
URBAN SYSTEMS RESEARCH: PAST, PRESENT, AND FUTURE.
A PANEL DISCUSSION*

Urban Systems Research: An Overview

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My intention in organising this “written panel discussion” is to solicit a personal statement concerning the evolution of urban systems research -- the nature of past research, the current “state of the art”, and an agenda for future research -- from each of a group of scholars who have undertaken considerable work in the field. Research on urban systems continues to occupy an important place in the literature of regional science, urban and economic geography, urban and regional economics, and related fields. Recently, however, many of those actively engaged in this area of research have begun to feel that, whether due to the nature of the field itself or due to changes in the broader societal context, interest in urban systems is on the wane. Is this the case? If so, why is this, and what readjustments need to take place? In sum, it is perhaps an opportune moment to take stock of this field of enquiry. The texts presented here are meant to contribute to this effort.

My own comments will be structured according to the general theme of the discussion: the past, the present and the future of urban systems research.

The texts that appear here were originally presented in the context of a panel discussion on urban systems research that took place at the annual meeting of the Canadian Regional Science Association held in Ottawa in June 1998.

The Past¹

Urban systems research has changed considerably since its origins. While it is not my intention to present a detailed history of the field, it is interesting to note, first, that work on urban systems is now well into its second century and, second, that early approaches were organised around a small set of specific themes. We find explicit work on the hierarchy, specialisation and spacing of cities in the writings of the German economist, Kohl (1841), and the French geographers, Reynaud (1841), and then Reclus (1906) and Levasseur (1909). However, the notion of an urban system was perhaps formalised in the decade before the Second World War in the work of Christaller (1933) and Lösch (1940) on what has come to be known as *central place theory*. This approach was considerably enhanced and refined in the 1960s and 1970s by geographers such as Berry (1961, 1964, 1967), Bourne et al (1978, 1984), Philbrick (1957), and Pred (1973, 1977), among others, and by economists such as Beckmann and McPherson (1970), Bos (1964), and Tinbergen (1964). These authors not only refined the notion of a system of central places, but also began to develop the concept of an urban system explicitly. A more recent variant of this approach is the contribution of White (1974, 1977), who develops a “dynamic” central place theory in which individual centres may grow and decline.

In parallel with these more spatial approaches, another set of work has dealt aspatially with *rank-size regularities* describing the form of the hierarchy within urban systems. The economist Pareto (1896), the sociologist Zipf (1941, 1946, 1949), the mathematician Yule (1925), the physicist Stewart (1947) and the multifaceted (cybernetician, mathematician, organisational analyst, to name a few) Herbert Simon (1955, 1973) have all contributed to this approach.

Finally, the concept of the *interaction between urban places* also occupied a central role in the early period of urban systems research. Interest in the interactions occurring between cities (which may be conceptualised as the “glue” that holds the system together) is also of relatively long date. Specific examples of this approach go back to the work of Ravenstein (1885) on migration, and continue with the contributions of Young (1924), Reilly (1929, 1931), MacKay (1958), Stewart and Warntz (1958) and the other members of the “social physics” school of the post-World War II period.

In sum, urban systems research in the “past” – the long period starting in the mid 19th century and perhaps running up to the end of the 1970s – may be characterised in several manners. First, one could argue that its primary concern has been with discovering static and descriptive statistical relationships that enable one to make relatively simple classifications: e.g., does a given national urban system obey the rank-size rule?; and is a given city at level 3 or 4 of the central place hierarchy, in terms of the goods and services that are available? Second, this

1. In an effort to reduce the length of this paper, the References section will provide detailed information on only the most recent, and thus most widely available, of the works cited.

research has been characterised by contributions from a wide variety of disciplines – not just regional science and geography. As we have seen, physicists, sociologists, mathematicians, and others have participated in urban systems research. Finally, and more generally, it is clear that urban systems research has been both influenced by, and contributed to, the rise of “systems thinking” (e.g., “the systems approach”, “systems analysis”, General Systems Theory) that characterised both the natural and the social sciences in the three decades after the Second World War. To the extent that they are composed of a set of elements (cities) and the interactions (social, economic, financial, informational and so on) between them, urban systems have readily lent themselves to analysis using this paradigm.

The Recent Period

During the past two decades, many of the intellectual currents of the past have continued – subject to appropriate technical and methodological refinements. Instead of merely counting the number of gas stations or dry cleaners in a central place, we are now more likely to perform a factor analysis or a cluster analysis upon sectoral data. Instead of using a simple gravity model to estimate the level of interaction between two cities, an entropy model is now more likely to be employed. Nevertheless, it seems to me that there are several important differences between the recent period of urban systems research and that of the past. Among these are:

- The scope of urban systems research has broadened to encompass not just the system (the whole) and the individual cities (the parts) themselves; increasingly, research has taken into consideration the broader context in which urban systems are situated. An issue of current importance is that of the relationship between the urban system and the region or regions in which it is located. An example of this concern is the approach which views certain urban units as “gateway cities” that function as relay points linking the region with the outside world. Certain urban areas even serve as “national” gateway cities that link their country to the global economic system. Further, much work has been done on the relationship between the economic role and performance of individual urban areas, on the one hand, and the performance of the region in which they are located, on the other hand. In the Canadian context, the relationship between the performance of Calgary and of the Prairies economy in the 1970s (boom) and 1980s (decline) is an obvious example.
- In the recent period, we have developed a fascination with the upper end of the urban hierarchy that contrasts with the previous emphasis upon smaller places. This fascination manifests itself in several ways. First, the notion of the “global city” has taken on a major degree of importance. In large measure, this interest follows from our almost pathological fixation on the phenomenon of “globalisation” (whose only rival would appear to be *El Nino*, in terms of

the quantity and range of impacts ascribed to it!). A large body of literature (e.g., Friedmann 1986; Sassen 1991) has documented the characteristics of global cities, as well as the rise and fall of individual cities in the context of globalisation (e.g., the prosperity of global financial centres such as San Francisco and Miami, and the decline of manufacturing centres such as Detroit and Nagoya). Second, much effort has been devoted to making comparisons (i.e., analysing the degree of competition) between places at the top of the global urban hierarchy. Is Paris overtaking London as a world business and financial centre? Is Los Angeles overtaking New York as the economic centre of the U.S.? Closer to home, how badly is Montreal faring relative to Toronto? These comparisons involve both city size and, perhaps more importantly, economic structural and functional characteristics. Finally, there has also been considerable interest in the spatial concentration of economic activities at the top end of national urban hierarchies. This is a specific example of the broader theme of uneven development. In France, Paris accounts for over 75 % of national employment in certain high order services. In Canada, one-half of national employment in business services can be found in the three largest metropolitan areas – which account for only one-third of the nation's population. Such research is obviously important in the context of regional development policy, if indeed this animal is not yet extinct.

- An important shift in the way in which we view the economic role of the elements of the urban systems has occurred. In the past, cities were viewed primarily in terms of central places that play a major role in the distribution of goods and services, i.e. in terms of their role in *consumption*. Increasingly, the individual elements of the urban system are coming to be viewed from the perspective of *production*, i.e. in terms of their capacity to produce goods and services. On the one hand, many studies have focused on the overall economic structure of specific urban systems, stressing the functional role of individual urban areas (e.g., Beyers 1989; Coffey 1994, 1996; Noyelle and Stanback 1984). On the other hand, there are also numerous analyses of the relative degree of specialisation of cities in certain “dynamic” sectors (e.g., high technology manufacturing, high order services). Certain of the more specialised places have come to be labelled as “technopoles”.
- Finally, more recent urban systems research has been based upon dynamic, rather than static, approaches. The traditional central place framework is founded upon the notion of the stability of an urban system. It is clear, however, that both the behaviour of an urban system and the relationships between the individual elements of the system are far from stable – they change, either gradually or abruptly, over time. Examples of this lack of stability abound: the economic role of Los Angeles and its position in the U.S. urban hierarchy over the past century; the reversal in position of Toronto and Montreal at the top of the Canadian urban hierarchy after the Second World War; and many less dramatic but nevertheless important changes involving the rise of high order service centres and the decline of older manufacturing centres. In the recent period, much urban systems research has adopted an explicitly dynamic

approach. Not only have more conventional analyses focused upon change, but attempts at modelling urban systems have also begun to involve dynamic frameworks developed in fields such as physics, mathematics and ecology (e.g., bifurcation theory, the theory of chaotic systems, the theory of complexity), as well as the aforementioned dynamic central place theory. One interesting aspect of this development is that, increasingly, researchers from seemingly distance fields have begun to study urban systems.

The Future

From a normative perspective, where should urban systems research be heading in the future? Here is an agenda that reflects my personal views on this question. In part, this agenda reflects specific research directions but, primarily, it reflects the necessity for the field to become better attuned to the broader scientific and societal context in which it is situated.

- Both those of us who regularly work in the field and, especially, those who do not, need a better working definition of urban systems research. In its present state, this area of research is remarkable for the fuzziness of its boundaries. This lack of clarity has, in turn, contributed to the decline of the field in both academic and public policy milieux (see the following point). What aspects of “urban systems” does this research area examine? Is work restricted to economic structure, population size and transportation and communications flows, or does social interaction, in its various forms, have a role to play as well? And even more fundamentally, does urban systems research involve, by definition, only groups of cities, or, rather, can it also involve the systematic analysis of one urban area? To cite a pertinent example of this distinction that has arisen in the context of the present “written panel discussion”, Roger White, an experienced urban systems researcher, has chosen to focus his remarks concerning recent developments in urban systems research upon the modelling of individual cities. In sum, what is urban systems research and what is not? This issue calls to mind the elegant phrase coined by Brian Berry during the 1960s: “cities as systems within systems of cities”.
- A major attempt must be made to stimulate – indeed, to resurrect -- interest in the field of urban systems research within both academic and policy spheres. On the one hand, in terms of courses taught and research published, the study of urban systems is an area of inquiry that has known a significant decline in importance relative to its halcyon days in the 1970s and early 1980s. Even recent attempts to create urban research associations (not just urban systems associations) have failed. On the other hand, the interest in this area of research has fallen off markedly in policy-making circles. Is the decline (at least according to these standards) of the field due to the fact that the concept of an “urban system” is less relevant in today’s context, where

much emphasis is placed upon the two extreme geographical scales – the global and the local? Or is it the case that the conceptual frameworks and the methods employed in the field are no longer relevant? Or, further still, from a practical perspective, is it because in many countries federal-level organisations with the mandate of regulating “the urban phenomenon” have been abolished, with their responsibilities partitioned among sectoral departments? This certainly has been the case in Canada, where the Ministry of State for Urban Affairs was disbanded in 1979, after little more than seven years of existence. Indeed, in the Canadian context, one can draw a parallel between the urban domain and that of regional development, which has been a much less dynamic field of inquiry since the federal government effectively withdrew from this area at the end of the 1980s.

- Following from the previous point, research on urban systems needs to make a better contribution to both the debate over, and the formulation of, public policy. As noted above, it has become increasingly difficult for the field to contribute to policy discussions given the absence of upper-level government actors working explicitly in the area of urban research. The task, then, is to demonstrate to a range of actors dispersed across a variety of organisations that urban systems researchers are doing useful work that has direct relevance for important public issues. This leads to the following point.
- In order to make more effective contributions to public policy, on the one hand, and to enhance the standing of the field with respect to other areas of research, on the other hand, urban systems researchers need to go beyond descriptive analysis and to attempt to explain the phenomena and processes that they observe. In the area of policy formulation and analysis, especially, it is of capital importance to understand the factors and mechanisms that underlie present conditions and historical trends. See Coffey and Shearmur (1998), for such an approach, one based upon hypothesis testing.
- In the future, researchers will need to devote more attention to the mid-range of the urban hierarchy. The upper end of the hierarchy (“world cities”, in particular), which has been the focus of the lion’s share of analysis in recent years, remains highly relevant and interesting. On the other hand, however, due to new information and communications technologies, and to “quality of life” decisions, many activities and functions that were once uniquely found in very large places are now getting shifted down the hierarchy. Mid-sized metropolitan areas, in particular, warrant more and more of our analytical interest.
- The scope of urban systems research needs to be expanded beyond its most conventional boundaries so as to include concepts and phenomena that are becoming increasingly relevant. For example, conventional approaches to the economic structure of urban systems have been based upon sectoral structure; these need to be complemented by approaches that involve the occupational structure of the labour force and the economic function of the urban units themselves. Similarly, interaction studies need to move beyond the analysis of telephone calls and airline passenger flows so as to include more relevant

(and difficult to measure) phenomena such as financial and information flows.

- Finally, urban systems research must continue to evolve in the direction of dynamic, rather than solely static, analysis. As mentioned above, the use of dynamic modelling frameworks coming from other fields is a feature of current research. This approach should be expanded upon, and the useful contributions that are available from seemingly unrelated fields need to be encouraged. Urban systems, like the world in which they are situated, are in a perpetual state of change. To paraphrase Heraclitus, one can never step in the same urban system twice.

In conclusion, I have every reason to believe that, issues of the organisation and the implementation of public policy notwithstanding, the field of urban systems research will continue to be of considerable relevance in the future. The modern world is characterised by two contradictory trends. On the one hand, various forms of supra-national integration are visible: the European Union, the North American trading bloc and so forth. On the other hand, nationalist movements have fragmented certain nation-states: e.g., the former Soviet Union, Yugoslavia, and Czechoslovakia, to name just a few; other cases involving Québec, Scotland, and Wales may be waiting in the wings. In this highly volatile context, it is urban areas that have become the basic building blocks, both structurally and functionally, of the modern world. It is urban areas – and the interactions between them -- that form the “glue” that holds the modern global economic and social system together. Now is not the time to abandon the study of urban systems.

The Other Contributions to the Discussion

The other papers that comprise this “written panel discussion” address many of the issues that have been raised in the present contribution, as well as identifying additional ones. Larry Bourne identifies a number of possible reasons for the decline of urban systems research, and makes some suggestions as to how researchers in the field could meet the challenge. Jim Randall puts the potential utility of urban systems research into perspective with some reflections upon the accuracy of predictions made by researchers a quarter of a century ago, and upon the durability of their research agendas. Wayne Davies presents an overview of the major themes addressed by urban systems research, and of the major approaches used to address these themes. Finally, Roger White focuses upon one aspect of urban systems research, that of modelling the behaviour of cities; he describes the most recent approaches in this area. Together, these nicely complementary papers help us to identify some of the issues, the problems, and the potential of urban systems research – past, present and future.

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URBAN SYSTEMS RESEARCH: PAST, PRESENT, AND FUTURE.
A PANEL DISCUSSION*

**Whither Urban Systems?
A Commentary on Research Needs
and the Marketing of Ideas**

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The Initial Premise

The concept of an urban system, both as a research paradigm and an analytical construct, has been around for almost a century. With its roots in seminal work on regional systems of central places in the early twentieth century, the concept has evolved over time into a much more comprehensive framework for examining cities in their varied national and international settings. Almost everyone now recognises that cities cannot be studied in isolation -- that is, separate from their linkages to other regions and cities. Nor can they be detached from their changing contextual environments -- the broad economic, social and political structures of which they are a part. However, despite widespread acceptance of the importance of these "external relations", and despite the current rhetoric on the increasing impacts of globalisation -- notably evident in flows of capital, goods, information, and other forms of interactions among so-called "world" cities -- the urban system paradigm has not received -- at least in my assessment -- the attention that it deserves in the urban literature. Why is this so?

This brief commentary examines this proposition, and as a means of stimulating further discussion offers a few possible explanations for what I see as the marginal status of urban systems research. It then outlines ways of responding to this challenge, while at the same time enhancing the potential contribution of urban systems concepts and methods of analysis in the highly competitive

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marketplace for ideas and funding. The paper concludes with suggestions on additional topics for research.

Perhaps I should begin with my own definition of an urban system. In my lexicon the urban system is both an object -- a "system" of linked and interdependent urban areas -- and a way of thinking about the processes of urbanisation operating at various spatial scales. The argument is simple, and by now well-known (Bourne 1995). In an urbanised society the economy of the nation and its regions, as well as its social and political structures, are increasingly dominated by, organised within, and function through, its set of urban centres, especially through its larger metropolitan regions. These areas, even when broadly defined, may occupy only 3 to 4 % of the national territory, as in Canada, but harbour 80 to 90 % of the nation's productive capacity, population and wealth. In effect, the urban system becomes the principal expression of the territorial organisation of the national economy and its social system.

Whither Urban Systems Research?

Why has the urban system, given its obvious relevance as a concept and as a framework for research, not been more frequently used? Five possible explanations come to mind here; readers may add others. One is the considerable analytical difficulty associated with applications of the concept, combined with the paucity of suitable data. The urban system approach, by definition, requires current data on flows, linkages and interactions of all types among all urban centres, and between those centres and the rest of the country and beyond. In most instances such data are not available, at least not at this level of geographic disaggregation. Among the most obvious gaps in our information base are sets of urban economic accounts, interurban trade flows, capital movements, income transfers and the like. Without such sources of information the urban system concept remains essentially a conceptual shell with little substance, and without a solid empirical base that would facilitate formal hypothesis testing.

A second possible explanation is that the urban system paradigm is more mundane than we might previously have thought. By this I mean that the concept does not in itself either contain, or call forth, a particular theoretical stance or set of arguments. This, of course, does not apply to certain sub-species within the paradigm. For central place systems and urban size distributions, for example, there are relatively well-defined bodies of theory, supported by substantial empirical evidence. But these theories apply to only a small and declining proportion of the structural attributes and organisational logic of urban systems. In effect we have no overarching theory of urban systems, and perhaps we cannot reasonably expect to develop such a theory in the near future. At the very least the weakness of our theoretical apparatus is part of the explanation for the under-use of the concept.

A third possible explanation is more pragmatic. That is, there is little

correspondence, at least in most western countries, between the structure of governments (or more broadly the state), and their associated planning and policy regimes, and the structure of the urban system. There are, in addition, few governments for whom explicit urban objectives are an important part of their mandate, and fewer still whose jurisdictions correspond to what we would define as the urban system at any meaningful scale. The simple fact that there is no one attempting to “manage” the urban system at the macro-scale, is one reason why there are few calls for applications of the urban system concept in basic research or in applied public policy studies.

A fourth possible explanation is that the topics of interest, if not the scale of analysis in conventional urban system research, have become out-dated -- bypassed or perhaps overwhelmed by other subject areas, other policy issues and different research priorities. One such priority is evident in the predominance of “sectoral” issues, such as the interest in financial services and high-tech industry, in both research and public policy. Another example is the shift in the focus of research attention to opposing ends of the spatial scale of urban system analysis: at one end, to the processes of globalisation and to the changing roles of and internal conditions in (e.g. social polarisation) the centres of global commerce; and the other end, to the local and regional scales, and to research on individual localities and regions (e.g. the new regionalism). Scholars working in these two sub-fields appear seldom to talk to each other. One of the drawbacks of both of these two areas of research is that they seem strangely detached from their spatial context -- as if they were floating in a spaceless world. In part this is because they tend to ignore the connections to the broader urban systems of which they are a part. An urban system perspective, in contrast, would argue that even global cities such as New York and Tokyo are still primarily dependent on connections to their immediate regional hinterlands and to their respective national urban systems. In effect, these two areas of research have bifurcated the urban system, in theory and in empirical analysis, into isolated segments. Even the global-local debate seems to leave out the centre of the urban system.

A fifth hypothesis as to why urban systems research has been truncated is rather more ambiguous. This argument relates to the increasingly intense competition among different research schools -- or communities of interest -- for greater visibility and a larger share of the research pie. By this I mean the operation of a “marketplace” for ideas, the arena in which different research paradigms compete for disciples, citations, research funding and publication outlets. I would argue that we, as proponents of the urban system paradigm and the analytical approaches associated with it, have not done a very effective job in selling our ideas and the comparative advantage of our way of thinking to the larger communities to which we report.

Future Research Challenges

How should we respond to these criticisms and to the challenges they pose for the future status of research on urban systems? One obvious implication of the above arguments is that we must do a better job of packaging and marketing our ideas and methodologies. As part of this initiative we need to undertake a careful re-assessment of the theoretical basis of the concept, while providing a re-conceptualisation of the urban system paradigm and illustrating its value as a comprehensive framework for empirical analysis. At the same time we must make more of an effort to identify the links between the research that we do and the requirement to provide the knowledge base for more informed policy formulation.

In terms of a re-invigorated theory, I would argue that we need to re-visit the “logics” that underlie the organisation and evolution of systems of cities. By logics I mean the set of processes that define and in turn condition the spatial structure, attributes and paths of growth of an urban system and its member cities. In a previous paper (Bourne 1997), I suggested that there were perhaps a minimum of five diverse logics. In most cases all five are superimposed in organising and giving shape to every urban system. These five reflect the diverse requirements, for both location and networks of interaction, of:

- the dominant type of production system (e.g. manufacturing);
- the nature of the distribution system;
- the structure of transportation and communication systems;
- the changing geography of consumption patterns and life styles; and
- the nature and form of controls and regulations placed on the system as a whole.

In the latter case I am thinking not only of the formal role of the state, both direct (as in urban policy) and indirect (as in taxation policy), and the effects of political decisions, in shaping and reshaping urban systems, but as well other types of control exerted by different actors and sectors in the economy (e.g. the banks). We do have theories for most if not all of these logics individually, but not for the varied and complex ways that they intersect in time and space.

Among the empirical investigations that are near the top of my priority list are those that deal with the intersection of the above logics, and the need to articulate how the relationships involved have changed over time. I am particularly interested in learning more about the relative importance of these logics: for example, is the role of the nation state diminishing in relation to the impacts of transnational trade and regulation; are changes in life styles and consumption behaviours overwhelming the requirements of the production system? How does the shift in importance in GNP from manufacturing to services alter the logics and distribution of growth and change? Are communication systems eliminating the effects of distance, only to be replaced by new barriers to interaction? Does globalisation imply a corresponding shift in networks of interaction from within a national urban

system to the global urban system? Is the urban system, as a result, becoming more unequal and more fragmented, and does it then show more unstable profiles of growth and change? Obviously, a response to these questions requires that we gain access to more robust data files on consumption behaviour, on trade and social interaction, and that we undertake more comparative analyses that are both transnational and that vary the scale of analysis within nations.

Conclusion

This personal note began with the proposition that concept of the urban system, as an object of analysis and as an analytical approach to research, has been undervalued in the academic and applied policy literature. It then suggested a series of reasons or explanations as to why this might be the case. The most obvious of these were, first, the real difficulties involved in research on objects as large and complex as entire systems of cities, in which we are compelled to focus not on distinct sectors or places but on the intersections among different yet interrelated processes of change; second, the absence of a parallel constituency for our research; third, the recognition that other topical concerns, competing concepts and sectoral issues may have overtaken the field; and fourth, the relative weakness of our efforts to illustrate the usefulness of the approach -- in other words, the failure to market our ideas effectively in the highly competitive marketplace for research. How should we respond?

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URBAN SYSTEMS RESEARCH: PAST, PRESENT, AND FUTURE.
A PANEL DISCUSSION*

Reflections on Urban Systems Research

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I will divide my contribution to this discussion on urban systems research into two parts. First, I will reflect on some of the urban systems research that has been carried out in the past. This reflection will focus specifically on the accuracy of the predictions made in the late 1970s regarding both the urban systems research agenda and change in the urban systems themselves. Second, I will comment on the current and future state of the urban systems research agenda.

Urban Systems Research: The Recent Past

It seems that the best way to frame a discussion of the state of urban systems research, and especially to provide insights into the types of research we might expect in the future, is to review the predictions that were made in the past about urban systems research today. In order to make this discussion manageable in the space available to me, the discussion in this paper will be shaped by only three bodies of work: Len Gertler and Ron Crowley's 1977 book, *Changing Canadian Cities: The Next Twenty-Five Years* (Gertler and Crowley 1977), a collection of papers that appeared at the same time by Larry Bourne and Jim Simmons in, *Systems of Cities: Readings on Structure, Growth, and Policy* (Bourne and Simmons 1978), and a set of six progress reports on urban and regional systems that appeared in *Progress in Human Geography* between 1977 and 1985 (Goddard 1977, 1978; Bourne 1980; Simmons and Bourne 1981, 1982; White law 1985).

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TABLE 1 Population of Canada and the Provinces ('000s), 1996 and 2001

Province/Territory	Projected Population ¹ 2001	Actual Population ² 1996
CND	29,734.6	28,846.8
NF	694.4	551.8
PE	181.6	134.6
NS	1035.9	909.3
NB	954.9	738.1
PQ	6,751.5	7,138.8
ON	11,038.9	10,753.6
MN	1,167.6	1,113.9
SK	866.1	990.2
AL	2709.9	2,696.8
BC	4,257.4	3,724.5
YK	36.9	30.8
NW	39.5	64.4

Notes: 1. Derived from projections made in 1975 in L. Gertler and R. Crowley 1977. *Changing Canadian Cities: The Next Twenty-Five Years*. Toronto: McClelland and Stewart.

2. From Statistics Canada. 1997. *A National Overview: Population and Dwelling Counts*. Ottawa: Industry Canada, Catalogue # 93-357-XPB.

The Canadian Urban System

The estimates of Canadian population growth presented by Gertler and Crowley twenty-five years ago are, in hindsight, grossly inaccurate. Although the aggregate national population prediction of 29.7 million in 2001 appears to be in line with current trends (28.85 million in 1996), most of the more geographically disaggregated predictions are less precise (Table 1). Their provincial predictions failed to anticipate the population stagnation in the Atlantic provinces (e.g., Newfoundland, Prince Edward Island), predicted major declines in Saskatchewan that did not take place, and did not anticipate the pace of Quebec and Alberta growth. As one might expect, their metropolitan projections tended to be even more inaccurate (Table 2). With the exception of Sudbury and Windsor, Gertler and Crowley's Census Metropolitan Area (CMA) population predictions are too conservative, especially for the smaller CMAs. In large part, they failed to anticipate the significance of rural-to-urban migration to these communities. The main point of this focus on these specific population projections is not merely to highlight the inconsistencies. More important is to show how even the simplest projections of the structure of urban systems are fraught with problems. Well-intentioned experts can never fully separate their projections from transitory events nor fully appreciate the impact of new political, economic and social events that often dramatically alter the magnitude and direction of projections.

TABLE 2 Actual and Projected Population for Metropolitan Area ('000s), 1996 and 2001

Metropolitan Area	Projected Population ¹	Actual Population ²
	2001	1996
Toronto	3,688.6	4,263.8
Montreal	3,355.3	3,326.5
Vancouver	2,101.5	1,831.7
Ottawa - Hull	1,031.5	1,010.5
Edmonton	898.8	862.6
Calgary	955.9	821.6
Quebec	746.0	671.9
Winnipeg	636.6	667.2
Hamilton	637.4	624.4
London	454.4	398.6
Kitchener	379.9	382.9
St. Catharines - Niagara	393.5	372.4
Halifax	285.2	332.5
Victoria	351.1	304.3
Windsor	360.5	278.7
Saskatoon	153.0	219.1
Regina	142.0	193.7
St. John's	163.4	174.1
Sudbury	289.7	160.5
Chicoutimi - Jonquiere	135.4	160.4
Saint John	101.2	125.7
Thunder Bay	110.4	125.6
Total CMA's	17,370.9	17,309.1
CMA's as % of Canada Pop ^a	58.4	60.0
	%	%

Notes: 1. Derived from projections made in 1975 in, L. Gertler and R. Crowley. 1977. *Changing Canadian Cities: The Next Twenty-Five Years*. Toronto: McClelland and Stewart.
2. From Statistics Canada. 1997. *A National Overview: Population and Dwelling Counts*. Ottawa: Industry Canada, Catalogue # 93-357-XPB.

The Urban Systems Research Agenda

The failure to appreciate the transitory nature of human events is perhaps more apparent in predictions of the issues that were going to dominate urban systems research. One of the best examples of the significance of current events in distorting predictions of the future research agenda is the exaggerated influence given to energy supply crises and price shocks, and the impact that these would have on urban form, urban policy and human behaviour (Gertler and Crowley 1977). Today, very few urban systems researchers are paying much attention to the

impact of energy prices on urban form. Another good example of a research issue that failed to generate the expected level of research attention was a concern for the most optimal or efficient city size (Gertler and Crowley 1977; Bourne and Simmons 1978). Since many cities were growing quickly in the 1970s, it was natural to critically examine the consequences of that growth. It was also natural to develop policy prescriptions to head off the problems of unbridled urbanisation, including the redistribution of manufacturing activity away from major metropolii to regional cities to reduce the stressful life of urban residents, and the integration of regional cities by high speed transit. However, even shortly after this body of literature gained attention, it became clear that a focus on optimality or efficiency as an end in itself was theoretically sterile (Bourne 1980).

Perhaps the largest error in anticipating an urban systems agenda has been the assumption that the state would continue to play a strong role in shaping the future of urban systems. We were still proposing “grandiose prescriptive solutions” to social and economic problems. In 1978, Bourne and Simmons justified incorporating the state within a national scale of analysis on the following grounds, “The reference to national urban systems tends to be a matter of convenience as well as a reflection that national governments have prime influence, if not responsibility, over the urbanisation process generally.” (Bourne and Simmons 1978, vi). In fact, many urbanists suggested that the state would play an even stronger role in shaping urban form. For example, Blumenfeld stated, “It is probable that public land ownership for urban development, by whatever level or combination of levels, will play an increasing role in the future form of urban development in North America, as it already does in Europe.” (Blumenfeld 1978: 564).

As we have seen from political and economic events of the past fifteen years, the state has retreated on many fronts, including direct intervention in regional economic development policy. For example, growth centre prescriptions for regional economic development that relied upon public investment to reduce regional economic inequities are now nonexistent. In fact, given the shift to fiscal conservatism that has occurred in Canada and elsewhere over the past fifteen years, it is almost bizarre to think of direct, centralised, regional economic development using public monies.

As academics, discussing urban systems and their accompanying research agendas as we approach the twenty-first century, this review of twenty-five year old predictions should humble us. Despite being “experts”, we could not escape the arrogance and shortsightedness that accompanied the events that were occurring around us. What has transpired over the past twenty-five years that was not anticipated when these predictions were made? Although a large number of demographic, political and economic changes come to mind, a few of the more important ones include:

- Changes in the structure of the average household (e.g., decreasing average size; increasing female labour force participation rate; decreasing fertility rate),

- Subordination of the federal and provincial states to the power of economic (multinational) entities. Although the importance of the role of large, transnational corporations in shaping the location of economic activity was apparent in the late 1970s (see Goddard 1977), the role that these entities and their advocates have had on shaping the discourse of political economy (e.g., the inevitability of freer trade, the necessity of competing in the “global marketplace”) was only rarely anticipated.
- Associated with the issue of state - corporate power relations has been a shift to a larger scale of urban systems research. Although attention in the past has focused on world cities and megalopolis, these were largely isolated examples based within a regional development framework (e.g., local multiplier effects, optimal city size). Although most researchers recognised that events and decisions in developed nations had consequences on other regions, we were rather smug in assuming that events elsewhere could only rarely penetrate our own personal quality-of-life. Today, we have repeatedly and bluntly been made aware of the interconnectedness of global events that is perhaps the most definitive feature of “globalisation”, with the Asian financial crisis being only the most recent exogenous event that has affected individual households half a world away. Twenty-five years ago we recognised that the developed economies have substantial impacts on developing economies but we mistakenly assumed that crises in the developing world could have little impact on our own personal lifestyles.
- Accompanying this has been the growing realisation that events that occur at a local level can lead to change at a larger scale. This, along with economic and demographic stagnation of many urban places, is at least partly linked to the increased attention being paid to environmentalism and sustainability.

An Urban Systems Research Agenda for the Future

This introspection should prompt us to proceed very cautiously in predicting either the substance of the urban systems agenda in the future, or the contextual events that will shape that agenda. Despite these misgivings, and tempered by the fact that I will only be peering a few years into the future, let me proceed.

- Even before entering into a discussion of the specifics of urban systems research, one general trend is apparent; urban systems research, as labeled, does not hold the same level of importance as it did twenty years ago. One of the best indicators of the waning fortunes of this body of literature is that there has not been a progress report on urban systems research in *Progress in Human Geography* since 1985. If this journal is to be considered a barometer of research interests, then urban systems research has not generated a lot of attention in the past fifteen years (after progress reports in each of the first five years of the journal). As is implied by the discussion above, urban systems

research has largely fallen off the policy agenda as well. In the late 1970s, national governments and international institutions were focusing their attention on the consequences of unchecked urbanisation (Bourne and Simmons 1978). Today, despite significant urban-based economic and social problems throughout the world, the plight of urban places as a group is rarely addressed at this macro level. Responsibility for maintaining a decent quality-of-life for residents has largely shifted to the municipal level, and is carried out off the international political stage. In defense of the urban systems agenda, one might argue that urban and regional systems research is more vigorous than ever, but it is increasingly being carried out under such diverse labels as industrial geography, the geography of money and finance, regional development policy research and the geography of services. For example, studies of networks of inter- and intra-firm relationships has helped us see the interconnectedness among cities, regions and nations, and lends itself directly to a better understanding of the evolution of urban and regional systems.

- More research on global-local interrelationships. Increasing attention paid to the global scale of interactions is inevitable, as is the local level, urban sustainability, community economic development literature. Although these two streams of research have been carried out largely in isolation of each other, there is a growing body of work that is examining the reflexive relationships between global and local change (Cooke 1989; Cox and Mair 1991). Although urban sustainability is sometimes mistakenly viewed as urban self-sufficiency, sustainability ultimately rests on the construction of steady-state systems of relationships among cities and regions. As above, much of the work that is establishing these global-local linkages is being carried out without explicit reference to urban or regional systems.
- A continued integration of the economic and the social in the examination of spatial systems. Economic and social geographic approaches to urban systems research over the past generation has been carried out largely by two separate groups. Some, such as Davies and Murdie (1991) and Balakrishnan (1982), have focused their attention on the variation in social characteristics across urban places without referring to the macroeconomy of those places. Others (e.g., Marshall 1989; Simmons 1991), have focused on the functional (economic) structure and interaction among urban places to the exclusion of the social characteristics of the human beings who live in those cities. Although both of these perspectives have been critical to furthering our understanding of the city, the implication of this separation was that the urban economy and urban society could be understood independently of each other. The integration of economic and social geography has already taken place in the discussion of specific urban settings such as Worcester (Hanson and Pratt 1988; Pratt and Hanson 1991) and Montreal (Villeneuve and Rose 1988), and has been reflected in the comparative urban analyses undertaken on the Canadian newsprint industry (Mackenzie and Norcliffe 1997; Rose and Villemare 1997). Rarely, however, has this integration been set within a comprehensive urban systems framework. This separation of the economic

and the social may be one of the root causes for the failure to arrive at a general theory of urban systems change. Although the scale of urban systems research has shifted to the global level, we seem to be left with the same problem articulated by Bourne who, in 1980, stated that, "Despite a flood of academic literature, some of it of impressive analytical or rhetorical abstraction, we still know relatively little about how urban systems grow and change." (Bourne 1980).

None of the research agenda items listed above should be too surprising since they are all, to a greater or lesser extent, taking place right now. What we cannot anticipate, as the earlier reflections show, are the unanticipated exogenous events that may take the urban systems agenda off in very different directions a generation from now. What we can say however, is that research on urban systems continues to be carried out by a large number of researchers, albeit in many different guises. Although on the surface this appears to be a healthy trend, the underlying threat of this fragmentation is that there is rarely an appreciation for the systems component of urban systems. Even more of a concern is that there are no attempts to bring all of this research together into a comprehensive framework. In effect, an urban systems perspective is being lost in a sea of "urban systems" research.

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URBAN SYSTEMS RESEARCH: PAST, PRESENT, AND FUTURE.
A PANEL DISCUSSION*

Urban Systems Research: Unfulfilled Promises?

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The study of urban systems has not fulfilled the potential that was promised during the 1960s and early 1970s. Although we do have a lot of knowledge about the nature and changing patterns of urban systems, progress has been less than expected. Part of the reason for this situation comes from the complexity of the phenomena being studied, but unresolved methodological and technical problems have also stymied development in the field. These issues can best be understood by providing a context for their identification: first, by identifying the main trends in the study of urban systems to the early 1970s; second, by summarising the key changes that have taken place since that time.

The Past

The field of urban systems research can be briefly defined as the study of the spatial and temporal variations in the character of urban nodes – or, more generally, settlements -- in any area, and the interactions between them, as impacted by the influences of the surrounding society. Five main approaches have been used to study urban systems: the characteristics of the nodes, the nature of the interactions, the effect upon spatial forms, the forces of growth and the role of the surrounding society. Most attempts to understand the nature of these systems has been directed at summarising either the general structures or patterns of the nodes at particular time periods, or the forces of growth, with occasional links to the spatial patterns that emerge. Far fewer analyses of the interactions between places have been carried out. Even less detailed work has addressed the societal forces that affect the characteristics of the nodes and the interactions between them, or the

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temporal changes that occur in these systems. Inevitably this has led to an unbalanced body of knowledge about the nature of urban systems.

Nodal Character

Until the early 1970s, the emphasis of urban systems research on the nature of nodes involved six aspects of their structures: the relative growth of places; their spacing; the size distribution of places -- initially linked to rank size and primate models, but later generalised to a series of other theoretical distributions; the analyses of the commercial importance of places -- often linked to central place theories; economic base ideas, associated with the differentiation of places by economic character; and general classifications of cities, mainly based on economic criteria. Many people viewed the basic structure of the urban system in any nation as being organised in some hierarchical pattern, such as the six grades of centres used in many central place schemas. However, there has never been any agreement upon the number of grades of place within any national system. And since most service centre studies were at a small town level, there were relatively few studies of the structure of national systems, except those using population data. Although there were some linkages between these six streams of research, most were pursued in isolation. Hence most of our knowledge of the character of urban systems came from analyses that deal primarily with one of the possible characteristics -- mainly population size, commercial importance or economic differentiation. So most research provided partial views of the nature of urban systems, perhaps not helped, by the use of increasingly sophisticated statistical techniques which emphasised analytical approaches. The adoption of multi-variate methods from the early 1960s did help create more integrated sets of results, by revolutionising the ability to handle larger data sets, especially in urban classification schemes, and showing how patterns and structures could be derived from the data, rather than being imposed by *a priori* decisions (Davies 1984). However, an increasing scepticism concerning the use of quantitative methods, at least by many geographers, has meant that relatively few new studies using these procedures have been made in the last decade, leading to an increasingly dated stock of research findings in many aspects of urban system research.

Interactions

The difficulty of getting adequate data on the flows between places meant that there were far fewer studies of the structure and nature of interactions between places (most were based on consumer behaviour flows associated with service centre studies, or analyses based on telephone or air line traffic), although these empirical analyses were complemented by the results from theoretical models produced from gravity and interaction frameworks. Unfortunately, there was a temptation to regard the pattern of flows in urban systems as hierarchical, ignoring

the fact that many investigators had shown that flow patterns were often function-specific; combined with the presence of back-flows, this complicated the concept of simple hierarchies.

Spatial Form

The concept of urban nodes as free-standing centres has long been modified by the relationships with neighbouring places, beginning with the coalescence of contiguous centres to create industrial conurbations in several areas. The accelerating sprawl of urban places and the spread of the influence of cities into rural areas -- due to widespread car ownership and the decentralisation of population and employment -- led to city-regions with ever extensive and ill-defined boundaries. At a continental scale, polynuclear urbanised regions emerged, composed of a number of large cities or city-regions, separated by rural land, but with high degrees of interaction. Gotman identified these areas with over 20 million people as a new scale of urban living, which he called a megalopolis.

Growth Forces and the Role of Society

The traditional emphasis upon descriptive studies, emphasising the unique principles of urban growth, or the effect of key decision makers, was largely abandoned in the late 1950s in favour of theoretical ideas based on economic principles or generalisations -- whether central place, long distance trade, industrial location -- or upon generalisations derived from studies of political factors or resort development. These can be called "single factor growth forces", which were in turn criticised by advocates of growth pole and cumulative development ideas from the late 1960s. Although these concepts provided important insights into the growth of urban systems, they were rarely integrated and were often regarded as competing, rather than complementary forces of change. This reduced their overall value since they were rarely considered in conjunction with one another, or were shown to have particular relevance only to certain areas or sets of towns. Most studies accepted the societal background of the urban system as a "given", so there were few attempts to search for explanations for growth in the mechanics of particular societies.

Recent Changes

The 1970s produced significant changes, in both the empirical character of urban systems and the intellectual tools with which we view them. These changes seemed to destroy many of the basic principles upon which city systems were conceptualised and structured, which in turn led to the abandonment of many of the older ideas.

First, in an intellectual sense, there was a new emphasis upon political economy approaches, especially the role of capitalism, which led many to focus upon the societal forces that created change, rather than upon the empirical characteristics of urban systems, or the single factor growth forces, which had dominated previous work. This was a long overdue trend. Unfortunately, the studies of societal influences were rarely grounded in empirical examples and usually ignored the previous findings of urban system structures, despite the fact that these single factor and cumulative growth forces were still relevant to particular aspects of urban systems.

Second, in terms of the character of the urban nodes, a series of changes cast doubt upon the utility of previous findings. Instead of the seemingly inexorable progress of population concentration – from rural settlements to urban, then metropolitan and mega-cities or perhaps megalopolis -- the so-called counter-urbanisation process of the early 1970s seemed to indicate the creation of a completely different trend, linked to urban stagnation or decline and the growth of rural areas. Similarly, concepts of functionally dispersed cities were introduced, which implied that commercial hierarchies were obsolete. Recognition of the increasing importance of quaternary and quinary services in large cities -- and especially the producer and consumer service distinction -- implied that older economic base ideas founded primarily upon industrial differences were outdated. Increased concern about the liveability and amenity of cities meant that the classification schemes based on economic and demographic criteria seemed of little value in the new world context of decision-makers; these schemes seemed to be merely static representations of urban differentiation of limited applied value, myopically ignoring the fact that such studies were equally one-sided in only dealing with part of urban system character.

Third, the increasing ability to communicate quickly and cheaply across distance added to the decentralisation pressures in urban systems. Larger numbers of long distance commuters to cities, and the increasing suburbanisation of employment -- which led to suburb to suburb flows -- also led to the breakdown of local urban systems and the emergence of more urbanised regions due to the coalescence of formerly independent city regions and the creation of complicated overlapping patterns of interaction, especially within the urbanised regions of heavily populated areas. In the context of flows, there were greater numbers of non hierarchical flows, creating more small town (or anyplace) linkages direct with large cities, bypassing the formerly intermediate district or regional centres. In addition, the decreasing costs of travel and goods transportation led to an explosion in international and long distance movements, linked to the creation of a new global economy in which goods produced in one country were transported all over the world. In Cairncross's (1997) recent term there may have been a 'death of distance', leading to new associations between places based on the decline -- perhaps even the loss -- of the old "friction of distance". Although there are almost no empirical studies of these flows, because of the difficulty of tracking these interactions -- especially those of information and capital -- there is an implicit assumption that the world is now a completely connected system of places,

characterised by instant interaction (presumably the complete connection model suggested in a typology of alternative interaction models) (Davies 1984). This implies that the search for the flow patterns or structures in areas is redundant, since all are interconnected.

Further, the increased size of the largest places and the new scale of interaction have created a series of prime movers in the world economy, called global cities, whose study seemed to take priority over other issues (Sassen 1994). By interacting together, in increasingly integrated ways, the growth of global cities is linked to each other and to the new global economy; the old national orders of urban systems seemed to be dissolving. Many centres grow because of forces generated from outside their area -- local and regional forces may be far less important than in the past -- producing quite discrepant trends of change. This means that the accumulation of information on urban systems at a national level, using measures such as average national trends, may not be the most appropriate form of generalisation or comparison. These global cities are complemented by new globally specialised places -- offshore banking centres and industrial processing zones -- also primarily linked to the world economy, not to the local place. In addition, new relationships between spatially separated, yet interacting sets of towns seem to have emerged; the development of urban networks also seemed to be a new trend that has further undermined the old order of the hierarchical system.

Barriers to Understanding the Effects of Change

Unfortunately, our understanding of the effect of these changes upon the nature of urban systems is limited because of at least five main problems. The first is that there is a relatively limited amount of research on urban systems occurring, because there seem to be only a handful of academics interested in the topic -- and many of these are nearing the end of their careers. The problem may be compounded by the anti-quantitative and anti-generalising approaches that inspire much contemporary work in human geography. Also, the fact that no government agency is responsible for monitoring changes in urban systems -- added to government cutbacks -- has reduced research money in the field. This compounds the problems of obtaining adequate knowledge about urban systems. The paucity of research is especially obvious in the context of studies of urban system dynamics, or long term studies of changes in urban systems -- although Bourne and his co-workers in Toronto represent a shining exception in the latter case.

A second problem is the *ad hoc* nature of most urban system research, which in turn is related to the difficulty of defining the phenomena to be studied. At an empirical level, it is rarely possible to fit individual pieces of research together, because researchers use different data inputs or techniques, or focus on very different areas. In a conceptual sense we seem to have borrowed new concepts and theories from different fields, rather than developing many of our own. We have

not been very successful in inter-relating the new ideas, linking them with older concepts, or grounding them to empirical research, although an attempt has been made (Davies 1986) to provide a rationale for urban system differentiation, linking urban classifications with the underlying societal forces for growth. In general, however, there is a pressing need for more integration in the field.

Third, there may have been an over-emphasis upon the utility of new ideas, and especially of their relevance to all places. New trends identified in one area often seem to be given universal status on very little justification, or without rigorous comparative research, at the same time as older ideas are ignored or downplayed. This does not mean that we can ignore the fact that there have been profound changes in the nature of urban systems in the past twenty years; rather, it indicates that the relevance of some of the newer processes *may* have been overstressed. The best example may be the way that "counter-urbanisation" was seen as a new trend obliterating older patterns, supposedly leading to a rural renaissance and to the declining influence of cities. This is not to dispute that there were decentralising trends in the 1970s, but their impact and long term effect upon the balance of urban or rural growth was exaggerated (Davies 1995). More detailed studies of the changes showed that there were considerable regional variations in the extent of growth in rural areas, and much of this was the result of the greater spread of metropolitan influences, rather than truly rural growth.

In Canada, one can argue that the urban system has become more focused on the three largest centres and their surrounding regions over the past forty years. This is not to deny that the new communications technologies mean that the proverbial stockbroker can continue part of his business from the ski slopes in Banff, or from a fishing lodge in Northern Ontario; rather, the economic and social advantages of the big centres or their surrounds still mean that most of such activities will be based in such areas. Similarly, are there really functionally dispersed cities out there, or does the concept apply to a limited number of places and especially the edges of large metropolitan fields? Commercial hierarchies may still be a viable description of the pattern of trade centres in many rural areas, perhaps modified from the rigidity of the past (Davies et al 1998). Economic base studies may still provide useful summaries of urban systems (Davies and Donoghue 1993). Also, the concept of urban networks is not new; classical Greek city states or the medieval Hanseatic League provide historic examples of urban networks. The concept of urban networks, therefore, like so many other of the so-called new processes and patterns, may be better seen as an additional relationship within urban systems, not as the complete replacement of older structures. Unfortunately, the limited amount of research makes even this statement an act of faith rather than a tested conclusion. So the new processes and patterns may have contributed to the increasing complexity of existing urban systems, rather than creating what seems to be regarded as "old" versus "new" urban system patterns and processes, on either side of the early 1970s.

A fourth point is a derivative of the third. To what extent are the "new" globalising forces really new? Or are they simply more widespread in different economic sectors and more rapid in their effect, a result of the differential effect

of new technologies, which have spawned a new set of relationships and local specialisations to add to previous ones? In the context of so-called global cities, surely London was a global city from the late eighteenth century, whilst many political empires of the past had large and often continental coverages. Moreover, commercial plantations from the sixteenth century or furs from Canada a century later contributed to an Atlantic economy, whilst spices from the Indies have been part of a global economy for over four hundred years. The existence of many small mining towns has long been subject to global forces, for most of their product often goes to industries in other countries, so their contributions are more “global” than most of the big nodes. There are many other examples. Perhaps the global city distinction in this context is not as much with the “product” as with the organisation and packaging of the products, which relate to information as much as to any material entity.

A fifth point can be made about the recent lack of attention paid to explicit government policies designed to bring about changes in urban systems. Reviews of national urban system policies by Rodwin as well as Bourne in the early 1970s have not been updated. A decline in the government will to alter the urban system using explicit policy means less interest in the topic. This change in government attitudes in many countries can be attributed to two factors. One is the trend to conservative tendencies from the late 1970s, which led to less interventionist approaches. Another was the belief that urban systems policies have not been effective. Certainly many policies did not fulfil the anticipated goals, but others have led to important changes – although perhaps not on the scale of the inflated expectations on which many policies were based. Since U.N. surveys show that many countries consider the spatial distribution of their population to be unsatisfactory, there may be a need to return to evaluations of government policies in the field. However, the role of implicit, as well as explicit, government policy needs to be applied to studies of deliberate change. It has also been argued that it is important to integrate policies in the fields of population, land use, employment and regional infrastructure, as well as those that are specifically orientated to settlements, in order to provide a comprehensive list of the range of policies that can be adopted (Davies 1991). It might also be noted that the past concern with growth and its distribution may be replaced with a wider concern for the potential decline of most settlements in the developed world in future years, if the current below-replacement fertility levels are maintained in the western world.

These and other problems need to be resolved if the study of urban systems is to develop as a comprehensive and systematic body of knowledge in future years. The field does suffer from the fact that urban systems are often seen more as a consequence of other forces, rather than the main subject of interest. In addition, the multi-dimensional character of the phenomena being dealt with, the difficulty of defining and measuring the component parts, as well as their constant change, will always provide difficulties for researchers. However, these should not be regarded as permanent handicaps, but as challenges to be faced and solved.

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URBAN SYSTEMS RESEARCH: PAST, PRESENT, AND FUTURE.
A PANEL DISCUSSION*

Dynamic Integrated Urban Models

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Why Model Cities?

To understand them. To work with them. A city is more than a localised part of an economic or demographic system. It is an integrated whole made up of a number of physical, biological, and human subsystems; and as an increasing number of researchers in the natural and social sciences are recognising, none of the subsystems can be fully understood if they are considered in isolation from the others. Thus the search is on for a comprehensive, integrated approach.

Cellular automata based integrated modelling is emerging as the most promising framework for understanding urban and regional dynamics (Cecchini 1996; Couclelis 1985, 1988, 1989, 1996; Engelen et al 1997; Portugali and Benenson 1995; Portugali et al 1994; White 1998; White and Engelen 1993, 1997a, 1997b; White et al 1997; Wu and Webster 1998; Xie 1996). The cellular approach formalises the view that a city is a self-organising, evolving entity with an open future. In contrast, equilibrium based approaches start with the assumption that a city changes only when it is perturbed by some external event. Since standard economic theory is equilibrium based, so are most of the models currently used in regional science. Thus while we are interested in forecasting and planning only because we know that change is an inherent, fundamental feature of our world, the standard approaches in regional science treat change as an isolated event, an accident.

At the heart of a cellular automata based simulation model is a set of rules that describes the behaviour of the agents in the system. The rules are implemented inside a time loop, so that the actions specified by the rules are sequential, and

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each action is taken in a context which includes the results of previous applications of the rules. Thus, even though the model is formally specified, it has something of a post-modern quality about it in that its behaviour is always context dependent, with the context generated both by the past behaviour of the model itself and by any external events that have been fed into it. It is this recursive context dependence, together with a stochastic element, or nonlinearities generating a deterministic chaotic element (or perhaps nonlinearities generating deterministic chaotic perturbations), that is responsible for the open future in the modeled city.

An open future implies uniqueness. Every city generated by a given model is unique. But a model calibrated to a particular city will produce a family of very similar results -- all runs of a model of St. John's, for example, will produce simulated cities that are similar to each other and to the actual city, although all will differ in detail. On the other hand, models calibrated to different cities will produce results that are as different as the cities being modelled, but the results will nevertheless share certain generic qualities such as a declining population density from centre to periphery or a certain size spectrum of commercial centres. The models can therefore be used both to give realistic representations of particular cities and to predict (and in a sense, explain) generic empirical regularities common to all cities.

How Can We Model a City in All its Complexity?

When modelling a specific city, a GIS database is a good place to start. The GIS, after all, contains a high resolution description of the city. But the data in the GIS by itself tells us nothing about why the city has the particular spatial configuration that it does, or what that configuration will be in 10 or 20 years time, or what its significance is for the local economy. To address these questions, we need a process model that can be applied to the data.

Cellular automata are currently the favoured modelling technique for this purpose because of three key characteristics:

- they are inherently spatial and deal efficiently with high resolution data;
- they are inherently dynamic; and
- they are rule based.

A cellular automaton is essentially a grid (like a raster based GIS) in which each grid cell can have one of several states, and the state of a particular cell depends, according to a set of rules, on the states of the cells in some neighbourhood around the cell. Thus in a typical urban simulation (e.g. White and Engelen 1993; White et al 1997; Xie 1996) the cell states would represent land uses, and the land use of each cell would depend on the land uses in a neighbourhood of that cell according to rules representing the attractive or repulsive effect of the various land uses in the neighbourhood. However, cell states may also represent other phenomena, such as

socio-economic status (e.g. Portugali and Benenson 1995; Portugali et al 1994) or population density (Wu and Webster 1998).

Furthermore, rules may be formulated to take into account the intrinsic characteristics of particular cells. For example, the rule that determines the probability of a particular cell changing from agriculture to residential use may look not only at the land use of cells in the neighbourhood, but also at the slope of the particular cell (steep sites are more expensive to build on) and the cell's zoning status (it may not be zoned for residential use). In this way the cellular automaton can be specified to model a particular city, with its particular site characteristics and planning regulations. In other words, including cell-specific characteristics permits a wide range of locationally specific environmental and regulatory factors to be integrated into a land use model. These factors may themselves be the output of other, linked, models.

Finally, the rules must typically reflect aggregate demand for various land use types. But since the amount of land demanded for a particular purpose depends on the scale of the activity generating the demand, such rules permit a direct link between standard economic and demographic models and land use dynamics. For example, when an Input-Output (I-O) model predicts changes in sectoral outputs, these are fed into the cellular automata rules as changes in the sectoral demands for land, and so the I-O model indirectly generates functionally and locationally specific changes in land use. Conversely, information from the cellular level can be fed back to the economic and demographic models. Thus if suitable land for a particular activity becomes harder to find, or available land is less suitable than previously (e.g. steeper), this implies an increase in cost of the land factor, or a decrease in productivity, or both, and thus changed technical coefficients in the I-O model. A rule based cellular model thus provides a platform for a relatively detailed, specific, and realistic modelling of linkages between various environmental factors and economic and demographic phenomenon -- in other words, it provides the foundations for true integrated modelling (see, for example, Engelen et al 1995, 1996; White and Engelen 1997b, 2000).

Cellular automata based integrated models have now been used successfully to model land use change in cities like Cincinnati, Ohio (White et al 1997) and St. John's, Newfoundland (White 1998), and social structure in Tel Aviv, Israel (Portugali et al 1994). Currently the approach is being used at Los Alamos National Laboratory in the US where existing models of weather, surface and groundwater hydrology, vegetation cover, wildfire propagation, and traffic flow are being integrated through a cellular automata based land use model in order to create a comprehensive model of urban growth and development; the test city is Los Angeles. Groups at Los Alamos are also using cellular automata for micro-simulations of traffic generation and flow (Nagel 1997); one of these models is now being tested in Portland, Oregon.

Similar models can be applied to larger regions. Cellular based models have been developed for the island of St. Lucia as a tool for understanding the possible socio-economic effects of climate change in the Caribbean (White and Engelen 1997a), and for the southwestern arm of the island of Sulawesi, Indonesia. In this

latter application, the aim is to be able to forecast the interactive effects of the expansion of paddy rice and shrimp farming, deforestation of the mountainous interior, and water management projects in the vicinity of a rapidly growing urban area (Uljee 1996). Finally, a cellular automata based model with a 500m resolution has been developed for The Netherlands. This model integrates a land use dynamics model with regionalised models of economic and demographic dynamics. The aim is to improve land use forecasting by making better use of regional estimates of economic activity and population, and in turn to improve the regionalised economic and demographic forecasts by taking into account localised effects of crowding and environmental degradation (White and Engelen 2000).

What are the Theoretical and Methodological Foundations of Cellular Automata Based Integrated Urban Models?

Dynamic modelling of urban and regional systems, though it has independent roots, is now being integrated into the broader mainstream of research into self-organising systems. This emerging field represents a fusion of three areas:

- *The theory of systems that are far from the thermodynamic equilibrium.* Structure proliferates in systems that are far from thermodynamic equilibrium (see, for example, Prigogine and Stengers 1984; Nicolis 1989). Cities, like all living systems, are far from equilibrium, maintained in that state by a constant influx of energy and a constant export of entropy in the form of waste products. Such systems generate their own structure as they episodically pass through bifurcation points where a restructuring takes place; for example, as energy use increases, a monocentric city may become unstable and quickly evolve to a polycentric form.
- *The theory of complex systems.* This is a rapidly developing theory of the nature of evolving rule-based structures (see, for example, Forrest 1991; Langton et al 1992; Stein 1989). Cities are certainly such structures, and one result from complexity theory throws some light on the significance of that classic urban system curiosity, the rank-size rule: linear rank-size distributions are characteristic of systems that are capable of sufficiently complex behaviour that they can be said to compute; they are probably also characteristic of systems that are able to evolve (Kauffman 1989, 1990; Langton 1990, 1992).
- *Fractals.* Geometrical structures generated by non-linear systems, fractals are indefinitely complicated yet orderly structures, which, as Mandelbrot (1983) pointed out, seem to represent the geometry that characterises nature, or, more generally, evolved systems. Cities, in almost any way examined, are fractal objects: The boundary of the urbanised area, the density pattern of the urbanised area as well as of individual land uses, the route network of transit systems, the cluster sizes of particular land uses -- all of these features have

been found to be fractal in the many cities from around the world examined so far (Batty and Longley 1994; Batty and Xie 1994; Frankhauser 1991, 1994; White and Engelen 1993, 1994). What previously seemed to be messiness in the urban form, or noise in the data, is now understood to be highly structured, functionally important complexity, with fundamental implications for planning policy (White and Engelen 1994).

Putting the urban and regional models in the context of these more basic theories and techniques has several advantages. First of all, it means that the conceptual and occasionally the methodological foundations for integrating models of the physical, biological and human systems that together make up a region become clearer, thus facilitating the integration. More generally, it may provide novel interpretations of urban phenomena, as in the case of the rank-size rule, or even suggest the existence of phenomena which were previously unobserved, like the fractal nature of urban land use patterns. Finally, the rapid progress in the field of self-organising systems means that there is a steady supply of new techniques and approaches which can be adapted for use in urban modelling.

Is All This of Any Importance for Regional Science?

To return to our initial observation, a city is functionally coherent and highly organised in space. It is composed of physical objects -- people, cars, buildings, garbage -- but also of perceptions and ideas. It functions by means of flows -- of air and water, people and goods, but also of money and information. And it grows and evolves. How can we capture all this in a model? In the past it seemed hopeless to try. But with the revolution in concepts and techniques now underway, it is increasingly possible, and the models are rapidly becoming more sophisticated and realistic -- and more useful. Most of the modelers, however, are physicists; few are geographers or regional scientists. Is regional science what regional scientists do? Or is it what they *don't* do?

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