is production costs, w is wages, and DSP is distance to Sao Paulo City. Varian [1978:15] has demonstrated that, using the Cobb-Douglas

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15 All companies have to obtain a license to invest in industrial plant, equipment and buildings and another license to start production. During 1977 to 1979, 8022 licenses were issued for plants to start production; 56.7 percent were in Grande Sao Paulo.

Table 4.7

Productivity Gradients and Wage Gradients for Manufacturing Industry in Sao Paulo State, 1980

	Productivity Gradient (1)		Wage Gradient (2)		Percent of New Industrial Jobs Planned in GSP 1977 - 1979 (3)
	Ln (DSP)	(t-stat)	Ln (DSP)	(t-stat)	
All Manufacturing	-.129	(-3.04)*	-.174	(-7.60)*	57
Innovative Sectors					
Machinery	-.150	(-1.54)	-.170	(-12.38)*	50
Electrical	-.096	(-0.87)	-.017	(-0.28)	67
Pharmaceutical	n.a.	n.a.	-.276	(-5.98)	48
Perfume	n.a.	n.a.	-.121	(-1.26)	70
Plastics	-.020	(-0.13)	-.111	(-1.74)*	85
Diverse	-.298	(-2.93)*	-.196	(-5.89)*	57
Intermediate Sectors					
Transport	-.296	(-2.16)*	-.198	(-6.19)*	38
Chemicals	n.a.	n.a.	-.226	(-16.93)*	65
Non-Metallic Minerals	n.a.	n.a.	-.367	(-16.55)*	48
Metals	n.a.	n.a.	-.034	(-2.19)*	72
Rubber	n.a.	n.a.	-.179	(-7.72)*	51
Paper	n.a.	n.a.	-.127	(-6.29)*	61
Printing	n.a.	n.a.	-.055	(-0.98)	74
Mature Sectors					
Textile	-.027	(-0.20)	-.025	(-1.46)	43
Clothing	-.097	(-1.35)	-.045	(-4.07)*	55
Food	-.174	(-1.00)	-.155	(-13.69)*	55
Beverages	-.174	(-1.00)	-.047	(-1.54)	18
Tobacco	n.a.	n.a.	n.a.	n.a.	37
Leather	n.a.	n.a.	-.053	(-2.02)*	46
Wood	n.a.	n.a.	-.125	(-5.21)*	52
Furniture	n.a.	n.a.	-.054	(-1.71)*	51

1/ Productivity gradients from Tables 4.1 and 4.3.
2/ Wage gradients from Tables 4.5 and 4.6.
3/ CETESB files of industrial establishments granted production licenses, 1977-1979.

n.a. - Not available.
* - Indicates coefficient is significantly lesser than zero at 95 percent level.

production function, the wage elasticity of costs is equal to the labor elasticity of output. Recall from equation (1) (p. 86) that the labor elasticity is simply coefficient c . Under conditions of non-constant returns to scale, the labor elasticity and the wage elasticity are adjusted slightly to equal c/b+c (using notation from equation (1)) [Varian, 1978]. From Tables 4.1 and 4.3, we can derive the labor elasticity for manufacturing industry in Sao Paulo state: the estimated coefficient for Ln(L) is equal to b+c - 1.0; b is the estimated coefficient for Ln(K/L); subtracting (b - 1.0) from the coefficient for Ln(L) gives c ; and c/b+c is both the labor elasticity of output and the wage elasticity of costs under increasing (or decreasing) returns to scale. It is possible, therefore, to calculate the rate at which costs decline with distance using the coefficient estimated in the productivity and wage analyses. Once a cost gradient is calculated, it can be compared directly with the productivity gradient to evaluate more accurately the locational implications of the productivity and wage trade-off. In this way, the influence on a firm´s profitability of the changes over distance from Sao Paulo City in productivity and in costs due to wages can be illustrated.

In Table 4.8, the productivity differential between a location in Sao Paulo City (calculated at DSP = 10 km.) and a location 200 km. from Sao Paulo City is calculated for five individual manufacturing sectors and for all manufacturing. These five sectors are chosen because the productivity gradients have a t-ratio equal to or greater than one (from Table 4.3). The differentials in wages between the two locations is similarly derived for these industries based upon the wage gradient estimates in Tables 4.5 and 4.6. The wage differential is weighted by the labor elasticity to reflect the

Table 4.8

Estimated Net Production Advantages of Plant Location at a Distance 200 Km. from Sao Paulo City in Contrast to Location in Sao Paulo City by Productivity and Wage Differences

	Productivity Index (Sao Paulo City = 100) [a]			Wage Index (Sao Paulo City = 100) [b]			Wage Elasticity [c]	Net Production Advantages (DSP=200)
	Sao Paulo (DSP=10 Km)	Non-GSP (DSP=200 Km)	Productivity Differential $\frac{(1)-(2)}{(1)}$	Sao Paulo (DSP=10 Km)	Non-GSP (DSP=200 Km)	Wage Differential $\frac{(4)-(5)}{(1)}$	$\frac{\partial C}{\partial w}$	Labor Cost Savings - Productivity Losses [(6) x (7) - (3)]
Industry	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
All Manufacturing	100	67.9	32.1	100	59.4	40.6	.722	-2.8
Machinery	100	63.8	36.2	100	60.1	39.9	.405	-20.0
Diverse	100	40.9	59.1	100	55.6	44.4	.809	-23.2
Transport	100	41.2	58.8	100	55.3	44.7	.554	-34.0
Clothing	100	74.8	25.2	100	87.4	12.6	.913	-13.7
Food	100	59.4	40.6	100	62.9	37.1	.778	-11.7

a Calculated from Tables 4.1 and 4.3.

b Calculated from Tables 4.5 and 4.6.

c Wage elasticity calculated from productivity equation (Tables 4.1 and 4.3) as described in text. Example: for all manufacturing, from Column (1) in Table 4.1, b+c - 1.0 = .1102 and b = .3083. The wage elasticity = c/b+c = .8019/(.3083 + .8019) = .7223.

cost savings a firm can attain because of the lower wages at a location 200 km. from Sao Paulo City. If the difference between the labor cost advantages and productivity disadvantages of a location 200 km. from Sao Paulo City vis-a-vis location in Sao Paulo City is positive, then the distant location offers a net production advantage. If that difference is negative, the central location is more advantageous.

The first row in Table 4.8 shows the productivity and wage differentials for aggregated manufacturing industries. The average manufacturing plant has 32.1 percent lower productivity at a location 200 km. from Sao Paulo City than in Sao Paulo City (DSP = 1), but other things being equal, has 29.3 (= 40.6 x 0.722) percent lower production costs at the more distant location owing to the lower cost labor. Thus, our calculations suggest that manufacturing plants with a central location have a slight net production advantage over plants in outlying areas. But, because the advantages of the central loction are slight, this result implies that, in aggregate, manufacturing plants face a nearly equal trade-off between the productivity advantages of central areas and labor cost advantages of outlying areas.

The estimates of net production advantage for central or non-central plant location is sensitive to our estimated wage elasticities (or labor shares). However, our estimated labor shares appear very reasonable because they conform closely to those estimated by Rocca [1970], about 0.8, and by Henderson [1982], about 0.75, in their production function estimations using Brazilian census data for 1960 and 1970, respectively.

The trade-off between central productivity advantages and outlying area labor cost advantages for the individual industries, however, suggests that plants would be notably better off if they located in central areas. Comparison of a location at 200 km. versus 10 km. from the center of Sao Paulo City shows that losses in productivity outweigh labor cost savings by anywhere between 11 percent and 34 percent. Our calculations of the productivity-wage trade-off for these individual industries, however, are not consistent with the extent to which new jobs in these sectors are decentralized (see Table 4.7). Over 40 percent of new jobs in these sectors is outside GSP. Although our calculations suggest that the transport sector, for instance, should be highly centralized, some 62 percent of new transport sector jobs lie outside GSP. Even if the labor share for the transport sector has been underestimated and is actually much higher, say 0.8, transport plants would still be better off locating in the center. For the individual sectors, more detailed analysis is required to resolve the apparent discrepancy between our calculations, which suggest that these industries should be centralizing, and the extent to which these industries are actually decentralizing.

Why is such a high proportion of manufacturing employment locating outside GSP? There must be some other forces that we have overlooked. Several possible explanations were assessed. First, the influence of government intervention into industrial location processes has already been discounted because of a lack of any major spatial incentives or regulations. Second, is it possible that plants in outlying areas are able to achieve greater labor cost savings than our calculations show because they use lower quality labor? In other words, plants may have to resort to a semi-skilled worker instead of a skilled worker in outlying areas due to the non-availability or high cost of skilled labor -- and so doing, their labor cost savings would be greater than what is reflected in our calculations. This possibility is rejected because the GSP-non GSP variation in the proportion of workers in different skill classes is slight.[16] Moreover, the ratios of wages for different skill classes of workers, for example, wages for semi-skilled workers to wages for skilled workers, do not differ between GSP and outside GSP in a way that is consistent with the possibility of a shift in labor use. In other words, plants do not appear to be shifting from higher quality to lower quality labor as they decentralize. Though we are still at a loss for explaining why such a high proportion of employment in certain industries is decentralizing, the lack of evidence to support a shift in labor use tends to reinforce the conclusions of the productivity analysis. If plants are not using lower qualty labor in outlying areas, then the productivity gradient reflects genuine declines in multifactor productivity rather than merely a decline in labor productivity.

Another explanation for the discrepancy between actual industrial location trends and our estimations lies in the possibility that since the wage gradients are derived in a cross-sectional analysis, they may reflect some short run distortions or adjustment processes in labor markets rather than long run equilibrium wage differentials. It is possible that wage gradients are underestimated but certain labor markets, particularly those in the "ring" region which surrounds GSP, were not in long run equilibrium in

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16 Hamer and Dillinger [1983] compare the distribution of labor force by skill category for GSP and the "ring cities" (consisting of the 30 cities with populations of over 50,000 in 1980, lying within 150 km. of GSP). GSP and the ring cities account for 64 and 22 percent of all manufacturing employes in the state, respectively. The percent of industrial labor force classified by labor skill category (manual, semi-skilled, skilled, technical, and administrative) differs by only a few percentage points between GSP and the ring cities.

1980. It is conceivable that in 1980 wage levels in the cities of the ring region have been bid up temporarily due to the increased demand for labor stemming from very rapid industrial growth, but they have not yet been counteracted by immigration attracted by the temporarily higher wage. If the labor markets of the ring region were in the process of adjustment with temporarily high wages, and other regions including GSP had equilibrium wages, one could argue that the long run wage gradient is steeper than the wage gradient estimated in our cross-sectional analysis.

Unfortunately, wage data for other years sufficient to test this proposition is unavailable. Nonetheless, this proposition, if substantiated, would mean that labor cost savings would increase the distance from Sao Paulo City more rapidly than what is estimated here, and would help to explain better the observed degree of industrial decentralization.

In sum, our calculation of estimated production advantages over space nonetheless offers a preliminary explanation about the influence of productivity and wage differentials over space on industrial decentralization. In the case of aggregated manufacturing, the evidence overall accords reasonably well with expectations about the trade-off between productivity and wages and the decentralization of new manufacturing employment. The productivity advantages of the metropolitan area are strong and exact a strong locational pull on many manufacturing activities. Conversely, wages constitute a countervailing force which provides a strong economic rationale for manufacturing activities to shift to outlying areas. For aggregated manufacturing, the high degree of decentralization is consistent with the roughly even productivity-wage trade-off. At the level of the individual industry, however, the evidence is fragmentary and more research is required to fully substantiate the hypothesis. Whereas the productivity and wage analyses have identified important market signals that affect location choice, the next section attempts to assess what factors, in fact, are important to industrialists in deciding where to put their plant.

Evaluating Productivity, Wage and Land Cost Differentials Using A Model of Industrial Location Choice

In this section, the trade-off between central productivity advantages and the labor cost advantages of outlying areas in Sao Paulo state is further explored using a model of industrial location. This modeling exercise is a way to cross-check the evidence of the preceeding section. Moreover, the model provides a quantitative basis to determine the factors influencing new plant location in Sao Paulo state. Specifically, it is possible, using the discrete choice methodology adopted, to determine the extent to which plant managers and proprietors are sensitive to, among other things, wage and productivity differentials between alternative locations in their choice of plant location.

As before, the hypothesis in question is that the central productivity advantages generally associated with agglomeration economies are offset to some degree by the factor cost disadvantages in central area, and therefore, that locations outside Metropolitan Sao Paulo provide competitive production sites for manufacturing plants owing to lower labor and land costs.

This analysis focuses on the choice of location for new branch plants (branches) and for plants that are relocating (transfers). [17] The location of branch and transfer plants is best described as a discrete choice problem in which the firm is deciding in which city or area it should establish its plant. This discrete choice behavior can be modelled using conditional logit: given that a firm has decided to establish a new branch plant or to relocate, where will it locate. The location choice is based on comparison of the characteristics of alternative sites. Both Carlton [1979] and Reif [1981] have demonstrated the potential of this methodology for analyzing the determinants of industrial location.

In this model of industrial location behavior in Sao Paulo state, a firm's choice of location is based on where it can earn the greatest profit. Profit in any city, i, can be expressed simply as a function of the factors that influence profitability in city i, X_i:

$$\pi_i = f(X_i) + \xi_i \qquad (3.1)$$

where π_i is profit in city i, and ξ_i is an error term.

In conditional logit analysis, the probability that a firm will choose to locate in city i is:

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[17] As Carlton [1979] has indicated, a model of location choice for new single establishment firms requires a specification different from that of branch and transfer plants because the number of new single establishment firms born in an area depends on both the number of local entrepreneurs capable of starting such a firm and the economic conditions of the area. For branch plants, the number of potential entrepreneurs in an area is not expected to be as crucial a determinanct of location, because multiplant firms typically relocate entrepreneurs after the most suitable location has been chosen. For branch plants, the choice of location is expected to depend on the economic climate of that area relative to the rest of other potential sites.

$$P_i = \frac{\exp F(X_i)}{\sum_j \exp F(X_j)} \quad (3.2)$$

if the error terms in equation (3.1) are independent across alternative locations, that is, $\xi_i \neq \xi_j$, and assumed to be identically distributed Weibull [McFadden, 1974].[18] In other words, the probability that a firm will choose to locate in any given urban area is a function of the profitability at that location relative to the profitability at all competing location.

A multiplicative specification for profits (equation (1)) is assumed such that:

$$\pi_i = F(X_i) = \sum_m \mathrm{Ln}(X_{im}) \beta_m \quad (3.3)$$

where X_{im} is the m^{th} factor influencing profitability in city i and β_m is the parameter to be estimated.

Substituting equation (3.3) into equation (3.2), the probability of choosing city i can be expressed as:

$$P_i = \frac{\exp [\sum_m \mathrm{Ln}(X_{im}) \beta_m]}{\sum_j \exp [\sum_m \mathrm{Ln}(X_{jm}) \beta_m]} \quad (3.4)$$

A maximum likelihood procedure is used to estimate the parameters, β_m's .[19]

In the determination of profitability in this model, production cost factors are given emphasis over revenue factors. It is assumed that output prices (f.o.b.) do not vary over space and that firms simply locate in

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18 The Weibull or extreme value distribution is similar to the normal distribution but is slightly skewed and has fatter tails.

19 The interested reader can refer to Appendix B for a detailed presentation of the derivation of the restricted profit function used to model profitability.

response to input price differentials over space. In this model, firms choose to locate their plant in one of two places: either inside Grande Sao Paulo or outside Grande Sao Paulo. The choice between these two locations is modelled in terms of three factors (locational characteristics) that influence profitability, or more correctly, that influence production costs. These characteristics of the location are: the wage rate, the price of industrial land, and total factor productivity. The way in which wage rates and land prices affect production costs in a location is relatively self-evident; however, total factor productivity deserves additional explanation. Total factor productivity (TFP) is an expression for the ratio of output per worker to inputs per worker. In terms of the earlier productivity analysis, total factor productivity is synonymous with Hicks-neutral productivity which essentially accounts for all factors, other than explicitly recognized inputs such as capital and labor, that influence output per worker. As emphasized so far in this study, agglomeration economies constitute an important component of total factor productivity. As such, a measure of total factor productivity, then, reflects the production cost savings associated with agglomeration economies. In this model of industrial location behavior, the difference in TFP between the two locations therefore represents an important production cost differential. The purpose of the model is to examine just how important this differential is, relative to other factors, in the choice of plant location.

The same sample of new manufacturing establishment that was used in the productivity analysis is used in this model of industrial location choice. The sample here consists of 244 plants (112 fewer plants than in the productivity analysis) since only branch and transfer plants are considered and new single plant firms (births) are excluded. Each of the 244 plants is an observation. The dependent variable in the model is simply a dummy variable that takes on the value of 1.0 if the plant located in GSP and 0.0 otherwise. The independent variables are the differences in wages, in land prices, and in total factor productivity that exist between GSP and locations outside GSP. The wage rate in each location is measured as the average monthly income in 1970 of workers in a particular two-digit manufacturing industry with 6-9 years of education in the city or metropolitan area. Data on 1980 prices for unserviced industrial land of similar quality for selected municipalities in Sao Paulo state are used to measure land cost differences. Locational differences in the total factor productivity of a plant are estimated using the parameters derived in the productivity analysis from Table 4.2. Total factor productivity is calculated as:

$$TFP = a = \frac{V/L}{(K/L)^{b} \, L^{b+c-1} \, ADMIN^{d} \, T^{e}} \qquad (3.5)$$

It is only possible to observe the TFP of the plant in its actual location. In order to determine the productivity differential, a measure of TFP for the plant in the alternative location is estimated. If the plant located in GSP, then the TFP that the plant would have attained at the non-GSP location is assumed to be equal to its actual TPF in Grande Sao Paulo discounted by the effect of accessibility, that is, discounted by the estimated parameter of distance (Ln DSP from Table 4.2). Conversely, if the plant actually located outside GSP, the TFP of the plant is derived for the GSP alternative by increasing the observed TFP in proportion to the estimated parameter of distance. Hence, the locational differential in the total factor productivity of a firm is simply related to the advantages of accessibility to Sao Paulo City.

The results of the logit model estimation are presented in Table 4.9. The coefficients of the variables can be interpreted as being proportional to the change in the probability that results from a one percent change in the independent variable.[20] A direct comparison between the sizes of the coefficients of different variables can reveal which factors exert the most influence on location choice.

Parameter estimates for the entire sample are shown in column (1). The results are partially contrary to expectations. The coefficient for productivity (TFP) is positive as expected and significant, however, the signs of the coefficients for both wages and land prices are the opposite of what was expected. The positive signs of the coefficients for wages and land prices suggest that an increase in the wage or land price differential between Grande Sao Paulo and outlying areas raises the probability of plant location in GSP, other things being equal. However, it is not very plausible, other things being equal, that a manager would decide to locate his plant where his

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[20] Note that the coefficient shown in the results is not an elasticity.

If $$P_i = \frac{\exp\left[\sum_m Ln(X_{im})\ \beta_m\right]}{\sum_j \exp\left[\sum_m Ln(X_{jm})\ \beta_m\right]}$$

then $$\frac{\partial P_i}{\partial\ Ln(X_{im})} = \frac{\partial P_i}{\partial X_{im}} \cdot X_{im} = \beta_m P_i (1 - P_i)$$

The elasticity of the probability of choosing alternative i with respect to any independent variable, X_{im}, is:

$$\eta_{im} \equiv \frac{\partial P_i}{\partial X_{im}} \cdot \frac{X_{im}}{P_i} = \beta_m (1 - P_i).$$

Table 4.9

Parameter Estimates of Factors Influencing the Probability of Plant Location in Metropolitan Sao Paulo

Variable	All Sectors	Innovative Sectors	Intermediate Sectors	Intermediate & Mature Sectors 1/
Ln(TFP)	7.173 (6.98)	6.857 (4.24)	12.86 (2.89)	7.14 (4.70)
Ln(WAGES)	1.016 (1.63)	2.247 (1.97)	-3.932 (-1.60)	-.4184 (-.45)
Ln(LAND)	.4541 (2.45)	.2727 (.93)	.7775 (1.76)	.6351 (2.31)
Constant	-2.986 (-5.09)	-2.722 (-2.97)	-2.021 (-1.82)	-2.913 (-3.48)
n	244	106	67	116
Percent Correctly Predicted	77.46	82.08	85.07	69.83
Likelihood Ratio Index	.426	.513	.461	.335

1/ A separate estimation for mature sector plants did not converge.

Source: Equation (3.4).

t-ratios in parentheses.

labor or land costs would be higher. Nevertheless, the results do indicate that productivity differentials exert a very strong influence on the probability of new plant location in GSP. Specifically, the coefficient for Ln(TFP) indicates that a one percent increase in the productivity differential between GSP and outlying areas increases the probability of location in GSP by 7.2 percentage points. Therefore, these results are consistent with the hypothesis that productivity differences exert the most significant influence on new location. The explanatory power of the model is quite strong. In logit analysis, a value for the likelihood ratio index -- roughly the equivalent of R^2 in OLS regression analysis -- which ranges between 0.2 and 0.4 is considered an extremely good fit [Hensher and Johnson 1981].

In view of the difficulties encountered by other studies attempting to distinguish between productivity and wages (for example, Hoch [1972], Moomaw [1980]), the fact that the results are not consistent with expectations is not a complete surprise. The result of positive coefficients for all three independent variables can be understood since productivity, wages, and land prices are all high in GSP and all low in outlying areas and since the majority of new plants did locate in GSP. It is also conceivable that the result of positive coefficients for wages and land prices is due to an omitted variables problem. In fact, it is quite likely that the variation in wages and land prices is correlated with other factors, not included in the model, that are favorable to a GSP location. Another explanation consistent with the results is that wage and land price "bargains" exists in outlying areas that more than compensate for central productivity advantages, but plant managers are not aware of them. Locational search costs may be such that only the most cursory review of location alternative is undertaken by many firms. Other research suggests that firms in Sao Paulo state commonly use very limited search procedures (Townroe [1981] and Hamer [1982]).

Another set of estimations are conducted in order to examine the hypothesis that, in their choice of location, plants in innovative sectors are more sensitive than plants in intermediate and mature sectors to locational differentials in productivity (for example, agglomeration economies) and vice-versa to diffentials in wage and land prices Columns (2) through (4) in Table 4.9 present the parameter estimates of subsamples of plants by product cycle group. The signs of the coefficients for the innovative sector plants (Column (2)) are all positive but the coefficients for wages is not significant. Productivity again exerts the greatest influence on plant location. Columns (3) and (4) show the results for plants in intermediate sectors and in intermediate and mature sectors (separate estimation of a mature sectors subsample did not achieve convergence). In both cases, the sign of the coefficient for wages is negative. Although the coefficient is subject to wide confidence intervals, the negative sign suggests that wage differentials may influence choice of location by plants in non-innovative sectors in a way consistent with expectations. That is, other things being equal, these non-innovative sector plants will locate where wage rates are lower. The coefficent for land prices remains positive in both cases. Overall, in spite of the result that productivity remains the dominant influence on location choice regardless of sectoral grouping, the intermediate and mature sector plants appear to be more likely to choose a non-GSP location on the basis of labor cost differentials than innovative sector plants. This result therefore offers some support to the hypothesis.

Summary

The purpose of this chapter was to examine the forces underlying recent industrial decentralization in Sao Paulo state in somewhat greater detail than was possible in Chapter 3 with census data. In particular, I wanted to examine whether the trend of industrial decentralization was occurring because agglomeration economies of the metropolitan area were petering out or because the differential in factor prices between Grande Sao Paulo and the outlying areas was making the outying areas competitive. This objective was accomplished by analyzing spatial variations in the productivity of new manufacturing plants in the state and by measuring manufacturing wage differentials across the state.

The result of the productivity analysis demonstrated that the Metropolitan region still has substantial agglomeration economies which enhance the productivity of plants located there. After controlling for numerous factors -- including capital intensity, internal economies of scale, education and skill of the labor force, transportion costs, and sector -- the results indicate that plant productivity is much greater for plants located close to Sao Paulo City. In fact, a doubling of distance from the center of the metropolitan region is associated with an 8.9 percent decline in productivity. Therefore, with this result, the hypothesis that GSP´s agglomeration economies have petered out can be rejected.

As to the existence of factor price advantages in outlying areas, the results of the wage analysis indicated that wages decline very rapidly with distance from the center of the metropolitan area. For manufacturing industry in aggregate, a doubling of distance from Sao Paulo City is associated with a

12.1 percent decline in wage levels. This result suggests that labor, controlled for various worker characteristics, is substantially cheaper outside the metropolitan region. A firm's costs will decline with distance in proportion to the wage gradient times the wage elasticity of costs. Therefore, in the case of all manufacturing, a doubling of distance from Sao Paulo City is associated with an 8.7 percent decline in costs [12.1 x .722].

Comparison of the decline in productivity and decline in costs associated with a doubling of distance from Sao Paulo shows that a fairly even trade-off exists between the productivity disadvantages and wage advantages of plant location outside GSP. This trade-off, though not as balanced in individual industries as in aggregate manufacturing, helps to explain the recent trends of industrial decentralization.

Finally, we examined how much these spatial differences in productivity, wages and land prices have actually influenced location decisions of new manufacturing plants in Sao Paulo state. The results of this logit modeling exercise indicated that entrepreneurs are most sensitive to productivity differentials. In other words, the productivity differential between GSP and the rest of the state had the strongest influence on where industrialists locate their plant. Finally, manufacturing sectors classified by product cycle stage as mature or intermediate sectors appear to be more sensitive to spatial differences in wages than innovative sectors. The policy implications of these findings are discussed in the following chapter.

Appendix A to Chapter 4

MEASUREMENT OF THE INFLUENCE OF AGGLOMERATION ECONOMIES ON NEW PLANT PRODUCTIVITY IN SAO PAULO STATE

The productivity analysis in Chapter 4 has established that new manufacturing plants close to Sao Paulo City have higher Hicks-neutral productivity than plants located further away. It is suspected that the productivity advantages of central areas are due to agglomeration economies, since numerous other factors potentially responsible for higher plant productivity in central areas -- such as capital intensity, plant size, company size, high quality labor inputs, product mix, and transport costs -- are controlled for. In view of both the academic and policy interest in measuring these economies, an effort is made here to determine what specific agglomeration economies effects, in addition to that of "accessibility" to Sao Paulo City, influence new plant productivity. Using the production function framework introduced in Chapter 4, three influences are examined: inter-industrial linkages; localization and urbanization economies; and intra-firm linkages.

Inter-Industrial Linkages

The analysis thus far has established that manufacturing sites near Sao Paulo City offer significant productivity advantages. However, the need to locate close to the metropolitan center may be offset somewhat if a peripheral center specializes in specific industries which offer particularly important inter-industrial linkages. Inter-industry relationships influence the extent to which industries can benefit from external economies. For example, vertically related industries can reduce transport and communications costs by locating in proximity to each other.

The influence of inter-industrial linkages on plant productivity is explored using measures which show the extent to which each new plant is surrounded by production in industries related through input-output linkages. The geographical dimension of these linkages is examined through two gravity model indices: one measures backward linkages to nearby suppliers and the other forward linkages to nearby customers. The backward linkage index for a firm in industry j in city n, BL_j^n is constructed up from a measure of the relevant linkages within any particular city. For each potential input supplied by industry i to industry j, a calculatation is made of the importance of that industry as a supplier, $a_{ij}/\sum_i a_{ij}$, and normalized by the national importance of that specific industry $(VA_i^{BR}/\sum_i VA_i^{BR})$. Similarly, the importance of each industry in another nearby city, m, $VA_i^m/\sum_i VA_i^m$ is found and again compared with the national importance of the industry $(VA_i^{BR}/\sum_i VA_i^{BR})$. [1]

If industries which are relatively important suppliers to a given industry (as shown by the input-output coefficients) also tend to be important producers in nearby cities, then the first term within the brackets in equation (1), below, will tend to be high when the second term is also unusually high. The stronger the relationship between an important supplying industry and an unusually high nearby concentration of this industry, the more this interaction between these bracketed terms will contribute to the size of the final index. On the other hand, if there are no particularly important supplying industries, in the sense that purchases from each industry reflect only its role in the national economy (that is, the ratio of sectoral value

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1 Townroe and Roberts (1980) and Reif (1981) develop similar gravity model indices to measure inter-industrial linkages.

added to total national value added), and if there is no particular concentration of related industries, in the sense that nearby industry reflects only the national distribution of industry, then the concept within the inner brackets will tend to take on the value of one.

Subsequently, after the potential linkage index is calculated over all supplying industries i for each of the m surrounding cities the overall linkage index for a plant in city n is calculated as the weighted sum of industry linkages obtainable from all m cities surrounding a site. In each instance, the relevant support from all cities is defined as the sum of values of the relevant industry linkage index within each city multiplied by the total amount of industry in that city discounted by an impedence factor which reflects the distance from that city to the site of production.

Formally,

$$BL_j^n = \sum_m \sum_i \left\{ \frac{a_{ij}}{\sum_i a_{ij}} \left[\frac{\dfrac{a_{ij}}{\sum_i a_{ij}}}{\dfrac{VA_i^{BR}}{\sum_i VA_i^{BR}}} \quad \frac{\dfrac{VA_i^m}{\sum_i VA_i^m}}{\dfrac{VA_i^{BR}}{\sum_i VA_i^{BR}}} \right] \cdot VA_i^m \cdot e^{-\delta D^{mn}} \right\} \qquad (1)$$

where: BL_j^n is the backward linkage index for industry j in city n,

a_{ij} is the (input-output) technical coefficient of sector j's purchases from sector i per unit of sector j output (from the 1970 Brazil Input-Output Table [IBGE 1977].

VA_i^m is the 1975 value added in 2-digit sector i in city m.

VA_i^{BR} is the 1975 value added in 2-digit sector i in Brazil.

D^{mn} is the straight line distance in km. between city m and city n.

δ is the transfer cost exponent. δ is assumed to be one in the basic empirical work. [2]

The forward linkage index (FL) is parallel to the backward linkages concept. It measures the extent to which customers for sector i's output are located nearby within the local economy. The forward and backward linkage indices are calculated for all 2-digit manufacturing sectors present in each of Sao Paulo state's 581 city-counties (municipios).

The forward and backward linkage indices developed above are fairly crude measures of interindustry relationships within a local economy and cannot be expected to be particularly precise. First, the indices are constructed at the two-digit industrial sector level, which may reduce the accuracy of the indices. Second, the input coefficients are from the 1970 Brazilian Input-Output table and therefore may not reflect the particular industrial flows within Sao Paulo state. Therefore, these indices may not show the full contribution in a subregional context.

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2 Hay (1979, p.111) estimated gravity model distance coefficients for Brazilian two-digit industries in 1939 and 1962 from interregional trade data. Hay's 1962 values were generally fairly close to one. Linkage indices were also determined using Hay's gravity coefficients as well as various extrapolations designed to bring these estimated up to date for 1980. These alternative values never improved the basic results of the linkage index with the gravity coefficient set equal to one.

Nonetheless, in order to test the effects of backward and forward linkages on plant productivity, these variables are added to equation (3) in Chapter 4 so that,

$$\text{Ln }(V/L) = \text{Ln } a + b \text{ Ln }(K/L) + (b+c-1.0) \text{ Ln }(L) + d \text{ Ln }(ADMIN) + e \text{ Ln } BL \text{ (or } FL) \qquad (2)$$

where e is expected to be positive for BL (or FL) reflecting the advantages of production within an industrial complex.

Table A.1 presents empirical results for the inter-industrial linkage measures. Columns (1) and (2) show that the coefficients for both the backward and forward linkages are positive and insignificant. When the distance variable, DSP, is included in columns (4) and (5) neither linkage effect is significant. These results imply that in Sao Paulo state industrial complex effects, to the extent that they exist at all, are subsumed within central agglomeration economies, as measured by distance to the center of Sao Paulo City; and it is not possible to detect forward and backward linkage effects within this data.

When the inter-industrial linkage effects are tested separately for plants within Grande Sao Paulo and for plants outside GSP, they appear substantially stronger for plants within GSP as shown in columns (7) through (10).

Table A.2 shows the industry estimates of the effect of inter-industrial linkages on productivity. The backward linkage measure is positive and significant in one industry while the forward linkage measure is significant in two industries. These results are presented in the first two

Table A.1

The Effect of Interindustrial Linkages on Hick-Neutral Productivity
of New Manufacturing Plants in Sao Paulo State

Equation -->	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable								
Constant	8.32	8.09	9.68	9.55	8.85	7.41	8.58	8.93
Ln (K/L)	.3066 (6.05)*	.3065 (6.08)*	.3048 (6.09)*	.3072 (6.15)*	.3237 (4.39)*	.3406 (4.70)*	.2789 (3.80)*	.2781 (3.79)*
Ln (L)	.1230 2.12)*	.1206 (2.09)*	.1146 (2.00)*	.1120 (1.96)*	.1075 (1.46)	.0990 (1.36)	.1535 (1.59)	.1603 (1.67)*
Ln (ADMIN)	.2240 (2.74)*	.2164 (2.64)*	.2028 (2.50)*	.2035 (2.50)*	.2567 (2.50)*	.2500 (2.44)*	.1541 (1.11)	.1651 (1.19)
Ln (DSP)			-.1491 (-3.03)*	-.1486 (-2.76)*				
YROP	.1526 (3.00)*	.1473 (2.84)*	.1545 (3.01)*	.1592 (3.09)*	.1596 (2.53)*	.1540 (2.45)*	.1531 (1.66)*	.1548 (1.68)*
Ln (BL)	.0636 (.82)		-.0713 (-.80)		-.0254 (-.15)		.0119 (.11)	
Ln (FL)		.0409 (1.38)		-.0218 (-.59)		.0674 (1.35)		-.0199 (-.42)
n	356	356	356	356	223 (GSP)	223 (GSP)	133 (Non-GSP)	133 (Non-GSP)
Adj. R^2	.156	.159	.176	.175	.147	.154	.140	.141
Standard error of estimation	1.075	1.073	1.062	1.063	1.050	1.046	1.120	1.119

Source: Regressions based on equation (5) in Chapter 4.
t ratios in parentheses.

* Indicates significantly greater than zero at the 95 percent level; for DSP, a negative one-tail test.

Table A.2

The Effect of Inter-Industrial linkages on Hicks-Neutral Productivity of New Manufacturing Plants in Sao Paulo State: Summary Results for Eight Sectors 1/

	Machinery	Electrical	Transport	Plastics	Textiles	Clothing	Food & Bev.	Diverse
Ln (BL)	.7003	-.0129	.9979	-.0306	-.2033	-.1776	1.0396	.3757
	(1.23)	(-.03)	(2.15)*	(-.07)	(-1.24)	(-1.41)	(1.24)	(1.51)
Ln (FL)	.1923	.1053	.2221	-.0262	-.0645	-.0590	.2583	.1648
	(1.75)*	(1.13)	(2.22)*	(-.17)	(-1.19)	(-1.15)	(1.05)	(1.55)
Ln (BL)	.2074	-.6423	.5495	.0263	-.2455	-.2585	.8692	-.2322
	(.27)	(-1.09)	(.72)	(.38)	(-1.37)	(-2.39)+	(.71)	(-.69)
Ln (DSP)	-.1259	-.2371	-.1681	.0264	-.0945	-.2096	-.0496	-.3695
	(-.95)	(-1.39)	(-.74)	(.11)	(-.67)	(-2.57)*	(-.20)	(-2.54)*
Ln (FL)	.1421	.1919	.1341	-.0354	-.0921	-.0965	.1697	-.0673
	(.95)	(.80)	(.69)	(-.13)	(-1.49)	(-2.18)*	(.51)	(-.49)
Ln (DSP)	-.0654	.1105	-.1406	-.0115	-.1359	-.2043	-.0968	-.3449
	(-.50)	(.40)	(-.53)	(-.04)	(-.91)	(-2.45)*	(-.41)	(-2.46)*

1/ These regressions are based on equation (2). However, only the coefficients and t-statistics for the forward and backward linkage indices and for distance are reported here.

Source: Regressions based on equation (2).
t-ratios in parentheses.

* Indicates significantly greater than zero at the 95 percent level; for DSP, a negative one-tail test.
\+ Judged to be insignificant because of wrong sign.

rows in Table A.2. However, as shown in the remaining rows, when distance is included, the backward and forward linkage effects are not significantly greater than zero in any industries. In general, these results imply that in Sao Paulo state, inter-industrial linkages are overshadowed by overall agglomeration economies, as measured by distance to the center of Sao Paulo City, and are probably stronger nearer the center.

Overall, these results indicate that outside the metropolitan core, inter-industrial linkages are not great enough to confer substantial production advantages. The effect of inter-industrial linkages in the periphery of the state is probably swamped by inter-industrial flows to and from GSP. The prevalence of GSP as a single major industrial complex suggests that the state of Sao Paulo is not a context in which strong inter-industrial linkage effects can be expected in secondary centers. More substantial inter-industrial linkage effects on plant productivity could perhaps be detected in data for other countries as, for example, Korea, where development has relied more heavily on the formation of separate and distinct industrial complexes [Westphal, 1979].

Localization and Urbanization Economies

A further attempt is made to examine the influence of agglomeration economies on manufacturing productivity by measuring the effect of localization and urbanization economies. To do this, proxies for the two external economies are simply added to the basic equation. Since localization economies are defined as the cost savings accruing to firms with a single industry in a single area, they can be measured by total employment (or output) in that industry in that urban area. Hence, 1975 industry employment (IND) in the same industry and urban area as the observed plant constitutes the measure of localization economies. Urbanization economies defined as the cost savings possible in large cities that accrue more generally to all firms are measured by population size of an urban area. The 1980 population size (POP) of the urban area of the observed plant is used as a measure for urbanization economies.

Table A.3 shows results when such concepts are added to the basic equation. As shown in colums (1) and (2), only the city size effect is significant. However, when distance is included neither effect is significant (columns (3) and (4)). In the complete sample, city size and distance are strongly correlated (r = -.74) so it is relatively difficult to isolate the two effects. Nonetheless, the results suggest that, again, distance is the dominant effect. The results for subsample of plants within GSP (column (5)) indicate that urbanization economies influence Hicks-neutral productivity only within GSP; the city size effect for the subsample of plants outside GSP is insignificant and is not reported.

The estimates of the influence of localization and urbanization economies on individual sector productivity are presented in Table A.4. In the absence of the distance variable, localization economies and urbanization economies appear to influence productivity in one and three sectors respectively. When distance is included, localization economies are significant for one sector, machinery, and urbanization economies in none (although the coefficient is only slightly below significance for machinery and electrical). These results suggest that localization and urbanization economies are probably greater closer in to the center of the metropolitan region. Overall, these patterns suggest that distance is the dominant effect in the total sample, and, to the extent that the data can reveal, urbanization

Table A.3

The Effect of Industry Size and Population Size on Hicks-Neutral Productivity of New Manufacturing Plants in Sao Paulo State

Equation -->	(1)	(2)	(3)	(4)	(5)
Variable					
Constant	8.41	7.73	9.58	8.94	7.67
Ln (K/L)	.3040 (6.04)*	.3128 (6.21)*	.3091 (6.19)*	.3096 (6.17)*	.3399 (4.73)*
Ln (L)	.1248 (2.18)*	.1167 (2.03)*	.1081 (1.89)*	.1094 (1.91)*	.0921 (1.26)
Ln (ADMIN)	.2219 (2.72)*	.2043 (2.49)*	.1978 (2.44)*	.1985 (2.43)*	.2353 (2.29)*
Ln (DSP)			-.1744 (-2.77)*	-.1202 (-2.22)*	
YROP	.1522 (2.94)*	.1494 (2.90)*	.1570 (3.06)*	.1564 (3.04)*	.1567 (2.50)*
Ln (IND)	.0339 (1.56)		-.0311 (-0.98)		
Ln (POP)		.0709 (2.08)*		.0116 (0.27)	.0639 (1.67)*
n	356	356	356	356	233 (GSP)
Adj. R^2	.160	.165	.176	.174	.158
Standard error of estimation	1.072	1.069	1.062	1.063	1.043

Source: Regression based on equation (3) in Chapter 4 with terms added for (IND) and (POP).

t-ratios in parentheses.

* Indicates significantly greater than zero at a 95 percent level. For DSP, a negative one-tailed test.

Table A.4

The Effect of Industry Size and Population Size on Hicks-Neutral Productivity of New Manufacturing Plants in Sao Paulo State: Summary Results for Eight Sectors 1/

	Machinery	Electrical	Transport	Plastics	Textiles	Clothing	Food & Bev.	Diverse
Ln (Industry Size)	.1262	.0101	.1067	.0089	-.0170	-.0477	.0602	.0650
	(2.40)*	(.20)	(1.10)	(.18)	(-.24)	(-.81)	(.57)	(1.02)
Ln (Population Size)	.1552	.1067	.1291	-.0554	.0143	.0454	.1203	.2518
	(2.18)*	(1.67)*	(1.19)	(-.58)	(.16)	(.53)	(.88)	(2.75)*
Ln (Industry Size)	.1808	-.0533	-.2613	-.0088	-.0355	-.0688	-.0474	-.3031
	(1.92)*	(-.69)	(-1.47)	(-.12)	(-.41)	(-1.26)	(-.28)	(-2.85)+
Ln (DSP)	.1180	-.1851	-.6450	.0001	-.0647	-.1661	-.2372	-.7379
	(.70)	(-1.09)	(-2.37)*	(.00)	(-.39)	(-1.85)*	(-.82)	(-4.07)*
Ln (Population Size)	.1354	.1566	.0040	-.0712	.0005	-.0133	.0344	.1396
	(1.55)	(1.52)	(.03)	(-.61)	(1.49)	(-.13)	(.15)	(1.20)
Ln (DSP)	-.0461	.1068	-.2929	-.0457	-.0260	-.1088	-.1388	.1996
	(-.39)	(.62)	(-1.69)*	(-.24)	(-.11)	(-.93)	(-.46)	(1.53)

1/ These regressions are based on equation (3) in Chapter 4. However, only the coefficients and t-statistics for the industry and population size variables and for distance are reported here.

Source: Regressions based on equation (3) in Chapter 4.
t-ratios in parentheses.

* Indicates significantly greater than zero at the 95 percent level; for DSP, a negative one-tail test.
\+ Judged to be insignificant because of wrong sign.

economies appear more important than localization economies for manufacturing plants in Sao Paulo state.

Intra-Firm Linkages

The flow of information and inputs between plants of a multiplant firm is an intra-firm linkage that can convey productivity advantages and reduce the need to exploit external economies. Pred [1975] has argued that much spatial diffusion now takes place within the boundaries of organizations, particularly large firms. If information availability is an important consideration in production, producers in remote areas are handicapped because they do not have access to the necessary information. If, however, the producing unit in question is a subsidiary plant, and particularly a subsidiary plant of a large enterprise, then such an information deficit is much less likely to be important. The required information can simply be transferred within company channels from colleagues based in more centrally located areas; managers in the outlying areas are therefore much less hampered by their location. Similar reasoning applies in the case of foreign owned firms.

Within the sample of plants, it is possible to isolate those plants which are subsidiaries either because they are direct subsidiaries to other (domestic) firms or because they are branch plants to their own firm. A subsidiary plant is expected to have greater advantages than other single plant firms in the same location. Therefore, the subsidiary plant effect is estimated, controlling for distance from the center. In the formulation adopted the dummy variable, SUBSIDIARY, takes on the value 1.0 if an establishment is a subsidiary plant and 0.0 otherwise.

$$\text{Ln }(V/L) = \text{Ln } a + b \text{ Ln }(K/L) + (b+c-1.0) \text{ Ln }(L)$$
$$+ d \text{ Ln }(\text{ADMIN}) + e \text{ Ln }(\text{DSP}) + f \text{ YROP} + g \text{ SUBSIDIARY} \qquad (3)$$

The effect of intra-firm linkages of Brazilian subsidiary plants can be compared with the possible advantages of intra-firm linkages for foreign owned firms. Foreign ownership is measured by the percentage of firm assets that are foreign owned. This is expressed as a continuous variable, FOREIGN, ranging from 0.0 to 1.00, rather than as a dummy variable.

Table A.5 presents empirical results for the subsidiary plant and foreign ownership variables. Column (1) shows that subsidiary plants are on the average 52 percent ($e^{.4201} - 1$) more productive than non-subsidiary plants located in similar areas. Inclusion of Hicks-neutral dummies or industry dummy interactions with capital intensity does not alter these estimates. This evidence suggests that subsidiary plant operation offers substantial productivity advantages to new plants.

Column (2) adds percent of foreign control to column (1). The effect of foreign control is significant and extremely strong; a completely foreign controlled firm is 154 percent ($e^{.9321} -1$) more productive than a completely domestically owned firm. [3] The subsidiary coefficient declines from .4201 in column (1) to .3126 in column (2), so

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3 Recall, however, that Tyler [1978] found positive foreign effects in a pooled sample, but much less of a foeign impact in individual industries. Part of the explanation for this extremely high foreign effect may be simply due to the possibility that foreign firms pay higher wages than domestic firms. If so, these higher wages are reflected in the value added per worker variable and contribute to Hicks-neutral productivity.

Table A.5

The Effect of Subsidiary and Foreign Owned Status
on Hicks-Neutral Productivity of New Manufacturing Plants in Sao Paulo State

Equations -->	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variable							
Constant	9.40	9.76	9.60	9.05	10.37	9.29	10.45
Ln (K/L)	.2883 (5.79)*	.2469 (5.02)*	.2579 (5.24)*	.3094 (4.35)*	.2818 (3.86)*	.2932 (4.13)*	.2242 (3.09)*
Ln (L)	.0751 (1.30)	.0319 (0.56)	.0537 (0.95)	.0802 (1.12)	.0958 (.92)	.0388 (.54)	.0705 (.75)
Ln (ADMIN)	.1957 (2.44)*	.0734 (0.89)	.0669 (0.81)	.2228 (2.21)*	.1238 (.91)	.1098 (1.04)	.0011 (.01)
Ln (DSP)	-.1238 (-2.94)*	-.1194 (-2.92)*	-.1229 (-2.99)*	-.1031 (1.04)	-.3284 (-2.12)*	-.1266 (-1.30)	-.2484 (-1.65)*
YROP	.1681 (3.31)*	.1753 (3.54)*	.1679 (3.38)*	.1694 (2.75)*	.1668 (1.83)*	.1659 (2.72)*	.1746 (2.00)*
Subsidiary	.4201 (3.00)*	.3126 (2.27)*		.5620 (3.31)*	.0792 (.30)		
Foreign		.9321 (4.61)*	1.0091 (5.05)*			.9305 (3.80)*	1.1008 (3.09)*
n	356	356	356	223 (GSP)	133 (Non-GSP)	233 (GSP)	133 (Non-GSP)
Adj. R^2	.195	.239	.230	.191	.165	.204	.223
Standard error of estimation	1.050	1.020	1.026	1.022	1.104	1.015	1.065

Source: Regressions based on equation (6) in Chapter 4.
t ratios in parentheses.

* Indicates significantly greater than zero at the 95 percent level. (Significantly lesser than zero for distance coefficient.)

about 44 percent of the total subsidiary effect in column (1) arises from the fact that subsidiaries are more likely to have foreign ownership. In addition, the effect of ADMIN, the percentage of white-collar workers is strong in column (1), but declines substantially once foreign control is added. High-level labor skills appear to have their primary impact as a proxy for foreign control (or vice-versa). This is consistent with the idea that foreign firms make their contribution through highly skilled knowledge workers, which would be expected in a situation of technology transfer. Column (3) suggests that little of the overall strong effect of foreign control can be attributed to the subsidiary effect. The foreign control effect is almost as strong when the subsidiary variable is included as in its absence. Overall, intra-firm linkages within a foreign owned firm seems to be more effective in its influences on productivity than Brazilian intra-firm linkage effects.

An attempt was made to control for large company (as opposed to large plant) size effects on productivity. However, the high correlation between large company size and subsidiary and foreign ownership status confounded the results. [4]

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[4] It is possible that both the subsidiary and foreign ownership effects may in part reflect large company advantages. Hence, a firm size variable was included to the equations (columns (1) and (2) in Table A.5) to account for the likely advantages possessed by large firms in information, specialization, and scale economies. Once the firm size variable is included, the subsidiary plant effect is much smaller (.1244) and insignificant. The foreign ownership effect remains very strong (.8667) and significant. Although the subsidiary plant effect is insignificant once company size is included, since there is a high correlation between subsidiary status and large company size, it does not seem adviseable to dismiss altogether the possibility of a substantial subsidiary effect.

In evaluating alternative procedures for decentralization policy, it is of interest to see if the productivity advantages of subsidiary and foreign-owned plants hold both within and outside Grande Sao Paulo. Hence, columns (4) through (7) take the subsidiary and foreign ownership effects which have been established for the total sample and examine this with GSP and outside the metropolitan area. The subsidiary plant effect is very large within the metropolitan area and insignificant outside the metropolitan area. Subsidiaries are therefore particularly useful in bringing information to non-central locations within the metropolitan area, but do not effectively convey information to the hinterlands. This suggests that information carried with a firm is most helpful when the recipient plant has access to at least some other sources of information and is not unduly isolated.

The foreign ownership effect, on the other hand, is very large and significant both within and outside the metropolitan area (columns (6) and (7)). This result implies that a decentralization policy that promotes the location of foreign owned plants in outlying areas may be particularly effective.

Table A.6 indicates the effect of intra-firm linkages in the individual industry regressions when the subsidiary and foreign ownership variables are added to the basic equation. The first row indicates that the subsidiary variable has the expected positive effect in five of the eight industries considered. Consequently, there is also evidence that a substantial positive subsidiary effect is fairly prevalent in many industries, although not universal.

Table A.6

The Effect of Subsidiary Status and Foreign Ownership on Hicks-Neutral Productivity of New Manufacturing Plants in Sao Paulo State: Summary Results for Eight Sectors [1/]

	Machinery	Electrical	Transport	Plastics	Textiles	Clothing	Food & Bev.	Diverse
Subsidiary	.2288 (.83)	.5879 (1.89)*	.6503 (1.62)*	1.5051 (4.42)*	-.9830 (-1.53)	-.1861 (-.61)	1.5824 (2.52)*	1.1187 (3.57)*
Foreign	-.0122 (-.03)	1.1720 (3.70)*	No foreign plants	-.8876 (-1.10)	-3.0758 (-.61)	1.7811 (2.51)*	2.3361 (2.48)*	1.2286 (1.70)*

1/ These regressions are based on equation (3). However, only the coefficients and t-statistics for the subsidiary and foreign ownership variables.

Source: Regressions based on equation (3).
t-ratios in parentheses.

* Indicates significantly greater than zero at the 95 percent level.

The second row of results in Table A.6 shows the effect of the foreign control variable. Foreign plants are significantly more productive in three of the seven industry samples with foreign owned plants. In addition the effects are often extremely substantial.

In comparison with accessibility and other agglomeration economies effects, intra-firm linkages exert the most discernable influence on Hicks-neutral productivity within the detailed industry data. These results suggest that more attention should be focussed on the role subsidiary plants and multinational firms can play in industrial development and industrial decentralization through intra-firm transmission of goods and information.

By taking stock of the various types of agglomeration economies by individual industries, it is possible to test partially the product cycle hypothesis. As elaborated in Chapters 2 and 3, recall the hypothesis that agglomeration economies are more important for innovative industries than for mature industries. In summary form, Table A.7 reports the sensitivity of sectoral productivity to agglomeration economies with sectors classified by product cycle stages. The eight manufacturing sectors included in the productivity analysis are fairly evenly represented in at least two of the three broad product cycle groups as classified in Chapter 3. In general, these agglomeration economies measures — assessibility to the center of Sao Paulo, inter-industrial linkages, external economies, and intra-firm linkages -- were most frequently important for innovative sectors as expected. However, the results were not entirely unambiguous especially since the distance effect, a measure of overall agglomeration economies, was significant in only one out of four innovative sectors. The results, therefore, provide only weak support for the product cycle hypothesis. More support is provided, however, in that all the industries for which external economies effects have statistically significant influences on productivity, are innovative sectors.

In sum, this analysis of the spatial variation in Hicks-neutral productivity of new plants in Sao Paulo state suggests that substantial agglomeration effects exist -- and that agglomeration economies have not petered out. The evidence shows that, despite an overall trend toward the decentralization of manufacturing employment in the state, production in central areas still retains strong economic advantages.

Table A.7

Summary of Statistically Significant Influences on New Plant Productivity in Sao Paulo State by Industry

	Accessibility	Inter-Industrial Linkages		External Economies		Intra-Firm Linkages	
	DSP	BL	Fl	Localization	Urbanization	Subsidiary	Foreign
Innovative Sectors							
Machinery			X	X	X		
Electrical					X		X
Plastics							
Diverse	X				X	X	X
Intermediate Sectors							
Transportation	X	X	X			X	
Mature Sectors							
Textiles							
Clothing							
Food & Bev.						X	X

Appendix B to Chapter 4

DERIVATION OF THE RESTRICTED PROFIT FUNCTION

The restricted profit function is derived from a Cobb-Douglas production function with decreasing returns in variable inputs as follows:

$$V = F(X,Z) = AX^{\alpha}Z^{\beta} \quad (1)$$

where V is output; X is variable inputs; Z is fixed inputs; A, α and β are constants.

Profit is defined as current revenues less current total variable costs and can be written,

$$\pi' = p.\ AX^{\alpha}Z^{\beta} - c'X \quad (2)$$

where π' is profit, p is the unit price of output, and c' is the unit price of variable input.

Optimal marginal productivity conditions are given

$$\frac{\partial \pi'}{\partial x} = p.\ \alpha AX^{\alpha-1}Z^{\beta} - c' = 0 \quad (3)$$

If we let $\pi \equiv \frac{\pi'}{p}$ and $c \equiv \frac{c'}{p}$ such that π is defined as the unit output price profit or UOP profit and c is the price per unit output of variable input, then (3) can be rewritten as

$$\frac{\partial \pi}{\partial x} = \alpha AX^{\alpha-1}Z^{\beta} - c = 0 \quad (3.1)$$

Optimal quantities of variable inputs, X^*, is

$$X^* = \frac{c}{\alpha AZ^{\beta}}^{\frac{1}{\alpha-1}} \quad (4)$$

X^* is then substituted into the UOP profit function.

$$\pi^* = AX^{*\alpha}Z^{\beta} - cX^* \qquad (5)$$

$$= A \frac{c}{\alpha AZ^{\beta}}^{\frac{\alpha}{\alpha-1}} Z^{\beta} - c \frac{c}{\alpha AZ^{\beta}}^{\frac{1}{\alpha-1}}$$

$$\pi^* = A \frac{c}{\alpha AZ^{\beta}}^{\frac{\alpha}{\alpha-1}} Z^{\beta} - \frac{\alpha AZ^{\beta} c}{\alpha AZ^{\beta}} \frac{c}{\alpha AZ^{\beta}}^{\frac{1}{\alpha-1}}$$

since $\frac{1}{\alpha-1} = \frac{\alpha}{\alpha-1} - 1,$

$$\pi^* = A \left(\frac{c}{\alpha AZ^{\beta}}\right)^{\frac{\alpha}{\alpha-1}} Z^{\beta} - \frac{\alpha AZ^{\beta} c}{\alpha AZ^{\beta}} \frac{\alpha AZ^{\beta}}{c} \left(\frac{c}{\alpha AZ^{\beta}}\right)^{\frac{\alpha}{\alpha-1}}$$

$$= A \left(\frac{c}{\alpha AZ^{\beta}}\right)^{\frac{\alpha}{\alpha-1}} Z^{\beta} - \alpha Z^{\beta} \left(\frac{c}{\alpha AZ^{\beta}}\right)^{\frac{\alpha}{\alpha-1}}$$

$$= A \frac{c}{\alpha}^{\frac{\alpha}{\alpha-1}} (AZ^{\beta})^{\frac{-\alpha}{\alpha-1}} Z^{\beta} - \alpha Z^{\beta} \left(\frac{c}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} (AZ^{\beta})^{\frac{-\alpha}{\alpha-1}}$$

and since, $\frac{-\alpha}{\alpha-1} = -1 - \frac{1}{\alpha-1}$, $A.A^{\frac{-\alpha}{\alpha-1}} = A^{-\frac{1}{\alpha-1}}$

$$\pi^* = (1-\alpha)\ A.A^{\frac{-\alpha}{\alpha-1}} \left(\frac{c}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} Z^{\beta\frac{-1}{\alpha-1}}$$

$$= (1-\alpha)\ A^{-\frac{1}{\alpha-1}} \left(\frac{c}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} Z^{\beta\frac{-1}{\alpha-1}}$$

$$\pi^* = (1-\alpha)\ A^{\frac{1}{1-\alpha}} \left(\frac{c}{\alpha}\right)^{\frac{\alpha}{\alpha-1}} Z^{\frac{\beta}{1-\alpha}} \qquad (6)$$

Equation (6) is the restricted UOP profit function in terms of the costs of variable inputs, c, and quantities of fixed inputs, Z.

Chapter 5

CONCLUSIONS AND POLICY IMPLICATIONS

The results of this study are very different from what most researchers of industrial decentralization in developing countries would expect. A researcher would typically expect to find most industrialists and entrepreneurs extremely reluctant to locate their plants outside the central metropolitan region, even if production advantages actually favored outlying areas. As Hirschman [1958] and others have suggested, entrepreneurs tend to overestimate the profitability of the center relative to the periphery because of the lack of objective knowledge about the periphery, because of the relative ease of making new investment at the center, and because of their strong preference for the metropolitan center. In Sao Paulo state, however, we seem to find a different situation. The decentralization of manufacturing employment is substantial. Forty-three percent of new manufacturing jobs created in the state from 1977 through 1979 have been established outside Grande Sao Paulo (GSP). In this chapter we will offer some explanations for these counter-intuitive findings before turning to discuss the implications of our results for public policy.

Why Is Industry Decentralizing in Sao Paulo State?

Industrial decentralization, as shown in Chapter 3, has been under way in Sao Paulo state since the 1960s. From 1960 to 1975 manufacturing employment became less centralized within Grande Sao Paulo and expanded rapidly in secondary cities and towns in the rest of the state. This decentralization has been a relatively "spontaneous" process. It has occurred largely without any direct government policy either forcing industrialists to locate their plants outside the metropolitan region or luring them to outlying locations with financial and tax incentives.

The results of the analysis of the trade-off between productivity and wages suggest that industry is decentralizing in Sao Paulo state not because GSP has lost its absolute productivity advantages which stem from its agglomeration economies, but because, on balance, GSP's production advantages are offset by labor cost savings possible in outlying areas. For total manufacturing, we find that firms can be just about equally profitable whether they locate inside or outside of GSP. As shown in Chapter 4, a doubling of distance from Sao Paulo City is associated with an 8.9 percent decline in plant productivity and with an 8.7 percent decline in labor costs. Although these numbers indicate that firms closer to GSP have a slight production advantage over more distant firms, the slight difference between these figures can be disregarded for two reasons. First, the labor cost gradient figure is sensitive to the estimate of the labor share in total manufacturing. The labor share used (0.72) is derived from the production function analysis. It would take only a small, 0.02 point rise in the labor share, to 0.74, to make the labor cost gradient exactly equal to the productivity gradient. Second, due to the level of aggregation of the entire analysis, the difference between these two numbers is negligible and can be discounted. So it seems fair to conclude, on the basis of the results of the productivity-wage trade-off for total manufacturing, that entrepreneurs in general can be indifferent in choosing where to locate their plant. This conclusion is consistent with the high level of employment decentralization in the state between 1977 and

1979. And, therefore, in general it appears that firms are locating where they should be.

This conclusion is not supported at the individual industry level, however. In all five industries for which data is available (see Table 4.8, p. 120), the productivity-wage trade-off predicts that firms should not be decentralizing because GSP's productivity advantages outweigh labor cost advantages in the outlying areas. But the evidence shows that employment in each of these industries is decentralized; over 40 percent of newly created jobs in these industries lies outside GSP. These results suggest that the location decisions of entrepreneurs in these individual sectors are out of line with major market forces. However, the estimates for the individual industries are less reliable than those for total manufacturing. The individual industry results are especially suspect for two reasons. First, as explained in Chapter 4, precise estimation of the productivity gradients at the individual industry level is handicapped by problems of small sample size. Second, also as indicated in Chapter 4, it is possible that temporary tightness in industry labor markets of outlying areas is distorting our picture of the wage gradients for individual industries, and that long run labor cost savings in outlying areas are greater than indicated by our individual industry estimates for 1980. Although this distortion argument could apply to the wage gradient estimate for total manufacturing, short run distortions are likely to be magnified in individual industry labor markets, whereas such distortions would tend to be averaged out in an aggregated labor market analysis. Thus, because of these two problems with the individual industry estimates, the results of the productivity-wage trade-off analysis for total manufacturing are interpreted with greater confidence.

Notwithstanding the problems confronting individual industry analysis, future research at the individual industry level is highly recommended; and a brief digression is warranted. This study has identified and attempted to test a variety of hypotheses about the different locational propensities of different industries. Drawing from the product cycle model, we expected that newer, more innovative industries would be attracted to the agglomeration economies (productivity advantages) of the metropolitan center and the mature, more standardized product industries would be drawn to cheaper production sites (labor cost advantages) in outlying areas. The crude analysis of sectoral differences in employment decentralization using census data for 1960, 170, and 1975 in Chapter 3 indicated that employment was more decentralized in the mature sectors than in the innovative sectors. But attempts to test this proposition in the productivity and wage analyses in Chapter 4 were confounded by data problems and did not constitute a conclusive test of the degree to which sectors benefit differently from central agglomeration economies or from labor cost advantages in outlying areas. More detailed research at the individual industry level is needed to shed further light on these questions. Because of the difficulties inherent in making inferences about location behavior without information on changes over time in the factor costs of alternative locations, a longitudinal approach is specially recommended (over cross-sectional analysis) for future research on industrial location behavior.

In sum, our results suggest that industrialists are locating as they "should" be in terms of private costs and benefits. For manufacturing industries combined, the high degree of decentralization of employment is consistent with our results which suggest that firms face a fairly equal trade-off between productivity advantages and labor cost advantages of locations in Sao Paulo state. The results imply that entrepreneurs can be ambivalent about where they locate, and they are. We conclude that industrialists are responding to market forces and thus, from a private as against public view, appear to be locating in accordance with where they should be.

Such a conclusion is obviously an oversimplification and can be challenged on at least two grounds. First, industrialists may not be fully aware of opportunities and economic conditions in outlying areas. Information markets are by no means perfect in Sao Paulo state, and information and perceptions about conditions in outlying areas are distorted [Townroe, 1981]. Other analysis of industrial location behavior in Sao Paulo state indicates that firms conduct a limited search in making location decisions [Hamer, 1981]. Second, other non-market factors such as the personal considerations of the industrialist and senior management can have a strong influence on industrial location and can run counter to the influence of market signals. These reservations notwithstanding, the bulk of the evidence supports the conclusion that industrialists are sensitive to prevailing market signals.

Bearing in mind these conclusions about industrial location behavior from the perspective of the private entrepreneur, the remainder of this chapter focuses on analyzing industrial location behavior from a social perspective and evaluating the need for public policy to influence industrial location in Sao Paulo state.

Policy Implications

Since we have concluded that industrialists, by and large, are responsive to market signals in choosing where to locate their plants, the remaining questions center on whether or not those market signals are distorted. In our analyses in Chapter 4, we have explored productivity and wage differentials over space, but have not allocated particular proportions of those differentials to market factors under neoclassical equilibrium versus differentials due to distortions within these markets. Our ability to distinguish between a market-equilibrium signal and a distortion-induced signal is restricted by the available data and thus lies beyond the scope of this study. Nonetheless, culling from other studies, some judgments can be made about the direction and degree to which wages and productivity "signals" may be distorted.

If we assume that market signals are free from distortion, then what we see under way in Sao Paulo state is a spontaneous process of industrial decentralization which coincides with the social objective of an efficient allocation of resources. The process may also coincide with social equity objectives if the pace of industrial decentralization exceeds a desired threshold rate. Thus, if firms are decentralizing in response to undistorted market signals and the decentralization of industry meets both social equity and efficiency criteria, then no public policy intervention is required.

But what if market signals are distorted? Then perhaps the process of decentralization could proceed even faster if the distortions were removed. Two possible distortions can be considered: distortions in the labor market and distortions in the product market.

Product market distortions implicit in Brazil's macro-sectoral industrial promotion incentives can create spatial biases. Analysis of the regional impact of the combined effects of tariffs, fiscal exemptions, and interest rate subsidies by sector suggests that in the state, GSP is a favored beneficiary of these subsidies [Hamer, 1983]. However, this favoritism results because of GSP's mix of industries; the subsidies are awarded to specific industries, not to location. Thus, these subsidies do not influence levels of productivity in an industry over space. However, they can impart an indirect spatial bias on productivity in two ways. First, if these subsidies to particular recipient sectors concentrated in GSP are reflected in lower local output prices, then local firms in other related industries benefit. Second, if these subsidies are administered in such a way that by locating in GSP firms gain easier access to these subsidies, then a spatial bias is associated with sectoral promotion incentives.

Industrial location behavior may also be affected by policy-induced distortions in wage signals. It is possible that, although average wages are higher in GSP than elsewhere in the state, wages in GSP are lower than what they ought to be in the absence of intervention. One would expect that urban disamenities such as congestion and pollution would be fully compensated for in wage levels, requiring higher wage levels and equal productivity in GSP. However, an offshooting benefit to urban workers in GSP is the high level of public services which they receive. Dillinger [1982] compared the level of public utility provision in the metropolitan area with that in secondary cities in the state. He found that the spatial allocation of per capita investments in selected public utilities (water and sewer) in the state over the past three decades unquestionably favors the metropolitan region even though funds for these investments are drawn from spatially uniform resources. This fiscal favoritism amounts to a transfer of resources by non-metropolitan firms and dwellers to Grande Sao Paulo. Because workers in GSP benefit from a subsidy in terms of water, sewer, and possibly other urban services, they will accept urban disamenities and therefore will not demand higher wages. The magnitude of this subsidy cannot be quantified in money terms, but can be illustrated using the available data by comparing public utility investment in GSP with that in the rest of the state. Per household investments for water and sewer system construction during 1968-74 were four times as high in GSP as elsewhere [Dillinger, 1982]. Since resources for these utilities are derived from spatially uniform user charges and state and federal grants and loans, people and firms in GSP are favored.

The direction of possible distortions in the product and wage market signals suggests that industrial location in GSP may be occurring at a cost to the rest of the state. If these distortions are severe, it would make more sense to correct the distortion than to introduce a set of spatial initiatives designed to promote greater decentralization. In the context of the major sources of distortion -- non-spatial industrial promotion policies and public services resource mobilization -- the best spatial policy is a set of efficient sectoral policies.

Although this argument makes sense in a purely economic analysis, it probably falls short of the mark in the context of the boardroom of the regional planning commission for Sao Paulo state. There, multiple interests and objectives -- political, social, and economic -- generate a different set of circumstances for evaluating the desirability of an industrial decentralization policy. If policy makers decide that regional industralization objectives should be given higher priority than the current market allows, then a second best strategy of attracting industry to outlying areas may be most appropriate.

Several policy recommendations for such a second best strategy stem from the results of this study. The results of the productivity-wage trade-off suggest that industrial decentralization can be accelerated with minimal public effort because profits for the average manufacturing firm are roughly equivalent at locations inside and outside GSP. A well-managed publicity campaign about industrial sites and services in outlying areas may be an effective low-budget procedure to promote decentralization. Evidence of the limited search procedures employed by manufacturing firms in making locational decisions [Hamer, 1981] corroborates this suggestion. In addition, industrial decentralization can be accelerated by removing constraints to decentralization and by providing inducements for those manufacturing activities which have the greatest propensity to locate outside the metropolitan area. The productivity results implied that "mature" manufacturing sectors, foreign-owned plants, and subsidiary plants were the types of activities most able to operate effectively in outlying areas.

In efforts to pursue a second best strategy to foster developments in areas outside of Grande Sao Paulo, policy-makers should avoid strategies which lead to a diffuse distribution of manufacturing resources in the state. Lessons learned from past experience suggest that a strategy of "concentrated decentralization" [Rodwin, 1970] is preferred for two reasons. First, as this study and others have demonstrated, the productivity of manufacturing resources is enhanced by agglomeration economies resulting from clustering of economic activities. Second, though the provision of industrial infrastructure is crucial to releasing the growth potential of every region, spreading infrastructure over all regions and cities is extremely costly and is not likely to be effective. Thus, a policy which encourages the clustering of industries in a few existing secondary cities and towns of high growth potential, such as Campinas and Sao Jose dos Campos, is favored because it will yield higher output and promote a more efficient allocation for infrastructure investment than a policy which encourages a less concentrated pattern of investments.

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