Urban Concentration: The Role of Increasing Returns and Transport Costs

Paul Krugman

Very large urban centers are a conspicuous feature of many developing economies, yet the subject of the size distribution of cities (as opposed to such issues as rural-urban migration) has been neglected by development economists. This article argues that some important insights into urban concentration, especially the tendency of some developing countries to have very large primate cities, can be derived from recent approaches to economic geography. Three approaches are compared: the well-established neoclassical urban systems theory, which emphasizes the tradeoff between agglomeration economies and diseconomies of city size; the new economic geography, which attempts to derive agglomeration effects from the interactions among market size, transportation costs, and increasing returns at the firm level; and a nihilistic view that cities emerge out of a random process in which there are roughly constant returns to city size. The article suggests that Washington consensus policies of reduced government intervention and trade opening may tend to reduce the size of primate cities or at least slow their relative growth.

Over the past several years there has been a broad revival of interest in issues of regional and urban development. This revival has taken two main directions. The first has focused on theoretical models of urbanization and uneven regional growth, many of them grounded in the approaches to imperfect competition and increasing returns originally developed in the "new trade" and "new growth" theories. The second, a new wave of empirical work, explores urban and regional growth patterns for clues to the nature of external economies, macroeconomic adjustment, and other aspects of the aggregate economy.

Most of this work has focused either on generic issues or on issues raised by the experience of advanced market economies like the United States. Yet arguably the issues raised by the recent work are most salient for smaller, less-wealthy countries like Mexico and Brazil.

Why might the "new economic geography" be more relevant for the developing world than for industrial countries? First, the matter is an urgent one for real-world

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policy. Urbanization in developing countries, and particularly the very large agglomerations such as Mexico City and São Paulo, is widely regarded as a problem. Rural-urban migration has, of course, been the subject of a vast literature in development economics, with many papers suggesting that its pace is excessive from a social point of view. Moreover, the sheer size of some cities that such migration now feeds reinforces these concerns. Although nobody can claim to have made a thorough welfare-economic study of the consequences of the emergence of huge cities in developing countries, many observers believe that something has gone wrong, that such giant cities are in some sense parasitic entities that drain vitality from their host economies—Bairoch (1988) has called these metropolises "Romes without empires"—that the environmental and social problems posed by cities with populations in the tens of millions are even greater in poor nations than in the West.

Associated with concern about urbanization and metropolitan growth is related concern about regional inequality. In many developing countries the regions that contain the big cities are also much richer per capita than other regions. The problem of core-periphery patterns within countries is not only economic and social but political as well: it is no accident that a separatist movement has emerged in Brazil's relatively rich south or that armed opposition to the central government surfaced in the bypassed southern regions of Mexico.

On the bright side, urbanization and unequal regional development may be analytically more tractable in developing than in industrial countries. The models developed in recent years, which stress the role of relatively measurable factors like economies of scale and transportation costs in determining urban growth, often seem to miss much of the story in advanced economies. For one thing, in huge economies like the United States or the European Union static economies of scale tend to seem relatively unimportant. For another, in advanced nations that are increasingly in the business of producing information rather than tangible goods, the nature of both the external economies that induce agglomeration and the transaction costs that make distance matter becomes more and more subtle. By contrast, developing countries have much smaller internal markets. For example, although Mexico's population is one-third that of the United States, its dollar purchasing power is about the same as that of metropolitan Los Angeles. Thus conventional scale economies remain relevant. And these countries still devote much more of their labor force and expenditure to tangible products that must be transported by road or rail.

Finally, the radical policy changes that have taken place, or may be about to take place, in some developing countries are likely to have major impacts on urban and regional development, impacts that we want to be able to predict. One need only consider the case of Mexico: the federal district in that country became dominant during a prolonged period of both import-substituting development strategy and extensive government involvement in the economy. As the country has shifted to an export-oriented trade policy, the manufacturing center of gravity has visibly shifted toward the country's northern states. Will the combining of that shift with privatization and deregulation undermine Mexico City's special role, or will other activities maintain its position?

For these reasons, then, it is natural to ask whether, and if so to what extent, the new tools of urban and regional analysis apply to developing countries. The literature on urban and regional issues in development is immense. This article explores a narrow, indeed largely technical issue: what can we learn from looking at urbanization and regional inequality in developing countries through the lens of the specific approach to economic geography that has emerged out of the new trade and growth theories? The article sketches out a minimalist new economic geography model designed to highlight the way a tension between forces of agglomeration and forces of dispersal determines city sizes. The implications of that tension are illustrated by examining a particular issue: how trade policy may affect the tendency of developing countries to have very large, primate cities. Two other factors also are explored that probably have even more important roles in determining urban structure: the centralization of government and the quality and form of transportation infrastructure.

Approaches to Urban Development

Urbanization—and uneven regional development, which is a closely related process—clearly involves a tension between the "centripetal" forces that tend to pull population and production into agglomerations and the "centrifugal" forces that tend to break such agglomerations up. The following tabulation lists the major types of centripetal and centrifugal forces that appear in various models of urban growth:

Centripetal forces

- Natural advantages of particular sites
  - Harbors, rivers, and the like
  - Central locations
- Market-size external economies
  - Access to markets (backward linkages)
  - Access to products (forward linkages)
  - Thick labor markets
- Pure external economies
  - Knowledge spillovers

Centrifugal forces

- Market-mediated forces
  - Commuting costs, urban land rent
  - Pull of dispersed resources, such as farmland
- Nonmarket forces
  - Congestion
  - Pollution

Several key distinctions among these forces are worth pointing out. Among centripetal forces there is a basic distinction between natural factors that favor a site—

such as a good harbor or a central position—and external economies that are acquired and self-reinforcing advantages of a site. Among external economies there is a further key distinction between "pure" external economies, such as spillover of knowledge between nearby firms, and market-size effects, whether in the labor market or in the linkages between upstream and downstream industries.

On the side of centrifugal forces there is a similar distinction between nonmarket diseconomies (such as congestion) and factors such as land prices that are fully mediated through the market. A narrower but sometimes important distinction appears between forces that push business out of a large city, such as urban land prices, and those that pull business away, such as the existence of a dispersed rural market.

Which forces actually explain the pattern of urbanization in developing countries? The answer is, of course, all of them. Nonetheless, to say anything useful we must always rely on simplified models. The typical analytical approach therefore takes "one from column A and one from column B" and thus gets a particular story about the tension between the agglomeration and dispersion that creates an urban system. Several such approaches have achieved wide influence.

Neoclassical Urban Systems Theory

At least within the economics profession the most influential approach to urban development is probably what we might call neoclassical urban systems theory. This approach models the centripetal forces for agglomeration as pure external economies (therefore allowing the modeler to assume perfect competition)[1] and the centrifugal forces as arising from the need to commute to a central business district within each city, a need that leads to a gradient of land rents within each city. In the simplest case the tension between these forces leads to an optimal city size, though there is no guarantee that market forces will actually produce this optimal city.

This neoclassical approach has been extensively developed by Henderson (1974, 1977, 1988) and his followers, who added two important elaborations. First, Henderson pointed out that if cities are the "wrong" size, there are potential profit opportunities for a class of "city developers"; and as an empirical matter, large forward-looking private agents who seem to try to internalize external economies do play a large role in urban development in the United States. Thus Henderson-type models adopt as a working hypothesis the assumption that competition among developers produces cities of optimal size.

Second, according to Henderson, external economies may well be industry-specific (textile plants may convey external benefits to neighboring textile plants; metalworking plants may do the same, but it is hard to see why metalworkers want textile workers nearby). On the other hand, diseconomies of commuting and land rent depend on the overall size of a city, not the size of an individual industry within that city. Thus Henderson-type models predict the emergence of specialized cities, with each city's "export" sector producing a range of industries with mutual spillovers, and with industries that do not benefit from these spillovers seeking other locations. Since cities are specialized, this approach explains the existence of an

urban system with many different types of cities; inasmuch as the optimal size of a city depends on the relative strength of external economies and city-size diseconomies, and external economies are presumably stronger in some industries than in others, cities of different types will be of different sizes. Neoclassical urban systems theory therefore offers a framework that explains the existence not only of cities but also of a system of cities of differing sizes.

While the insights gained from this approach are impressive, it has important limitations. First, the external economies that drive aggiomeration are treated for the most part as a kind of black box, making it difficult to think about what might influence their strength and thus making it hard even to start to predict how policy or other changes might affect the urban system. Second, the reliance of much of this literature on the assumption of competition between city developers, while a useful clarifying device, strains credibility when applied to huge urban areas: the Irvine Corporation may arguably have played a major role in developing a particular "edge city" within metropolitan Los Angeles, but could any private agent internalize the externalities of São Paulo? Finally, neoclassical urban systems theory is entirely nonspatial: it describes the number and types of cities, but says nothing about their locations. In the past few years an alternative approach has emerged that shares much of the framework of urban systems theory but attempts to deal with these issues.

Monopolistic Competition Theory

In this new literature agglomeration economies are not assumed but are instead derived from the interaction among economies of scale at the plant level, transportation costs, and factor mobility. Economies of scale at the plant level inevitably imply imperfect competition; this imperfection is modeled using the same (unsatisfactory) monopolistic competition approach that has played such a large role in trade and growth theory over the past fifteen years. The "new economic geography" literature, begun in Krugman (1991a,b), bears considerable resemblance to the urban systems approach, but the black-box nature of external economies is gone, there is a spatial dimension, and the models no longer rely on the assumption of city developers who enforce optimal outcomes. In some respects, in fact, the new approach seems closer in spirit to the "cumulative process" description of urban and regional development associated with geographers such as Pred (1966).

The model described below is in this tradition, so it is worth noting the considerable limitations of this approach. Two points stand out. First, multiple-city systems are difficult to model using this approach. Where the urban systems approach easily tells a story of multiple cities of a number of different types, in monopolistically competitive spatial settings (see, for example, Krugman 1993b) multiple-city systems can at this point be modeled only with considerable difficulty, and initial efforts to get some kind of urban hierarchy have encountered surprisingly nasty problems (Fujita and Krugman 1993). Second, going from the black-box external economies of the urban systems model to the derived agglomeration effects of the monopolistic competition model may involve a degree of misplaced concreteness. We will have

a seemingly clear story about linkage externalities in the manufacturing sector, but it may be that, say, informational externalities in the service sector are equally important even in developing countries. Attempts to get specific, to open up the black box, always run this risk; nonetheless, it seems greater than usual in this case.

Finally, we should point out one additional risk in both the urban systems and the monopolistic competition approaches to urban modeling: we may be trying to explain too much, engaging in a kind of Rorschach test in which we are trying to find deterministic explanations of essentially random outcomes. While this notion does not exactly constitute a rival theory of urban systems, the idea that they are largely random creations requires at least some discussion.

Random Urban Systems

The general idea suggested by the tabulation above—that city sizes are determined by a tension between centripetal and centrifugal forces—seems to imply the conclusion that there will in any economy be a typical, equilibrium city size. In fact, one sees a whole range of city sizes. The urban systems theory explains that there are different types of cities, each with a characteristic size, and that the size distribution is actually a type distribution. While this argument surely has some validity, it may not be a full explanation. For one thing, urban specialization is increasingly difficult to detect in advanced countries. It is a familiar point that the mix of activities within U.S. metropolitan areas has become increasingly similar since 1950, and the influential study by Glaeser and others (1992) finds, as well, that individual industries seem to grow fastest in more diverse metropolitan areas.

Moreover, the size distribution of cities is suspiciously smooth and regular. City sizes in many countries are startlingly well described by a power law of the form

$$N(S) = AS^{-\alpha} \tag{1}$$

where $N(S)$ is the number of cities that are the same size as or larger than S. Furthermore, the exponent α is generally quite close to 1. In fact, when equation 1 is estimated for U.S. metropolitan areas, α is almost exactly 1, and it has remained close to 1 for at least a century. International evidence is not quite so strong, perhaps because of definitions of city boundaries: Rosen and Resnick (1980) show that when data for metropolitan areas rather than cities proper are used for a number of countries, α almost always moves substantially closer to 1.

Why should this matter? Because while a relationship like equation 1 is difficult to explain with an equilibrium story about determination of city size, it is quite easy to justify with a nihilistic story of the kind analyzed by Herbert Simon (Ijiri and Simon 1977). Suppose that for all practical purposes there is no equilibrium city size—that approximately constant returns to scale appear over some wide range of sizes. And suppose that cities grow through some random process, in which the expected rate of growth is independent of city size. Then as long as the random process generates a widely dispersed distribution of city sizes, that distribution will

be well described by a power law like equation 1. (A suggestive explanation of this result is given in the appendix.)

Worse yet, such a nihilistic approach can even explain the tendency of the exponent of the power law to be close to 1. Suppose that there is some minimum viable city size, say S_0, and that the distribution of city sizes above that minimum is well described by equation 1. Then the *average* city size is

$$\bar{S} = S_0 (\alpha/\alpha - 1). \tag{2}$$

In other words α close to 1 is equivalent to the statement that the average city size is large relative to the minimum. And it is easy to imagine why this might be the case. Suppose that urban population has grown substantially over a period during which, for whatever reason, few new cities have been founded. Then the existing cities must on average grow much larger than the minimum viable size, and the estimated α will be close to 1.

This nihilistic approach raises real questions about any kind of equilibrium model of an urban system; indeed, if this interpretation is correct, there may be no optimal or equilibrium city size, simply a random process that generates population clusters of many sizes. At some level this interpretation cannot be completely right: surely city size must matter. (This is the same issue that arises in studies of the size distribution of firms, which also seems to obey power laws.) Yet the data may contain less information than we think.

On the other hand, this approach suggests that estimates of relationships like equation 1, together with related measures like "primacy," may be a useful summary indicator of the structure of a country's urban system. Primacy describes the size of the largest city relative either to total population or to some other measure, such as the population of the n largest cities. Many have studied city size distributions: Carroll (1982) provides a survey; Rosen and Resnick (1980) is a particularly clear example; Ades and Glaeser (1993) is a recent study inspired by the new economic geography literature. This literature suggests several stylized facts that may help us to think about urbanization in developing countries.

Stylized Facts

While urban experience varies widely across nations, there seem to be four interesting empirical regularities about urban size distributions.

First, per capita income is negatively related to measures of urban concentration, whether one uses α from equation 1 or measures of primacy such as the share of the largest city in the population of the top ten. This observation confirms an impression of giant metropolitan areas in developing countries: to a large extent, of course, the developing world has big cities simply because it has so many people, but even in this light the biggest cities in these countries are disproportionately big.

Second, the concentration of urban population is closely related to the concentration of political power. Countries with federal systems, and thus geographically

diffused power, have flatter distributions of city size and, in particular, smaller biggest cities than countries that do not have federal systems. Thus Tokyo, the largest city in centralized Japan, is considerably larger than New York, the biggest city of federal America, even though the United States has twice Japan's population. Australia and Canada, though developed at about the same time, have much less urban concentration than do Argentina or Chile. Dictatorships have more concentrated urban centers than do more pluralistic systems, according to Ades and Glaeser (1993).

Third, the nature of transportation infrastructure has an important effect on urban concentration. Countries in which the capital city has a uniquely central position—something that Rosen and Resnick (1980) proxy by a measure of rail density—tend, not too surprisingly, to have more populous capitals. Obviously, this effect often works in tandem with centralization of political power.

Finally, a less dramatic but still visible relationship is apparent between trade openness and urban structure. More open economies, as measured by the share of exports in gross domestic product, tend to have smaller biggest cities. (This is an other-things-equal proposition. Countries with small populations tend to be open, and also to have a large share of their population in the biggest city—consider Singapore. But countries that are more open than you would expect given their population tend to have smaller biggest cities than you would expect given their population.)[2]

At this point, then, we have described a menu of ways (far from inclusive) to think about urban systems in developing countries and have very briefly set out some stylized facts. The next step is to sketch a particular model as a basis for trying to understand those facts.

A Model of Urban Concentration

This section presents a formal model of urban concentration; the full model is presented in the appendix. As pointed out above, numerous centrifugal and centripetal forces may affect urban concentration. All of them probably play some role in practice, yet the modeler normally chooses only a few to include in any given analysis. In my own work I have generally chosen to include only the centripetal forces that arise from the interaction among economies of scale, market size, and transportation costs, that is, backward and forward linkages. Other external economies are undoubtedly at work in real urban areas, but they are omitted in the interest of keeping the models as simple as possible and of keeping a reasonable distance between assumptions and conclusions.

For similar reasons we can handle only one centrifugal force at a time. It turns out to be useful to move back and forth between two different approaches. One, which is close in spirit to the neoclassical urban systems literature, involves commuting costs and land rent. The other involves the pull of a dispersed rural market. This second approach has already been described in a number of published articles, for example, Krugman (1991a,b, 1993b); thus the formal model described here does not include this effect.

As we will see, attempting to make sense of the stylized facts described above is easiest when keeping both approaches in mind. The role of trade openness in urban concentration is most easily understood by focusing on urban land rent, while one cannot model the effects of political centralization and infrastructure without some kind of backdrop of immobile population and purchasing power.

Imagine, then, a stylized economy consisting of three locations, 0, 1, and 2. Location 0 is the "rest of the world," while 1 and 2 are two domestic locations (say, Mexico City and Monterrey). There is only one factor of production, labor. A fixed domestic supply of labor L is mobile between locations 1 and 2, but there is no international labor mobility.

In this radically oversimplified model the issue of urban concentration reduces to just one question: how equally or unequally will the labor force be distributed between the two locations? It is, of course, a considerable stretch to relate results of this kind to the realities of multicity urban systems, but as always the hope is that despite their oversimplifications simple models yield useful insights.

To generate diseconomies of urban concentration, we assume that in each location production must take place at a single central point. Workers, however, require land to live on. To make matters simple, we make several special assumptions. First, each worker needs a fixed living space, say, one unit of land. Second, the cities are long and narrow, so that workers are effectively spread along a line. This assumption implies that the commuting distance of the last worker in any given location is simply proportional to that location's population (as opposed to depending on the square root of population, as it would in a disk-shaped city).[3]

The diseconomies arising from the need to commute will be reflected both in land rents and in commuting costs. Workers who live in the outskirts of the town will pay no land rent but will have high commuting costs. Workers who live closer to the city center will avoid these costs, but competition will ensure that they pay an offsetting land rent. The wage net of commuting costs will decline as one moves away from the city center, but land rents will always exactly offset the differential. Thus given any wage rate at the center, the wage net of both commuting and land rents will be a decreasing function of city size for all workers.

To explain agglomeration in the face of these diseconomies, we must introduce compensating advantages of concentration. These must arise from economies of scale. Unless economies of scale are purely external to firms, however, they must lead to imperfect competition. So we must introduce scale economies in a way that allows a tractable model of imperfect competition.

Not surprisingly, the easiest way to do this is with the familiar tricks of monopolistic competition modeling. We suppose a large number of symmetric potential products, not all actually produced. Each producer acts as a profit-maximizing monopolist, but free entry drives profits to zero. The result will be that a large concentration of population produces a large variety of differentiated products. (One might think that the average scale of production will also be larger. Unfortunately, in the Dixit-Stiglitz–type model used in the appendix, this plausible effect does not materialize: all scale gains appear in the form of variety rather than production).

Will this advantage make such a location attractive despite high land rent and commuting costs? Only if there are costs of transacting between locations, so that a location with a large population is a good place to have access to products (a forward linkage) and to markets (a backward linkage). Thus we next introduce transportation costs, both between domestic regions and between these regions and the rest of the world. For technical reasons involving the way that monopolistic competition must be modeled, it turns out to be extremely convenient, if silly, to assume that transport costs are incurred in the goods shipped, an assumption sometimes referred to as the iceberg assumption: if one unit of a good shipped between regions is to arrive, $\tau > 1$ units must begin the journey. The same applies to international shipments, except that the transport costs may be different.

We may think of interregional transport costs as "natural" consequences of distance (albeit affected by investments in infrastructure). The costs of transacting with the rest of the world, however, involve not only natural costs but artificial trade barriers. Thus the level of transport costs to and from the outside world can be seen as a policy variable.

And that's it (except for the details laid out in the appendix). The interaction among economies of scale, transport costs, and labor mobility is enough to generate economies of agglomeration; the need to commute generates diseconomies of city size; the tension between centrifugal and centripetal forces provides a framework for thinking about urban structure.

To understand how this model works, consider what would happen in the absence of foreign trade, and within that special case ask only a limited question: Under what conditions is concentration of all population in either location 1 or 2 an equilibrium? Once we have seen this case, it will be easier to understand the results when the model is opened up.

Suppose, then, that the cost of transacting with the outside world is very high, so that we can ignore the role of the rest of the world. Furthermore, consider the determination of relative real wages when almost all domestic labor is in region 1. If the real wage rate of a worker in location 2 is less than that of a worker in region 1 in this case, then concentration of all labor in region 1 is an equilibrium; otherwise it is not.

We first note that the nominal wage paid at the center of city 2 (w_2) must be less than that at the center of city 1 (w_1). The reason is that almost all output from a firm in 2 must be sold in 1 and must therefore incur transport costs. At the same time the zero-profit output for firms is the same in each location. So goods produced at location 2 must have sufficiently lower f.o.b. prices to sell as much in 1's market as goods produced at location 1. It can then be shown that

$$w_2/w_1 = \tau^{(1-\sigma)/\sigma} < 1 \tag{3}$$

where σ is the elasticity of substitution among differentiated products.

This wage premium at location 1, which results from its dominant role as a market, essentially represents the backward linkages associated with the concentration of demand there.

Next we notice that if almost all labor is in location 1, almost all goods consumed in 2 must be imported, implying a higher price of these goods:

$$T_2/T_1 = \tau \tag{4}$$

where T_i is the price index for goods (excluding land rent) at location i.

If the wage rate is higher in 1 and the price of consumer goods lower, must not real wages be higher in 1? No—because land rent or commuting costs (or both) are higher. With almost all of the labor force L concentrated in 1, the most remote workers in 1 must commute a distance $L/2$, and all workers who live closer to the center must pay a land rent that absorbs any saving in commuting costs. Meanwhile, the small number of workers in 2 pay almost no land rent and have essentially no commuting distance. So the real wage difference turns out to be

$$w_1/w_2 = \tau^{(2\sigma-1)/\sigma}(1-\gamma L). \tag{5}$$

In this expression the first term represents the centripetal forces—the backward and forward linkages described in equations 3 and 4, which arise from the concentration of suppliers and purchasing power at location 1; the second term represents the centrifugal forces of commuting cost and land rent.[4]

Our next step is to examine the relation between trade openness and urban concentration.

Trade Openness and Urban Concentration

The previous section demonstrates how a concentration of labor in one location may be sustainable, despite the commuting and land rent diseconomies of urban size, through forward and backward linkages. Now suppose that the economy is open to international trade, albeit with some natural and perhaps artificial barriers. How does this change the story? It should be obvious that the effect is to weaken the centripetal forces while leaving the centrifugal forces as strong as before.

Consider a hypothetical primate city, a Mexico City or São Paulo, in a country with a strongly protectionist trade policy. Firms will be willing to pay a wage premium in order to locate at that center precisely because so many other firms, and thus the bulk of their market, are concentrated there. They also may be attracted by the presence of other firms producing intermediate inputs—something not explicitly represented in the model in the appendix, but similar in its effect. On the other side workers will face high land rents or commuting costs, but these will be at least partly offset by better access to the goods and services produced in the metropolis.

But now throw this economy open to international trade. The typical firm will now sell much of its output to the world market (and perhaps get many of its intermediate inputs from that market as well). To the extent that production is for world markets rather than for the domestic market, access to the main domestic market

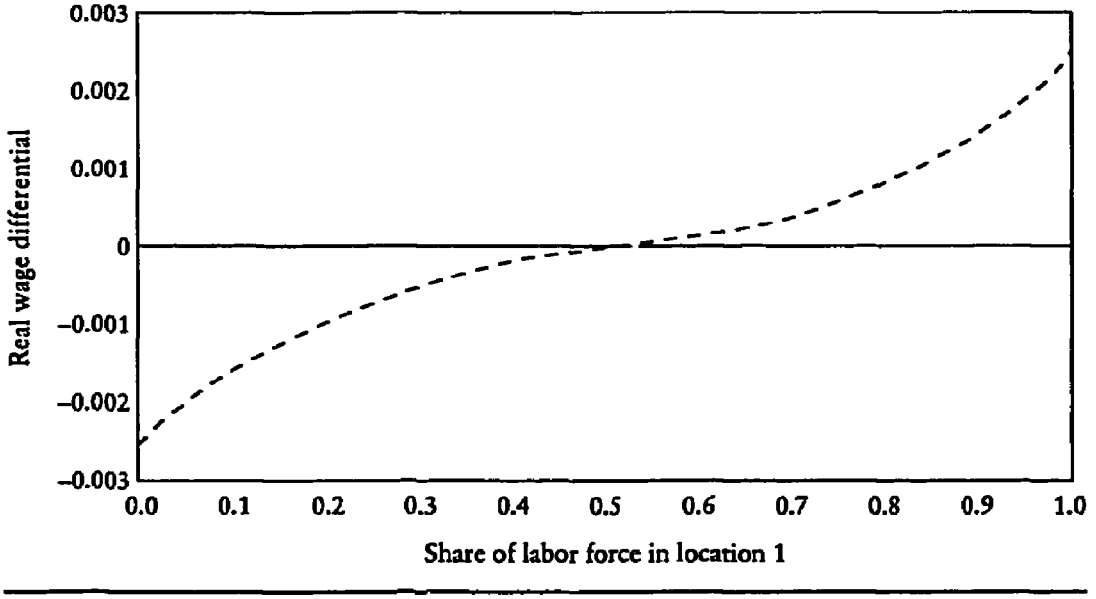
becomes less crucial—and thus the wage premium that firms are willing to pay for a metropolitan location falls. At the same time, workers will consume more imported goods; they will therefore be less willing to accept high commuting and land costs in order to be close to the metropolitan suppliers. The result can be to make a previously sustainable metropolitan concentration unsustainable.

The easiest way to confirm this intuition is through numerical examples. Figures 1 and 2 show, for one set of parameters, how the qualitative behavior of our two-location model changes as the economy becomes more open (that is, as the cost of shipping goods to and from the world falls). Each figure shows how equilibrium real wage rates in the two locations vary as the share of the labor force in location 1 changes. If we assume that workers move toward whichever location offers the higher real wage rate, these figures show a picture of the economy's dynamic behavior. When the real wage differential is positive, labor moves toward location 1; when it is negative, labor moves toward location 2.

When the costs of transacting with the outside world are fairly high, so that the economy is not very open, there is an equilibrium, though unstable, in which labor is equally divided between the two locations (figure 1). If slightly more than half the labor is in location 1, that location will offer higher wages, inducing more labor to move there. This will strengthen the forward and backward linkages and induce still more labor to move there, and so on. Thus in this closed-economy case a cumulative process leads to a concentration of population in a single metropolis. (Obviously this result does not fully obtain in practice, but perhaps it suggests how a very large primate city is established.)

If the economy is more open, we get a result like that in figure 2.[5] Now the equilibrium in which the population is equally divided between the two locations

Figure 1. *Response of Labor Force to Relative Wages under High Costs of Transacting with Outside World*



is stable, and a concentration of population in only one location is unsustainable. Thus in this situation we tend to have two equal-size cities rather than one very large metropolis.

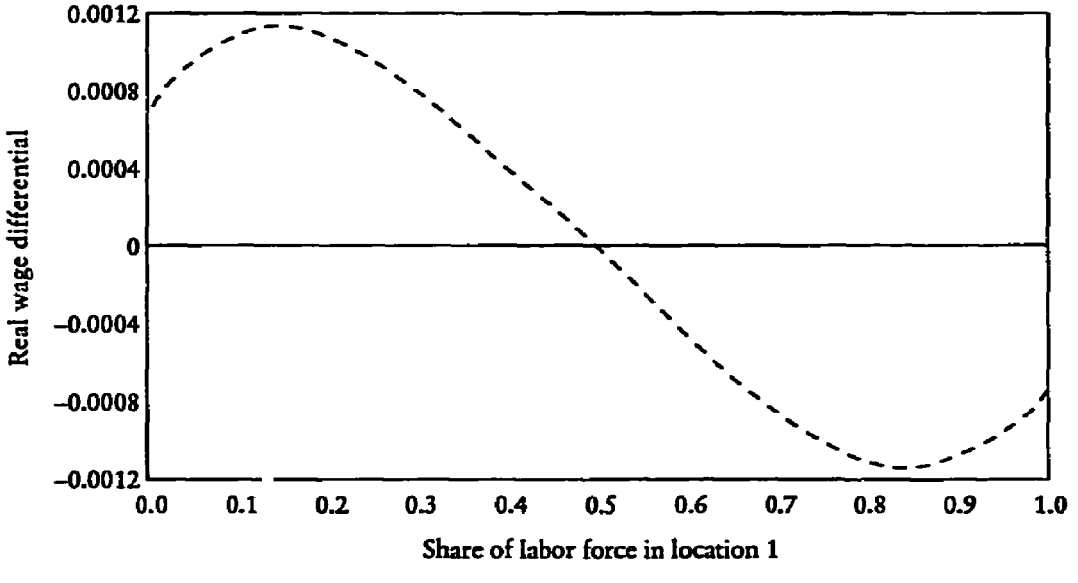
It is, of course, obvious that Mexican industry has been shifting its center of gravity away from Mexico City as the country has shifted toward exports. In that case, however, the explanation lies at least partly in the role of access to the U.S. border, as well as in the role of the *maquiladora* program in fostering export industry in the country's north. Our analysis suggests, however, a more generic reason why inward-looking policies may encourage the growth of primate cities, and outward-looking policies may discourage that growth; the empirical evidence described above offers at least modest support for the belief that such a generic tendency exists.

Political Centralization and Regional Inequality

While the theoretical and empirical relationship between trade policy and urban structure is a surprising, and thus gratifying, insight, it is surely not the most important reason why developing-country cities grow so large, or why regional inequality is so marked in developing countries. Almost surely the most important reason is the role of political centralization.

Political centralization has effects at several levels. The most obvious is that the business of government is itself a substantial source of employment: employment in Paris is larger than it is in Frankfurt in part simply because there are so many more people working for the government, or supplying nontraded services to those who work for the government.

Figure 2. *Response of Labor Force to Changes in Relative Wages under Relatively Low Costs of Transacting with Outside World*



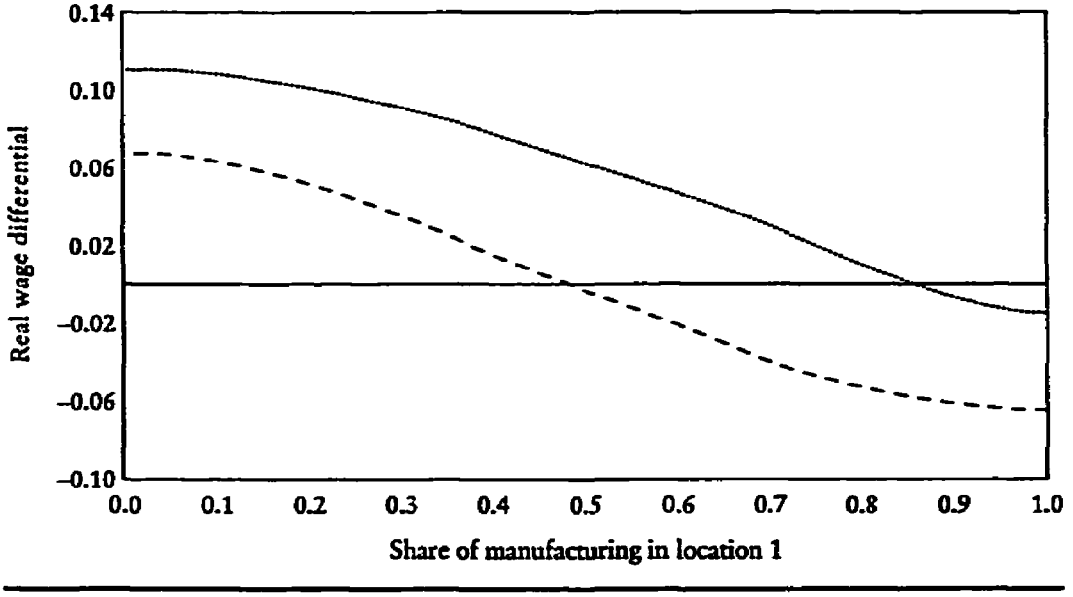
A more subtle source of urban concentration is the importance of access to the government, especially in highly interventionist states. In its simplest form this is simply a result of the concentration of lobbyists. More subtly, if government policies tend to be more responsive to those close at hand (if, say, subsidies or protection to prevent strikes are more forthcoming in the capital than in the provinces), this exerts a hard-to-measure but doubtless important attraction of the capital area for business.

Economic modeling per se cannot contribute much to our understanding of these political concerns. It can, however, help us understand a further consequence of political centralization: the multiplier effects on regional concentration that can result from asymmetric government spending.

Consider a variant on the approach described in the last two sections. Put the commuting and land-rent diseconomies to the side and suppose instead that there is an immobile rural population divided between two regions. Manufacturing will be drawn to concentrate in one region by the forward and backward linkages we have already seen in action, but against this force will be the pull of the market provided by the rural population. A model along exactly these lines is worked out in Krugman (1991b). I show there that the outcome depends on the parameters. For some parameters one gets the type of result shown by the dashed curve in figure 3: the stable equilibrium is one in which manufacturing is equally divided between the two regions.

But now suppose that a government collects taxes from the rural population in both regions but spends it all in one region. Obviously the latter region becomes the larger market, thus attracting more manufacturers. However, the forward and backward linkages that are generated attract still more manufacturing to that region, fos-

Figure 3. *Response of Manufacturing to Relative Wages*



tering a cumulative process of concentration. In figure 3 we start with an economy in which the natural state of affairs has 50 percent of manufacturing in each region. In this example a tax equal to 20 percent of rural income was collected in both regions, but spent only in region 1. The result is shown by the upward shift in the schedule relating the real wage differential to the allocation of manufacturing between the regions (the dotted curve). In this case the multiplier effects cause a concentration of approximately 85 percent of manufacturing in the favored region. The direct transfer of resources from the periphery to the core is only 8 percent of GDP, but the end result is to raise the favored region's share of GDP (before taxes) from 50 to 74 percent.

Although it is not explicitly modeled here, there ought to be an interaction between the strength of multiplier effects producing regional concentration and the degree of openness of the economy. Locating manufacturing near the capital in order to take advantage of the market that the government and its employees provide will be much less attractive in a very open than in a very closed economy.

Transportation Infrastructure

The extent and form of a country's investments in transportation infrastructure can affect the tendency to form large urban centers in at least two ways.

First, the higher transport costs are within a country, the stronger the advantages in terms of backward and forward linkages of locating production near an established metropolitan concentration. This effect may be seen directly in equation 5, which asks whether the linkages are strong enough to sustain an established concentration in the face of the diseconomies of urban scale. In this expression the higher are the transport costs, the more likely is the condition for sustainability to be satisfied.

The implication is that the tendency to concentrate economic activity in a single large city may be reinforced if the government neglects the transportation network. This makes intuitive sense, and corresponds to workaday perceptions about the contrast between location decisions in advanced and developing economies. In advanced economies good transportation to markets (and good communications) is available virtually everywhere, whereas in developing countries roads and telecommunications often peter out quickly as one moves away from the capital.

A more subtle issue involves the form of the transport system. A system that is centered on the primate city is more likely to promote concentration than one that does not favor movement of goods and services in any particular direction.

This point also seems intuitively obvious, but it may be worth sketching out how it works in formal models. Imagine, as in Krugman (1993a), a country with not two but three regions. And suppose that instead of being equal in all directions, transport costs between location 1 and both other locations are lower than those between 2 and 3, so that 1 is in effect the hub of the transport system. Then it is straightforward to show that even if all three regions offer the same size market, region 1 will be a preferred location for goods produced subject to scale economies: it offers bet-

ter access to the national market than does either of the other locations. Of course, such an advantage will not usually stand alone. Typically, concentration of population and centralization of the transport system reinforce one another: transport links point toward the primate city because that is where the markets and suppliers are, and business concentration is all the greater because of the role of that city as a transport hub.

One might speculate that the apparent tendency of developing countries to have more concentrated distributions of urban size is due to an important extent to the way that their relative poverty leads to a limited transport system. In advanced countries the volume of traffic is sufficient to ensure that good roads link even minor centers; railway lines will often provide direct connections that bypass the biggest cities.[6] In developing countries traffic is sufficient to support good roads pointing only toward the capital, if any at all. Here, too, there is probably a political linkage—a system that centralizes political power in the capital is likely to concentrate investment in infrastructure either near it or on projects that serve it.

Policy Implications

One wants to be very careful about drawing policy implications from any discussion of urbanization and regional growth. By its nature this is a subject that deals extensively with external economies and diseconomies; while neoclassical urban systems theory may suggest that competition among city developers yields optimal results, the newer literature does not contain any such suggestion. Yet the extent and even the direction of the deviations from optimality may be sensitive to the particular form of the external effects. One could in principle argue that since the growth of cities necessarily involves positive external economies, the biggest cities tend to be too small. Or one could argue that the diseconomies of congestion and pollution—or the inability of markets to internalize the benefits of creating new cities—mean that primate cities are too big. Most people have an instinctive feeling that the biggest cities are too big. I share that prejudice, but it must be said that it is only a prejudice at this point.

That said, the general moral of the models described here seems to be that a desire for cities in developing countries to be not quite so big may be fulfilled indirectly by the kinds of liberal economic policies currently favored by most international institutions for other reasons. Liberal trade policy appears likely to discourage primate city growth; so does a reduction in state intervention and a decentralization of power. Investment in better transportation infrastructure—a traditional role of government—also seems to work in the same direction.

The tentative conclusion, then, is that neoliberal policies seem likely to have the unexpected side benefit of partly alleviating any problems created by the growth of very large cities. The definite conclusion is that whatever the changes made in economic policies, their implications for urban and regional development within countries are an important, neglected issue.

Appendix

In this appendix I present the formal structure of the model of the determinants of urban concentration sketched out in the second section of the article and illustrated in the third. For a full description of how the model is solved, and an exploration of its properties, see Krugman and Livas Elizondo (1992).

A Formal Model of Urban Concentration

We consider an economy with three locations: 0, 1, and 2. Labor is mobile between 1 and 2, but not from the rest of world.

Each location is a linear city, populated by workers who must work in a central business district but require one unit of land to live on. Thus if a location has a labor force L_i, the distance the last worker must commute is

$$d_i = L_i/2. \tag{A.1}$$

We assume that commuting costs are incurred in labor: a worker is endowed with one unit of labor, but if he must commute a distance d, he arrives with a net amount of labor to sell of only

$$S = 1 - 2\gamma d. \tag{A.2}$$

These assumptions immediately allow us to describe the determination of land rent given the labor force at a location. Let w_i be the wage rate paid at the city center per unit of labor. Workers who live at the outskirts of the town will pay no land rent, but will receive a net wage of only $(1 - \gamma L_i)\, w_i$ because of the time spent in commuting. Workers who live closer to the city center will receive more money, but must pay an offsetting land rent. The wage net of commuting costs declines as one moves away from the city center, but land rents always exactly offset the differential. Thus the wage net of both commuting and land rents is $(1 - \gamma L_i)\, w_i$ for all workers.

The total labor input of a location, net of commuting costs, is

$$Z_i = L_i\,(1 - 0.5\gamma L_i) \tag{A.3}$$

and the location's total income—*including* the income of landowners—is

$$Y_i = w_i Z_i. \tag{A.4}$$

Next, we assume that everyone in the economy shares the constant elasticity of substitution utility function

$$U = \left(\sum_i C_i^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}. \tag{A.5}$$

To produce any good i at location j involves a fixed as well as a variable cost:

(A.6) $$Z_{ij} = \alpha + \beta Q_{ij}.$$

The properties of monopolistic competition models like this are by now very familiar. As long as many goods are produced, and as long as we make appropriate assumptions on transportation costs (see below), each producer faces an elasticity of demand equal to the elasticity of substitution, and will therefore charge a price that is a constant markup over marginal cost:

(A.7) $$P_j = (\sigma/\sigma - 1)\,\beta w_j.$$

Given this pricing rule and the assumption that free entry will drive profits to zero, there is a unique zero-profit output of each product:

(A.8) $$Q = (\alpha/\beta)\,(\sigma - 1).$$

And the constancy of output of each product implies that the number of goods produced at each location is simply proportional to its net labor input after commuting:

(A.9) $$n_j = (Z_j/\alpha\sigma).$$

It will save notation to make two useful choices of units. First, units are chosen to make the f.o.b. price of goods produced at any given location equal to the wage rate at the region's city center. Thus:

(A.10) $$P_j = w_j.$$

Second, there is no need to count goods one at a time. They can be equally well counted in batches, say, of a dozen each. To save notation, the batch size is such that

(A.11) $$n_j = Z_j.$$

To preserve the constant elasticity of demand facing firms, the costs of transacting between locations must take Samuelson's "iceberg" form, in which transport costs are incurred in the goods shipped. Thus we assume that when a unit of any good is shipped between location 1 and location 2, only $1/\tau$ units actually arrive; thus the c.i.f. price of a good shipped from either domestic location to the other is τ times its f.o.b. price. Only a fraction $1/\rho$ of a good imported from location 0 is assumed to arrive in either location 1 or 2. For simplicity, exports are assumed to take place with zero transport costs.[7]

We take τ to represent "natural" transport costs between locations. The parameter ρ, however, is meant to be interpreted as combining natural transport costs with artificial trade barriers. It would be straightforward (and would yield similar results)

in this model to introduce an explicit ad valorem tariff whose proceeds are redistributed, but here we simply imagine that any potential revenue is somehow dissipated in waste of real resources.

Given these transport costs and the utility function, we may define true consumer price indexes for manufactured goods in each location. First, let us define the shares of the three locations in the total number of products produced, which are equal to their shares of net labor input:

$$\lambda_j = \frac{n_j}{\sum_k n_k} = \frac{Z_j}{\sum_k Z_k}. \tag{A.12}$$

Let the wage rate in location 0 be the numeraire; then the true price indices are

$$T_0 = K\left(\lambda_0 + \lambda_1 w_1^{1-\sigma} + \lambda_2 w_2^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \tag{A.13}$$

$$T_1 = K\left[\lambda_0 \rho^{1-\sigma} + \lambda_1 w_1^{1-\sigma} + \lambda_2 \left(w_2 \tau\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{A.14}$$

$$T_2 = K\left[\lambda_0 \rho^{1-\sigma} + \lambda_1 \left(w_1 \tau\right)^{1-\sigma} + \lambda_2 w_2^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{A.15}$$

where

$$K = \left(n_0 + n_1 + n_2\right)^{\frac{1}{1-\sigma}}. \tag{A.16}$$

We will take Z_0 as given. Suppose we know the allocation of labor between locations 1 and 2. Then we can determine Z_1 and Z_2. As we will see, we can then solve the model for equilibrium wage rates w_j. Labor is, however, mobile, and we will have a full equilibrium only if all domestic workers receive the same net real wage. This net real wage in location j can be defined as

$$\omega_j = w_j (1 - \gamma L_j)/T_j. \tag{A.17}$$

A situation in which real wages are equal in the two domestic locations is an equilibrium. Such an equilibrium may, however, be unstable under any plausible adjustment story. To get some rudimentary dynamics, we impose a simple Marshallian adjustment mechanism,

$$dL_1/dt = -dL_2/dt = \delta\,(\omega_1 - \omega_2). \tag{A.18}$$

We have now laid out a complete formal model. It is not a model with a closed-form analytical solution. However, if one is willing to rely on numerical examples, it is straightforward to solve the equations on the computer for any given parameters and see how the wage differential depends on the allocation of labor between

the two locations, thereby deriving diagrams like figures 1 to 3. As explained in the text, such pictures allow us to see how the patterns of urban or regional concentration change as the parameters change.

City Growth and Power Laws

As mentioned in the text, the size distribution of cities is startlingly well described by a power law of the form

$$N(S) = AS^{-\alpha} \tag{A.19}$$

where $N(S)$ is the number of cities with populations larger than S, and the exponent is very close to –1. (As an illustration, figure A.1 plots the log of metropolitan area rank against the log of city population for the United States in 1991.)

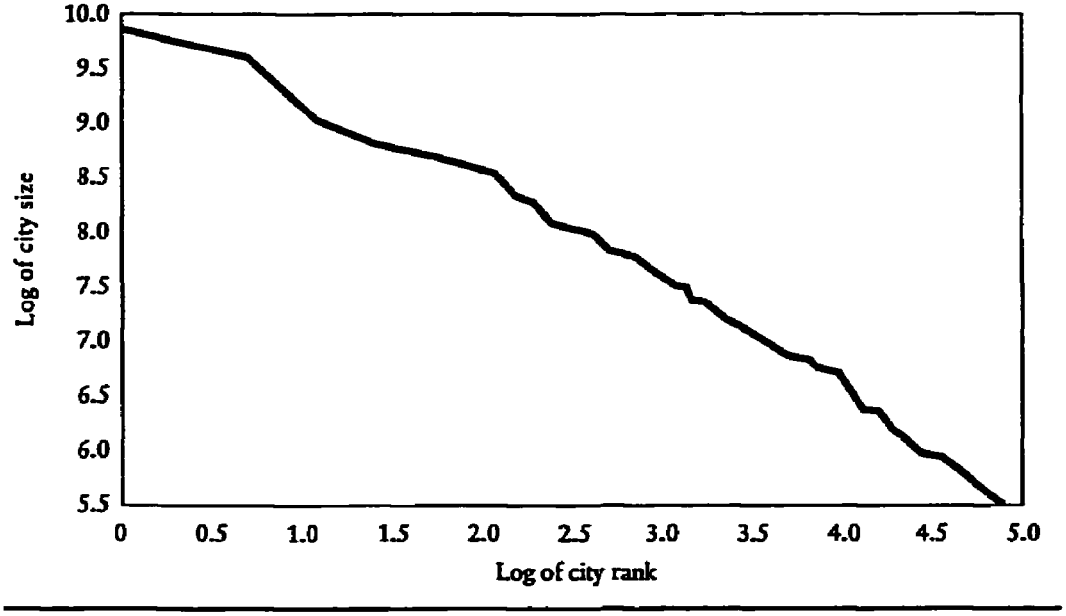
If the distribution of cities were continuous and there were no maximum city size, equation A.19 would be equivalent to saying that the density of cities of size S is

$$n(S) = \alpha A S^{-\alpha-1}. \tag{A.20}$$

Now imagine that cities come only in discrete sizes, with units of, say, 10,000 people. Let k be the number of units in the population, and $n(i,k)$ be the number of cities with i units; then equation A.19 with an exponent of –1 becomes the statement that

$$n(i,k) = B(k)i^{-2}. \tag{A.21}$$

Figure A.1 *Relation of U.S. City Rank and City Size*



Why should something like equation A.21 be true? In 1955 Herbert Simon offered an ingenious explanation, which is a bit short of a formal proof. I offer here a heuristic version of Simon's argument, which is in turn less than rigorous, so it should be viewed only as a suggestive justification.

Imagine that urban growth proceeds according to the following process: new units arrive in the economy successively over time; each new unit is attached to an existing city with a probability that is proportional to the number of units already there. (In Simon's original formulation, some units form the nuclei of new cities; I return to that issue below.) Thus a city of size i has a probability i/k of getting the next unit.

What is the expected change in the number of cities of size i when a new unit is added? That number can change in two ways. First, a city of size $i-1$ can acquire the new unit, in which case it becomes a city of size i, adding 1 to the total. Second, a city of size i can acquire the unit, in which case it becomes a city of size $i+1$, reducing the number of i cities. It therefore follows that

$$E[\Delta n(i,k)] = \frac{(i-1)n(i-1,k)}{k} - \frac{in(i,k)}{k}. \tag{A.22}$$

Now comes the crucial ad hoc step. Simon asks us to imagine that the frequency distribution of city sizes approaches a steady state. This cannot be quite right, since the largest city keeps on getting bigger. But suppose that it is approximately true. Then the number of cities of size i must grow at the same rate as the population, implying

$$E[\Delta n(i,k)] = \frac{n(i,k)}{k}. \tag{A.23}$$

From equations A.22 and A.23 it follows that

$$\frac{n(i,k)}{n(i-1,k)} = \frac{i-1}{i+1} \tag{A.24}$$

and thus that

$$n(i,k) = \frac{i-1}{i+1}\frac{i-2}{i}\cdots\frac{1}{3}n(1,k) \tag{A.25}$$

or

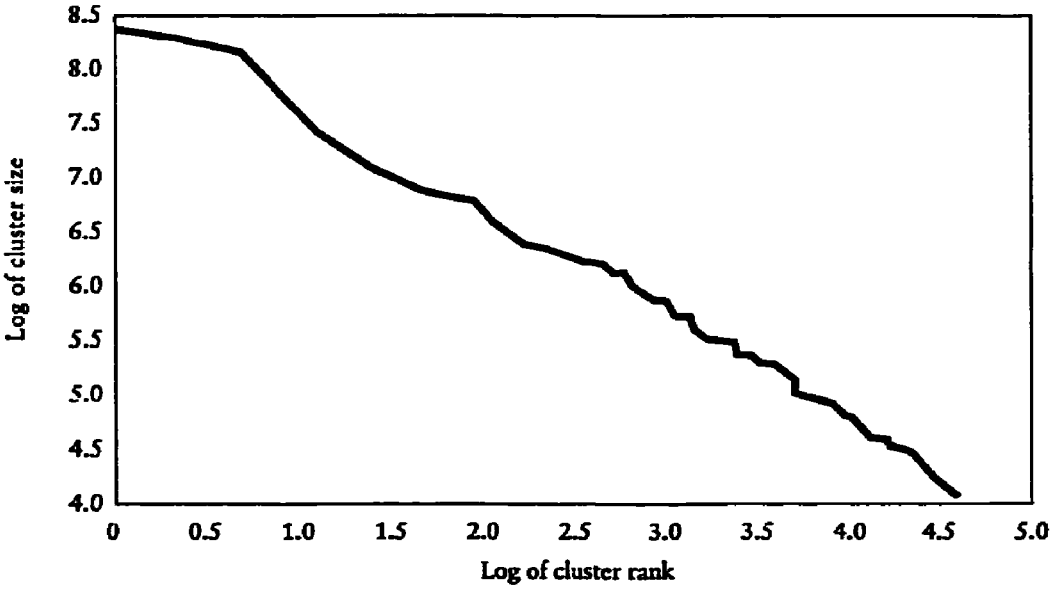
$$n(i,k) = \frac{2}{i(i+1)}n(1,k) \approx 2n(1,k)i^{-2} \tag{A.26}$$

for large i.

That is, in the upper tail of the size distribution, equation A.21 should be approximately true!

This derivation is a bit slippery. It can be bolstered, however, by simulation results; these show that a wide variety of stochastic growth models will produce upper tails for which equation A.21 is very close to true. For example, in Krugman

Figure A.2 *Relation of Simulated City Rank and Size, Top 100 Cities*



(forthcoming) I consider a model of the following form. A city is begun by an entrepreneur who starts a business. She has two foremen, each of whom with probability p leaves to set up a new factory in the same town. Each foreman has two foremen. Suppose that the probability of defection is close to 0.5, as it must be if towns are to grow very large. Then the results are startling. In figure A.2, I started with 1,000 original businesses, and set $p = 0.49$; the figure shows the relationship between rank and size for the top 100 "cities."

There is a close affinity between Simon's work and the trendy current work on "self-organized criticality," which attempts to explain such observed power-law relationships as the Gutenberg-Richter law relating the sizes and frequencies of earthquakes (Bak 1991).

Notes

1. It is possible, without any real change in the structure, to derive external economies from a monopolistically competitive sector that produces nontraded inputs. See Abdel-Rahman (1988) and Rivera-Batiz (1988).

2. Before the Rosen and Resnick study (1980) most writing on primacy assumed that export orientation would tend to *increase* primacy. The ruling image was of a primary exporting country in which the primate city would be the country's main port; the implicit argument was that the economies of scale involved in building infrastructure for exporting were larger than those involved in selling to the domestic market. One can hardly deny that this effect has existed in some times and places; the evidence that the effect runs the opposite way is not overwhelming. This kind of ambiguity arises in any attempt to summarize the richness of cross-national variation with a short list of explanatory variables.

3. In what are commuting costs incurred? It is easiest to assume that they are incurred only in workers' time, and that time spent commuting is time not spent working. In this case, as shown in the appendix, the net wage rate of the most remote worker in a city of population L takes the form $w(1 - \gamma L)$, where w is the wage at the center.