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There are two figures in the paper (Figure 1 and Figure 2). It is important that these should appear at the same size. I would also request that these appear as double-column figures; otherwise these will be difficult to read.)

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THE SPATIAL-CYCLE MODEL REVISITED

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Abstract: The spatial-cycle model (SCM) is concerned with a series of stages (based on population changes), through which a given area is expected to pass. Two versions of this model are explored: the more common "standard version"; and a proposed "alternative version". Taking a single-area perspective, consideration is given to the extent to which the sequence of stages within the SCM is consistent with observed outcomes. The model is then examined from a system-wide perspective. It is concluded that although the SCM is found wanting in a number of important respects, its apparent outright rejection does not seem warranted.

Key words: Spatial-cycle model Centralization Decentralization Overall population change

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INTRODUCTION

Starting some four decades ago, considerable effort has gone into the development of the Spatial-Cycle Model (SCM), as a means for coming to grips with population change in urban and regional systems.[1] Over the last ten years or so, however, interest in the model has fallen away in a dramatic manner, and it is not obvious why this should have been the case. Was the SCM simply a victim of fashion, a tendency that is all too common nowadays, or was it passed over because it suffered from certain conceptual weaknesses or expositional shortcomings, including the absence of a common terminology? The following discussion seeks to cast light on these questions, and also to evaluate the overall worth of the SCM. In particular, an attempt is made to identify various ambiguities and gaps in previous presentations of the SCM. Attention is also drawn to its general lack of predictive ability.

The SCM is concerned with population change within an area that can be meaningfully divided into two sections: a core and a ring. The core is typically viewed as some economic or social focus, while the ring represents a territory surrounding the core, usually in all directions. The two sections of the area are closely related to each other in terms of one or more interactions such as trade, commuting, migration, capital movements, etc. Central to the SCM is a series of particular

population changes in the core and the ring, which defines a set of stages of spatial change. These stages are held to exist in an ordered sequence to form a cycle, through which an area is expected to proceed over a specified time horizon. The time horizon comprises a number of consecutive intervals, usually of equal duration. N.B. The number of time intervals is wholly independent of the number of stages. As will become apparent, the SCM is not to be regarded as a theory of spatial development. Rather, it represents an empirically-based attempt at characterizing spatial population change over the long run.

The SCM may be applied in different settings, and for each case it is usual to impose some minimum threshold population for the overall area. One such setting is the "functional urban region" (FUR), as outlined by Hall and Hay (1980) and Cheshire and Hay (1989) among others. Here the core is typically represented by a central city (usually the political city). This is generally smaller than the "built city" (BC), i.e. the physical extent of the city or metropolitan area. The ring is composed of political or administrative units, and in Western Europe it is typically the municipality, the commune or some other type of local-government district, this forming the basic building block of the FUR. In the US the "Metropolitan Statistical Area" (MSA) is roughly equivalent to the FUR, with the county as the building block. The core is the central (political) city, and the ring consists of the rest of the county in which the central city is located, and sometimes includes one or more contiguous counties. A given unit (a municipality in Western Europe or a county in the US) is included within the overall area, if it meets certain criteria, the most important of which is a specified percentage of its workforce (often as low as 10% or 15%) being employed in the core. In this setting the ring contains a rural population as well as an urban population located in the vicinity of the core and/or in centres beyond the BC.

A second setting in which the SCM may be applied, involves an area that can be referred to as the "extended city". Here the core is the entire BC, while the ring (again containing a rural and urban population) is a territory which is economically linked to the core according to one of several

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well-defined criteria, relating to employment, consumption and the workforce (Parr, 2007). Depending on which criterion is being used, the core and the ring thus form a particular category of extended city, which would be less extensive than the FUR. In a third setting for the SCM the area is confined to the BC. In this case the core represents the central city, which has some functional, political or historical significance, and the ring comprises the remainder of the BC. The "Urbanized Area" in the US would be one example of this setting, as would the "Metropolitan County" in the UK, the unit replacing the "Conurbation", which is no longer used for official purposes and which appears to have lost much of its former currency. This third setting is necessarily of a more limited extent than the previous two settings. Additional settings for the SCM are possible, of course.

The comments below are of a general nature, so that no specific reference is made to the three settings of the core-ring structure outlined immediately above. Attention is initially focused on what is referred to here as the "standard version" of the model, the version employed in most studies of the SCM to date, where spatial changes in population are considered in absolute terms. This is followed by a parallel discussion of a suggested "alternative version" of the model, in which spatial population change is examined in relative terms. The possibility of utilizing such an approach appears to have gone largely unrecognized, limiting to some extent the scope of the SCM. Important differences are shown to exist between the two versions. The latter half of the paper examines the SCM from a single-area perspective. This is followed by the application of a system-wide perspective, which has a cross-sectional emphasis but also a longitudinal aspect.

THE STANDARD VERSION OF THE SCM

This section reviews the fundamentals of the version of the SCM that has been customarily employed, and also includes several modifications and extensions. The standard version of the SCM model considers population changes in the core and the ring in absolute (or numerical) terms over a specified interval. In order to track simultaneous population changes in the two sections of

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the area, use is often made of a diagram, similar to the one indicated in Figure 1. The horizontal axis of this diagram refers to ΔC, the absolute change in core population over a given interval, while the vertical axis is concerned with ΔR, the absolute change in ring population over the same interval. Each axis has a positive as well as a negative range. Thus, at any location to the right of the vertical axis the core population is growing over the interval, but declining at any location to the left of the axis. Correspondingly, for a location above the horizontal axis the ring population is growing, and a location below this axis indicates a declining ring population. A particular location in Figure 1 thus refers to a unique combination of absolute population changes in the core and ring over a given time interval. The significance of the two diagonal lines is discussed below.

Figure 1 about here---au

Specification of Phases and Stages

The two-dimensional space of Figure 1 can be divided into four quadrants, each representing a phase of change, and each being characterized by spatial-structure change over the entire area as well as its population change. The four phases, indicated as Roman numerals in Figure 1 and Table 1, are as follows: I. centralization and growth; II. decentralization and growth; III. decentralization and decline; and IV. centralization and decline.[2] A different designation of the four phases is presented in the Appendix. It is usual for all of the four phases to be divided into two sub-phases, with each regarded as a stage in the cycle. Each stage is represented in Figure 1 by a sector labelled with an Arabic numeral, and throughout the paper the numbering of stages follows the pattern adopted by Klaassen *et al*. (1981, Figure 2.1). Table 1 describes the distinguishing features of each stage, which refers to a distinct form of population change in the core-ring structure. Various other ways of describing the stages in this version of the SCM are outlined in the Appendix.

Table 1 about here---au

Application of the SCM initially involves plotting the population changes in the core and ring in Figure 1 for an individual area over a number of consecutive intervals. A simplification is

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introduced, by which any core-ring plot is required to lie wholly within a sector and is not therefore located on an axis or a diagonal. This assists with the characterization of phases and stages in Figure 1 and Table 1. By excluding the location of a plot on either diagonal, spatial-structure change at any stage involves either centralization or decentralization, while overall-population change is strictly positive or strictly negative, as discussed below. If, over two or more consecutive intervals, the core-ring plot for an area in Figure 1 continues to be located within a particular sector, the area remains at the same stage. If, on the other hand, the location of the plot changes to another sector, there is movement to a different stage.

It is usual to assume that the cycle starts at Stage 1, although some authors have suggested that the cycle starts at a different stage. Hall and Hay (1980, p. 184), for example, argue with some justification that by virtue of core population growth, Stage 8 marks the start of the cycle (in terms of the stage numbering used here). Cheshire and Hay (1989, pp. 29-30), on the other hand, place the start at Stage 7 (again in the numbering used here), probably on the grounds that core population decline is less than ring population decline. It will be argued later that under particular circumstances each of these two possibilities represents a valid start of the cycle. However, the start of the cycle is best determined on a case-by-case basis, according to the historical context of spatial change within an area. The trajectory of an area over a particular time horizon is assumed to follow the cycle of stages, represented by the numbered anti-clockwise sequence in Figure 1. It will be demonstrated that this is frequently at odds with reality. The stage at which the cycle finishes, is considered in a later section.

The Measurement of Decentralization and Overall Growth

The SCM can be extended to provide a quantitative measure of two particular kinds of change within the entire area over a given interval: change in the spatial structure of the area; and change in

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its overall population. It is possible to specify each in absolute terms by means of a simple expression. In the case of spatial-structure change,

$$K = \Delta C - \Delta R \qquad (K \neq 0;\ \Delta C \neq \Delta R) \tag{1}$$

where K measures the net shift of population to the core or to the ring over an interval that begins at time τ and ends at time t. The terms ΔC and ΔR represent the absolute population changes in the core and ring over the interval τ to t. If $K > 0$, there is centralization (a net shift to the core), while if $K < 0$, there is decentralization (a net shift to the ring). A given area is undergoing centralization, if the core-ring plot (and thus the relevant sector) in Figure 1 lies below the upward-sloping diagonal, but a plot (and its sector) located above this diagonal is indicative of decentralization.

With regard to overall population change, this can be expressed as

$$G = \Delta C + \Delta R \qquad (G \neq 0;\ \Delta C \neq \Delta R) \tag{2}$$

where G is the population change, with ΔC and ΔR as previously defined. If $G > 0$, there is overall population growth, but overall population decline is present if $G < 0$. Whenever $G > 0$, the core-ring plot for the area (and the relevant sector) lies above the downward-sloping diagonal, but when $G < 0$, the plot (and its sector) lies below this diagonal. The values of K and G for each stage are shown in Table 1.

AN ALTERNATIVE VERSION OF THE SCM

It is not at all obvious why applications of the SCM have always considered population changes within the core and ring in absolute terms. This section considers an alternative version of the SCM, in which population change is measured in a different manner. Although this alternative version is similar in several respects to the standard version, certain underlying differences are present. Most important is the fact that whereas the standard version considers population change in absolute terms, the alternative version is concerned with change in relative terms. The alternative

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version makes use of Figure 2, which bears a resemblance to Figure 1. Now, however, the horizontal axis refers to *c*, the rate of change in core population over a given interval, and the vertical axis refers to *r*, the rate of change in ring population over the same interval. The terms *c* and *r* are expressed as fractional rates of change, so that a fractional rate of change of 0.06, for example, represents a growth rate of 6 percent. Any location in Figure 2 refers to a unique combination of relative population changes in the core and the ring over the given time interval.

Figure 2 about here--au

Specification of Phases and Stages

As shown in Figure 2 and Table 2, there are four phases of change, indicated by Roman numerals. Each phase is divided into two sub-phases which are again regarded as stages, and which appear as sectors (numbered in Arabic numerals) in Figure 2 and Table 2. As before, the four phases are characterized in terms of spatial-structure change across the entire area and also its overall population change: I. centralization and eventual growth; II. decentralization and initial growth; III. decentralization and eventual decline; IV. centralization and initial decline. The term "eventual" used in connection with Phases I and III refers to population change in the second stage of the phase, while the term "initial" in Phases II and IV refers to population change in the first stage of the phase. For the remaining four stages (Stages 1, 4, 5 and 8), the overall-population change cannot be inferred from Figure 2, so that additional information is required, as will be discussed shortly. The defining features of each stage are described in Table 2.

Table 2 about here---au

In common with the standard version of the model, application of the alternative version commences with the plotting of population changes in the core and the ring (now in Figure 2) for an individual area over a number of intervals. Again, we employ the convenient assumption that no plot lies on an axis or on a diagonal. Since a plot is never on the upward-sloping diagonal, spatial-structure change must either involve centralization or decentralization (the downward-sloping

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diagonal is considered in the next sub-section). The alternative version is similar to the standard version in another respect: if over two or more consecutive time intervals the core-ring plot for a given area changes its location in Figure 2 from one sector to another, this indicates movement to a different stage. If, however, the location of the plot does not change to a different sector, the area remains at the same stage. It may be assumed that the cycle starts at Stage 1, as in the standard version, although a case can be made for Stage 8 or Stage 7 as the start. However, in contrast to the standard version of the SCM, no assumption is made in the alternative version regarding the manner in which an area will pass through the stages, nor about the final stage of the cycle.

Additional Features of the Alternative Version

In the alternative version of the SCM, it is possible to measure spatial-structure change and overall-population change, as was done in the standard version, though this is now undertaken differently. Spatial-structure change is measured by the index *k,* which is expressed as follows:

$$k = \frac{1+c}{1+r} \qquad (k \geq 0;\ k \neq 1;\ c, r \geq -1;\ c, r \neq 0;\ c \neq r) \tag{3}$$

where c and r are the fractional rates of population change for the core and the ring over the interval τ to t. If $k > 1$, the spatial structure of the area is undergoing centralization, and if $0 \leq k < 1$, there is decentralization. As with the standard version, centralization is evident if the core-ring plot for the area (and its sector) lies below the upward-sloping diagonal, while a plot (and its sector) lying above this diagonal involves decentralization. In the case of overall-population change the value of g, the fractional rate of change, is expressed as

$$g = \frac{Cc + Rr}{C + R} \qquad (c, r \geq -1;\ c, r \neq 0;\ c \neq r) \tag{4}$$

where C and R are the respective populations of the core and the ring at time τ (the beginning of the interval), with r and c defined as above. The values for k and g are shown in Table 2.

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It is known that the value of g is positive at Stages 2 and 3 (since c and r are both positive), and negative at Stages 6 and 7 (since c and r are both negative). In order to calculate g for the four remaining stages (i.e. Stages 1, 4, 5 and 8), further data are required. The reason for this is reflected in the structure of equation (4), where the value of g depends not only on c and r, the fractional rates of population change in the core and the ring, but also on the values of C and R, the core and ring populations at time τ. For Stages 1,4, 5 and 8, therefore, g may assume a positive, negative, or zero value.[3] An example, involving three cases, illustrates this point with respect to an area at Stage 4, as indicated in Figure 2 and Table 2.

In the first case it is assumed that at time τ the core and ring populations (in thousands) are C = 100 and R = 300, and that their rates of population change over the interval τ to t are c = -0.1 and r = 0.2. It follows from equation (4) that g = 0.125, indicating a positive growth rate in overall population. However, in a second case, where C = 300 and R = 100, with c and r remaining the same, g = -0.025, indicating a negative growth rate in overall population. In the third case, where C = 300 and R = 150 with c and r again remaining the same, g = 0, so that there is no overall-population change. Because of this feature of the alternative version of the SCM, the downward-sloping diagonal in Figure 2 does not have the same significance that it does in the standard model (Figure 1): it does not separate those plots (and their relevant sectors) involving overall population growth from plots (sectors) involving decline.

THE TWO VERSIONS CONTRASTED

In certain respects the two versions of the SCM are similar: both are concerned with population changes in the two sections of an area; both consider spatial-structure change and overall population change; both identify phases and sub-phases (or stages) based on such changes; and both arrange phases and stages in a sequentially related manner. As already noted, however, there are certain underlying differences between the two versions. First, the standard version is

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concerned with population change in absolute terms, whereas the proposed alternative version considers change in relative terms, a difference that is reflected in the labelling of stages in Figures 1 and 2, as well as their description in Tables 1 and 2. Because of this, the phases and stages within the two versions, although having a superficial correspondence, do not refer to the same aspects of change. As a consequence each version has its own distinctive spatial cycle. Second, whereas the standard version assumes that an area will pass through the stages in an anti-clockwise direction, no such assumption is present in the alternative version. A third important difference between the two versions involves overall-population growth of the area. While at each stage of the standard version it is possible to speak of overall population change in definite terms, this cannot be done without additional data in four of the eight stages of the alternative version, as was indicated at the close of the previous section. Such an apparent weakness of the alternative version is, in fact, an advantage, since for certain stages the alternative version is more versatile than the standard version, to the extent that there is no single direction of change in overall population (compare Tables 1 and 2).

A further difference between the two versions of the SCM, perhaps the most telling, concerns the position of a given area in the numbered sequence of stages. It may well be the case that with a particular set of population changes, an area is at Stage 2 of the standard version, for example, and is also at Stage 2 of the alternative version. This need not be the case, however, as the following example demonstrates. It is assumed that at time τ the populations of the core and the ring (in thousands) are such that $C = 200$ and $R = 100$, and that over the interval τ to t the core population increases to 215, while that of the ring increases to 110. In the standard version these changes are expressed as $\Delta C = 15$ and $\Delta R = 10$. From equations (1) and (2) it is the case that $K = 5$ and $G = 25$, indicating centralization and also an absolute increase in the overall population of the area. It can be seen from Figure 1 and Table 1 that the area is at Stage 2 (in Phase I) of the cycle.

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In the alternative version the same population changes in the core and the ring are expressed in relative terms as $c = 0.075$ and $r = 0.1$. According to equations (3) and (4) we have $k = 0.977$ and $g = 0.083$, indicating decentralization and an increase in overall population within the area. It is apparent from Figure 2 and Table 2 that the area is at Stage 3 (in Phase II) of the cycle. Thus under exactly the same conditions of change, the position (both the stage and the phase) occupied by the area in the alternative version is different from its position in the standard version. Although overall-population growth is reflected in both versions, spatial-structure change in the standard version involves centralization, but decentralization in the alternative version. This example is a further illustration of the fact that there is no general equivalence between the two versions of the SCM.

The question inevitably arises as to which of the two versions of the SCM should be employed. Clearly, the selection of one version of the SCM rather than the other cannot be a matter of indifference. There are, of course, bound to be situations where the nature of the analysis may require one version and not the other to be employed. However, since each version emphasizes aspects of spatial change that the other does not (so that each version has particular advantages over the other), there is an obvious complementarity between the two versions, whether a single-area or a system-wide perspective is being adopted. In many situations, therefore, it would be advantageous to make use of both versions: to rely on one version would be to disregard aspects of spatial change that are explicit in the other.

A SINGLE-AREA PERSPECTIVE ON THE SCM

As stated earlier, the trajectory of an individual area through particular stages can be recorded on a diagram similar to Figure 1 or Figure 2. A feature of the standard version of the SCM is that the progress of any area through the stages of the cycle will occur in an anti-clockwise direction, according to the numbered sequence of Figure 1. This is, in fact, an assumption, which is not

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satisfied in an uncomfortably large number of cases. We now consider the extent to which the SCM is consistent with reality, and also discuss the passage of an area through the cycle to its later stages. Unless stated otherwise, attention is confined to the standard version of the SCM, since the overwhelming majority of empirical studies have employed this version. It is the case that throughout this section the argument can be re-phrased in terms of the alternative version of the SCM.

Prolongation of a Stage

Perhaps the most important departure from the SCM occurs where an area stays at a given stage over the course of a lengthy time horizon. Such an occurrence does not refer to the common situation where an area remains at a stage over two or more intervals, but only as a pause before subsequent movement to another stage. The phenomenon of an area remaining at a particular stage over an extended period is not at all unusual. For example, in Western Europe approximately 30 percent of all FURs remained at the same stage over a 1951-1981 time horizon (Cheshire and Hay, 1989, p.145), while in the Federal Republic of Germany over a 1950-1970 time horizon, the stage attained was unchanged in 13 out of 78 cases (Hall and Hay, 1980, Table A. 45). Also, in the US the overwhelming majority of MSAs have been at Stage 4 since 1960, and show no signs of moving therefrom. Various general explanations may be put forward for this particular case, which involves increasing overall population, sometimes in modest terms. One such explanation is related to the "size ratchet effect", by which a combination of economic and political influences helps to maintain the population of an area above some minimum threshold (Thompson, 1965).

This prolongation of a stage over a large number of intervals is reflected in the fact that conditions within the area continue to satisfy the criteria that define the stage, as outlined in Table 1. As a consequence the core-ring plot remains in the same sector in Figure 1, though rarely at the exact location within this sector. It would be incorrect, therefore, to regard this prolongation of a

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stage as a state in which the spatial structure of the area and its overall population remained unchanged. The spatial-structure change will continue in the same direction as in the previous interval but most likely not with the same intensity. Thus at Stage 4, for example, decentralization will continue but at a faster or slower pace than previously. Similarly, overall-population growth will continue, though not at the higher or lower absolute level as previously. Moreover, during this period of prolongation it can be expected that there will be significant qualitative changes in the population with respect to age, gender, educational attainment, etc. There are also likely to be changes in the economy of the area in terms of sectoral structure, occupational structure, skill composition in the labour market, income levels and income distribution.

The Skipping of a Stage

Another departure from the expected sequence of stages occurs when an area skips or by-passes a stage. The phenomenon of a stage being skipped is not at all unusual. From data presented by van den Berg and van der Meer (1981, Diagram 10.1) for FURs in the Netherlands during a 1950-1978 time horizon, it can be determined that five out of 23 areas skipped from Stage 2 to Stage 4, and one skipped from Stage 3 to Stage 5. In the case of the Federal Republic of Germany during a 1950-1970 time horizon, data from Hall and Hay (1980, Table A.45) indicate that out of the 78 areas, 16 skipped a single stage while a further 23 skipped more than one stage.[4] The picture is similar for Italy over a 1951-2001 time horizon, as borne out in the data assembled by Cirilli (2009, Table 5). While it is not possible to ascertain the full extent of areas skipping stages, it can be inferred that as many as 16 out of 160 areas skipped two stages. The phenomenon of stages being skipped is often not remarked upon, because in the reporting of results, areas that have attained a particular stage over a given interval are grouped together or summarized as a numerical total.

Reversion to an Earlier Stage

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The reversion of an area to an earlier stage (usually the previous stage) represents a further exception to the restrictive assumption that the movement through the cycle will be according to the numbered sequence of stages. Various examples of this are revealed in the data presented by van den Berg *et al.* (1987, Table 8.6) on FURs in the Netherlands over a 1970-1982 time horizon. Rotterdam and The Hague moved from Stage 5 to Stage 4, while there was movement from Stage 4 to Stage 3 in the cases of Arnhem, Eindhoven and Heerlen.[5] Movement from Stage 4 to Stage 3 can also be observed over the intercensal decade 1990-2000 for a number of larger areas (MSAs) in the US, including Boston, Chicago, New York City, San Francisco, etc. (United States, 2005, Table 25). This particular reversion of an area to an earlier stage involves a revival of the core in terms of population growth, something that only occurs in the SCM after Stage 7 of the cycle. Much has been made of this recent development, although this has usually been of a modest nature. It remains to be seen whether the stage to which an area has reverted, will be prolonged, or whether this reversion will be a short-lived phenomenon, followed by a resumption of the cycle.

Entering and Exiting from the System

There exists an additional aspect that has usually not figured in applications of the SCM. This is concerned with an area entering or exiting the existing system of areas. The entry process refers to an area becoming part of the system of areas by reaching some arbitrary minimum threshold for overall population during the course of a particular interval, this entry being associated with the start of the cycle for the area in question. The entry of an area into an existing system (which occurs after time τ but before time t) necessarily refers to a stage in which overall population of the area is growing. In the standard version of the model this would involve any stage above the downward-sloping diagonal in Figure 1. Note that in the alternative version this could involve any stage other than Stage 6 and Stage 7. In both versions, however, entry at an early stage of the cycle is the most likely.

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Turning to the exit process, this is concerned with the overall population of an area falling below the minimum threshold during a given interval. For the area in question the cycle halts and the area is no longer part of the system. Taking into account the possibility of a catastrophic population decline in either section of the area, the exiting from the system could occur in the standard version during any stage below the downward-sloping diagonal in Figure 1. In the alternative version, however, this exiting from the system could occur during any stage apart from Stage 2 and Stage 3. For both versions, exiting during one of the later stages appears to be the most probable. Such entry and exit processes may represent important aspects of spatial change, although attention has seldom been drawn to these. In some instances, areas were only included in the analysis, if their populations were above the minimum threshold both at the beginning and the end of the time horizon, in which case the question of entry and exit did not arise.

Passage through the Cycle

It is worth emphasizing that in the majority of nations most areas are not well advanced in the cycle. In Japan, for example, 90 percent of the largest areas were at Stage 1 or Stage 2 over the interval 1975-1980 (Kawashima, 1987, Table 7.7). In a study of the Netherlands for the interval 1970-1978 only four areas out of 23 were beyond Stage 4 (van den Berg and van der Meer, 1981, Diagram 10.1). Comparable studies in other nations of Europe for the interval 1970-1975 (van den Berg *et al*. 1982, Table 7.7) and in the US for the interval 1975-1980 (Kawashima, 1987, Table 7.2) indicate that the overwhelming majority of areas have not passed beyond Stage 4. An area's movement through the sequence of stages depends on population changes in the two sections of an area, and it is not difficult to imagine situations where these changes do not result in movement to another stage. Nevertheless, cases can be identified where the later stages of the cycle have been attained, and these are now considered.

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Cases of Stage 6, where the population decline occurs more rapidly in the core than in the ring, tend to be infrequent. These have been observed in the Federal Republic of Germany during the interval 1971-1981, and involve FURs based on heavy manufacturing (Cheshire and Hay, 1989, Table A.1a). Stage 7, where the population of the core declines less rapidly than in the ring, is also infrequent. This stage has been identified in several areas of the UK over the interval 1971-1981 (Champion, 1986, Table 2), and typically exists when the ring represents an economically-depressed hinterland with a former export base in mining and metallurgical production. The case of Stage 8, involving population growth in the core and continued population decline in the ring is extremely rare. Depending on how the boundaries of the cores and the rings are defined, it is possible that several of the larger manufacturing FURs in the UK and Continental Europe have recently reached Stage 8, having moved to this position from Stage 7 or possibly from Stage 6. In all cases, however, the core growth is very small, in absolute terms. Stage 8 is not to be confused with a stage in which the resumption of core population growth is accompanied by continued ring population growth. Such a stage would involve the reversion of an area to an earlier stage, e.g. from Stage 5 or Stage 4 to Stage 3.

Finish of the Cycle

As with the start of the cycle there appears to be no unanimity as to what constitutes the finish. Following Klaassen *et al*. (1981, Table 2.2), Stage 8 is generally viewed as the finish of the cycle. However, both Hall and Hay (1980, p. 184) and Cheshire and Hay (1989, pp. 28-29) opt for an earlier stage, where population decline in the core is greater than the population decline in the ring, i.e. Stage 6 in the numbering used in this paper. In common with the start of the cycle, the finish is best determined with reference to the context of spatial change within an area. Mention may be made of a further element of uncertainty. This concerns an area that is observed to be at Stage 7 or Stage 8. Either stage could refer to a situation where an area has passed through all or most of the

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previous stages, and is at the finish of the cycle, as discussed in the preceding sub-section. However, it could also refer to a situation where the area is the start of the cycle. Such a stage would describe the case of an economically-backward area, based on subsistence activity or an inefficient agricultural sector, but where the core population was declining very slowly (Stage 7) or was even growing (Stage 8) as a result of an upturn in the level of economic activity, brought about by the process of economic modernization.

But what is the significance of the finish of the cycle, be this at Stage 6, 7 or 8? One possibility is for the final stage to be viewed as a steady state, involving an indefinite prolongation, the general occurrence of which was discussed in an earlier sub-section. Another possibility is to regard the final stage as the precursor to an area's exit from the system. In this case the SCM may be likened to a biological life cycle, which is obviously of limited duration. A third possibility is for the final stage to be seen as a stage heralding the re-start of the cycle. A number of authors have favoured this interpretation, with varying degrees of conviction. Such a view of the final stage implies that the SCM has the character of a recurring process (e.g. a business cycle, a planetary cycle or the cycle of an internal-combustion engine), where the finish of the cycle is followed by the re-start of the cycle. There is, however, little evidence to support this third possibility. Indeed, from what is known about the nature of urban and regional economic change, it is difficult accept the proposition that an area, which is at or near the finish of the cycle (and which has therefore experienced one or more stages involving overall population decline), will then re-embark on the passage through a set of stages comparable to those outlined above.

A SYSTEM-WIDE PERSPECTIVE

For either version of the SCM we now impose a different perspective, involving all areas belonging to a national or sub-national system. The usual approach is to plot the areas of such a system for a given interval on Figure 1 (Aydalot, 1985, pp. 325-326) or, if the alternative version is being

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employed, on Figure 2. In the case of a developed economy the resulting scatterplot will typically contain very few plots at the early stages, relatively many at the middle stages, and few at the later stages, largely because the frequency of such areas tends to be low, as discussed in the previous sub-section. This simple graphical device permits a useful cross-sectional classification of areas according to the stage attained. It also provides a measure of support for the notion of a cycle. Leaving aside the possibility of an area entering the system at some middle stage, an area at Stage 5 of the cycle, for example, is likely to have passed through at least some earlier stages.

This cross-sectional approach can be extended to include a longitudinal dimension, by comparing the plots for consecutive intervals. One approach initially involves the construction of a frequency distribution of the stages reached by the various areas during a particular interval. The serial numbers of the stages are indicated on the horizontal axis from left (Stage 1 or 8 or Stage 7) to right (Stage 8 or Stage 7 or Stage 6), while the vertical axis refers to the actual or percentage frequency of areas at each stage. Past studies have usually indicated a peaked distribution, in the approximate form of an inverted 'V'. When such a procedure is repeated for a series of consecutive intervals, there is a broad tendency for the mode of the distribution to shift to the right and for its height to be lower (Cheshire *et al*., 1986, pp. 1b-1h; Cheshire and Hay, 1989, Figure 7.1; Camagni, 1993, Figure 8.4). This suggests that the longer the time horizon, the more advanced (on average) is the position of areas within the cycle, and (over a certain range) the more even is the distribution of areas among the stages.

A presentational weakness of these inter-temporal approaches is that the trajectory of an individual area may become difficult to trace. One means of circumventing this problem involves the use of a n x n matrix, n representing the number of stages being used (Hall and Hay, 1980, p.184). Each non-zero cell specifies the frequency and identity of all areas that move from one stage to another (or do not move at all) between one interval and the next. The approach can be extended to consider the outcomes between any adjoining pair of intervals in the time horizon.

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Another method of maintaining the identity of areas among intervals involves the use of tabular displays (van den Berg and van der Meer, 1981, Diagram 10.1; Aydalot, 1985, Table 8.12; van der Berg *et al*., 1987, Table 8.6). This enables the passage of each individual area through the stages to be traced, and also permits the entry and exit of areas into the system to be recorded. Unfortunately, this approach becomes unwieldy, if the number of areas is large.

Various attempts have been made to extend the SCM. One of these involves going beyond the multi-area (system-wide) perspective considered above, and exploring the inter-area relations that exist within a system of areas, most notably with respect to migration. Work by van den Berg 1987, pp. 54-61) and van den Berg and Klaassen (1987, pp. 93-95) has drawn attention to the fact that a particular area does not exist as a closed or isolated entity, but has important spillover effects on areas of the next lower hierarchical level or size class which, in turn, influence areas of an even lower hierarchical level. Important as such an approach may be, it is ultimately limited by the sheer complexity of inter-area relations. It is at this point that the practical limits of the SCM are reached.

A CONCLUDING EVALUATION

The SCM is an attempt to generalize the process of spatial change over the last 200 years, drawing on the broad sweep of developments within economically-advanced nations of the world, admirably summarized by Hall and Hay (1980, pp. 27-28). The SCM has thus been concerned with an environment in which population growth and urbanization were taking place at a rapid rate. The expansion of population tended to result from economic growth, which was based in large measure on industrialization which, in turn, was dependent on mass production, made possible by immobile economies of scale. It is fairly obvious that this chain of relationships will not continue to be present in nations of the developed or the developing world. Furthermore, the anticipated downturn of total population over the next 50 years in Japan and certain nations of the former Warsaw Pact, for example, casts doubt on the validity of the SCM, certainly in terms of the sequence of stages

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proposed in the model. More generally, it is entirely possible that unforeseeable futures may bring in their wake, developments which give rise to wholly different sequential sets of stages, examples of such developments being changes in transport technology, energy availability and large-scale migrations (in Europe from east to west as well as from south to north).

Aside from questions about its long-term applicability and relevance, the SCM suffers from at least three drawbacks. The first concerns the fact that the positioning of an area at a particular stage is sensitive to the extent of the core and the ring. Even relatively small changes in the outer boundary of the core and/or that of the ring can place an area at a different stage, and this would almost certainly be the case if a given area was considered in terms of the three settings outlined in the Introduction. A second drawback is the impression conveyed by authors (intentionally or otherwise) that there is an inevitability to the uni-directional passage through the stages of the cycle beyond the initial stage of the standard version. Indeed, the very term "cycle" implies such movement, as does the use of directional arrows in diagrammatic representations of the cycle. It will be recalled that an area may remain at a particular stage for an indefinite period. Furthermore, an area skipping a stage, reverting to an earlier stage, as well as entering the system or exiting from it, all represent additional possibilities. For many areas the cycle of stages, to the extent that it can be said to exist, is irregular or incomplete or both, something that seriously weakens any predictive ability that the model might have. The fact that these complications come to the fore when a single-area perspective on the SCM is adopted, point to the system-wide approach as the preferred perspective, largely because of its less mechanistic character.

A further drawback of the SCM is that it comprises a set of propositions that is based exclusively on observed trends, and is thus more concerned with the phenomenon of spatial change than with explanations for this. The SCM gives little consideration to theories of urban and regional economic change, to the role of agglomeration economies and diseconomies, to the locational preferences of firms and households, to the effects of rising incomes, to the influence of changing

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modes of moving people and freight, etc. The SCM cannot, therefore, be seen as a theoretical framework, not that this has ever been seriously claimed. It is possible, of course, to construct a theoretical scheme along these lines that would provide *ex post* rationalizations for the different stages and their sequence in the cycle. A number of interesting (but partial and unconnected) attempts have been made in this direction (Klaassen and Paelinck, 1979; van den Berg *et al*., 1982; Aydalot, 1985; Camagni, 1995; Lever and Champion, 1996), but a comprehensive statement has yet to appear.

These various deficiencies notwithstanding and for the present at least, the SCM provides an important narrative background to spatial change, as well as a simple accounting structure for describing this. In addition, it offers an efficient means of organizing and presenting data on population changes across different areas and over various time intervals. The model can also be used as a basis for classifying areas within a national or sub-national system, as well as for the formulating and testing of hypotheses relating to spatial change. And the SCM is probably at its most illuminating when the results of a population-based application are related to applications based on employment and income (GDP), for both single-area and system-wide perspectives. As long as its various limitations are recognized (and these are sometimes severe), the SCM remains an important preliminary approach in the analysis of population change over space, primarily because most of the alternatives lack its comprehensive coverage. More than anything else, it was the failure to accept such an assessment of the SCM that led to disenchantment with the approach and to its virtual abandonment. This appears to be a further case (by no means unknown in the social sciences) of the useful being jettisoned along with the dispensable.

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APPENDIX

It is possible that acceptance of the SCM has been hindered to some degree by the lack of a consistent and commonly-accepted system of classification. This Appendix is concerned with the descriptions of phases and stages which have been used in the standard version of the SCM. The following sequence of phases has been commony employed: "urbanization"; "suburbanization"; "deurbanization" (sometimes termed "desuburbanization"); and "reurbanization" (Klaassen and Scimemi, 1981, pp. 13-15; Aydalot, 1985, pp. 320-327; Klaassen *et al*., 1987, pp. 87-88); Camagni, 1993, pp.269-272). This characterization of the phases is not entirely satisfactory for a number of reasons. It is broadly acceptable, however, when applied to the third setting of the SCM (referred to in the Introduction), where the area is wholly urban or metropolitan. For the first and second settings, which tend to be regional in extent (and thus typically contain rural and exurban populations), the characterizations of the four phases are less appropriate. In Figure 1 and Table 1 above the descriptions of the four phases have sufficient generality that these can be applied in all three settings.

The treatment of stages varies considerably in the literature on the SCM. Sometimes these are simply numbered or indicated diagrammatically but not characterized (Aydalot, 1985, p. 320 and Table 8.11). More usually, however, two types of description are used. In the first the qualifiers "absolute" and "relative" are applied to the two parts of each of the four phases mentioned above, in order to emphasize the intensity of the change. Thus, Stage 1 is referred to as "absolute urbanization" and Stage 2 is termed "relative urbanization", while Stage 5 is described as "relative deuburbanization" and Stage 6 as "absolute deurbanization", and so on (Camagni, 1993, Figure 8.3; and Cirilli (2009, pp. 12-14). This type of description of the stages is again only suitable for the third setting of the SCM.

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In the other type of description of the stages the terms "absolute" and "relative" are also used. These are now applied to the four phases above, but specifically to those facets of each phase involving centralization or decentralization and overall-population growth or decline. For example, Stage 1 is typically viewed as "absolute centralization under conditions of overall population growth" and Stage 2 as "relative centralization under overall growth", with Stage 3 seen as "relative decentralization under overall growth" and Stage 4 as "absolute decentralization under overall growth", and so on (Klaassen *et al.*, 1981, Figure 2.1; van den Berg, 1987, Table 9.8; van den Berg and Klaassen, 1987, Table 6.1. Expressed in such terms, this type of description of stages may be applied to all three settings. In certain cases the phases of the SCM are not considered, and attention is confined to the stages, utilizing this type of description or some variant of it (Hall and Hay, 1980, p. 184; Cheshire and Hay, 1989, Table 3.1).

It would have been very confusing to have used either type of description of the stages in the present paper, simply because the terms "absolute" and "relative" are employed exclusively to distinguish between the different kinds of population change in the two versions of the SCM. Instead, the stages are indicated as numbered sectors in Figure 1, and are characterized in Table 1.

NOTES

1. An early statement of the SCM was outlined by Hall (1971), with more detailed accounts subsequently presented by Klaassen and Paelinck (1979), Klaassen and Scimemi (1981), Klaassen *et al*. (1981), van den Berg *et al*. (1982), Cheshire *et al*. (1984), Aydalot (1985), van den Berg *et al*. (1987) and (Kawashima (1987). More recent discussions of the model include those by Camagni (1993), Ciciotti (1993), Lever and Champion (1996) and Cirilli (2009). Champion (1986) refers to the SCM as the "stages of urban development model".

2. To conform with what has emerged as the usual practice in describing spatial change in the SCM, the terms centralization and decentralization are used throughout the paper. These terms are

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certainly appropriate for the third setting (referred to in the previous section), where the focus is essentially urban or metropolitan. However, for spatial-structure change at the regional level (the first and second settings above) the terms "concentration" and "deconcentration" are usually employed in the wider literature on regional analysis. These terms have occasionally been used to describe spatial-structure change in the SCM (van den Berg *et al*., 1987, Table 8.6).

3. It can be shown, however, that if $g < 0$ at Stage 4, then $g < 0$ at Stage 5, but if $g > 0$ at Stage 4, then g may be greater than, less than or equal to zero at Stage 5. It can also be shown that if $g > 0$ at Stage 8, then $g > 0$ at Stage 1 , but if $g < 0$ at Stage 8, then g may be greater than, less than or equal to zero at Stage 1.

4. A careful reading of Hall and Hay (1989, p. 184) indicates that Stage 5 and Stage 7 (in the numbering used in this paper) were not considered. This did not materially affect their findings, since only a single area had passed beyond Stage 4.

5. The reversion of an area to a stage earlier than the previous one is possible, though unusual. From data on FURs in the Netherlands presented by van den Berg *et al.* (1987, Table 8.6), it is apparent that Groningen, Maastricht and Tilburg moved directly from Stage 4 to Stage 2 over a 1974-1982 time horizon.

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Table 1. Description of Phases and Stages in Standard Version of the SCM

Phase		Stage	Absolute population change in each section of the area	ΔC, ΔR	K	G
I.	Centralization and growth	1	Core growth and ring decline	$\Delta C > \lvert\Delta R\rvert$	$K > 0$	$G > 0$
		2	Core growth and ring growth	$\Delta C > \Delta R$	$K > 0$	$G > 0$
II.	Decentralization and growth	3	Core growth and ring growth	$\Delta C < \Delta R$	$K < 0$	$G > 0$
		4	Core decline and ring growth	$\lvert\Delta C\rvert < \Delta R$	$K < 0$	$G > 0$
III.	Decentralization and decline	5	Core decline and ring growth	$\lvert\Delta C\rvert > \Delta R$	$K < 0$	$G < 0$
		6	Core decline and ring decline	$\lvert\Delta C\rvert > \lvert\Delta R\rvert$	$K < 0$	$G < 0$

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IV.	Centralization and decline	7	Core decline and ring decline	$\lvert\Delta C\rvert < \lvert\Delta R\rvert$	$K > 0$	$G < 0$
		8	Core growth and ring decline	$\Delta C < \lvert\Delta R\rvert$	$K > 0$	$G < 0$

Note: a term within vertical bars indicates a value without respect to sign.

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Table 2. Description of Phases and Stages in Alternative Version of the SCM

	Phase	Stage	Relative population change in each section of the area	c, r	k	g
I.	Centralization and eventual growth	1	Positive core rate and negative ring rate	$c > \lvert r\rvert$	$k > 1$	*
		2	Positive core rate and positive ring rate	$c > r$	$k > 1$	$g > 0$
II.	Decentralization and initial growth	3	Positive core rate and positive ring rate	$c < r$	$k < 1$	$g > 0$
		4	Negative core rate and positive ring rate	$\lvert c\rvert < r$	$k < 1$	*
III.	Decentralization and eventual decline	5	Negative core rate and positive ring rate	$\lvert c\rvert > r$	$k < 1$	*
		6	Negative core rate and negative ring rate	$\lvert c\rvert > \lvert r\rvert$	$k < 1$	$g < 0$

IV.	Centralization and initial decline	7	Negative core rate and negative ring rate	$\lvert c\rvert < \lvert r\rvert$	$k > 1$	$g < 0$
		8	Positive core rate and negative ring rate	$c < \lvert r\rvert$	$k > 1$	$*$

Note: a term within vertical bars indicates a value without respect to sign. The symbol $*$ indicates a value of g greater than, less than, or equal to zero (see text).

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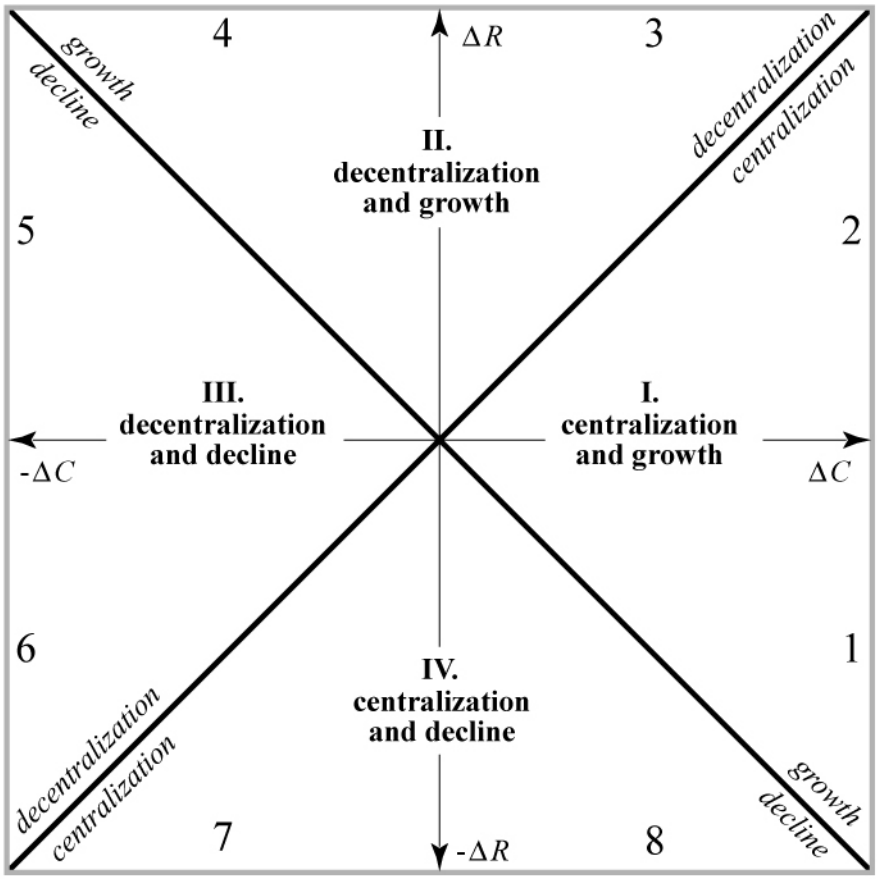

Figure 1. Phases and Stages in the Standard Version of the SCM

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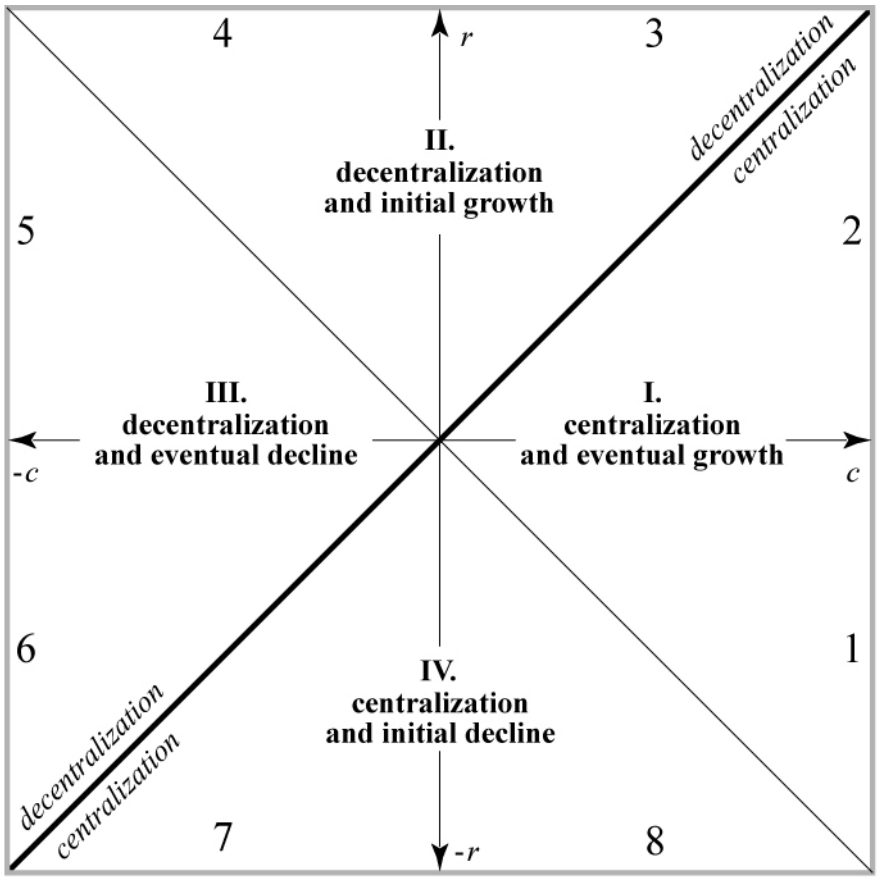

Figure 2. Phases and Stages in the Alternative Version of the SCM

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