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Development Similarity Based on Proximity: A Case Study of Urban Clusters in Canada

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Abstract. Neighbouring towns in urban clusters of Canada exhibit similar levels of socio-economic development. However, when measured by different development indicators, inter-town development association differs in both nature and degree. In core areas, for instance, only population and housing variables exhibit a strong spatial association, while that of employment-related variables – average income, and unemployment rate – is weaker. This tendency reflects the fundamental difference between the two groups of variables. While population and housing variables are associated with the clustering of residents in socially homogenous areas, inter-town development similarity in respect to employment-related variables is weaker, apparently due to long-distance commuting. The paper discusses the importance of urban clustering as a factor in regional development policies and programs, and provides support for including cluster-related elements in a strategy to enhance urban growth in underdeveloped regions.

Key words: urban clusters, urban clustering, Canada, spatial association, proximity

1 Introduction

Clustering and agglomeration have been subjects of in-depth analysis in classical studies of urban and industrial location (Weber 1909; Christaller 1933; Lösch 1939; Isard 1956; Beckmann 1968). In recent years, clusters of industries have attracted extensive empirical research (see *inter alia* Rogerson 1998; Shilton and Craig 1999; Wallcott 1999; Boddy 2000; Gordon and McCann 2000).

In contrast to industrial clusters, which are based on industrial cooperation and exchanges of goods, information and services and may spread over large areas, often over the entire national territory or even neighbouring countries (*ibid.*), urban clusters (UCs) are more localised and formed by adjacent urban localities (Portnov and Erell, 2001).

The studies of urban clustering remain infrequent. These studies refer mainly to four distinctive aspects of this phenomenon: a) the physical expansion of urban clusters (Fujita and Mori 1997; Schweitzer and Steinbink 1997; Portugali 1999); b) the provision of services and facilities in clusters of towns (Wellar 1982, 1988; McNiven et al 2000); c) the preconditions for sustainable growth of small and medium-size towns in UCs (Port-

nov et al 2000; Portnov and Erell 2001), and d) the development performance of UCs vs. centralized settlement (Krakover 1987).

However, this body of work does not address in sufficient depth development similarity between neighbouring towns in urban clusters (UCs). In particular, three central questions arise:

- Do adjacent towns in UCs exhibit similar development levels?
- Is there a relationship between areal proximity and the development association of neighbouring towns in UCs?
- Are there differences in the intensity of inter-town development association between centrally-located and peripheral areas?

Different research techniques may help to identify and measure the development association in urban clusters. A common approach is to analyse the flow of goods, investment, and people among localities (Paku 1998; Byers et al 2000; Casado 2000; O'Donohue 2000; Shin and Timberlake 2000). However, in the present study, an alternative approach is used. This approach is based on the analysis of spatial association of development rates exhibited by neighbouring towns, which is arguably more advantageous than the analysis of flows methodology, as discussed further in the paper. The proposed approach is based on the use of measures of spatial association (such as Moran's *I*) that provide summary information about the intensity of spatial interaction, thus helping to determine whether the values of a particular parameter are arranged in space in a systematic manner (Ord and Getis 1995; Anselin 1999; Sawada 2000).

The present paper attempts to analyse the *similarity of urban development based on proximity, using urban settlement in Canada as a case study*. Canada's urban settlement ranges from dense clusters in the centre of the country (Windsor-Montreal corridor) to nuclei of scattered clusters in the periphery, thus providing a range of settlement patterns for both analysis and comparison. The paper begins with a brief overview of previous studies of inter-urban development interaction, followed by an outline of Canadian patterns of urban development, and an analysis of spatial association of development rates exhibited by neighbouring cities and towns in selected UCs. The concluding section discusses the implications of the analysis for regional policy, and presents elements of a strategy of redirecting priorities to enhance urban growth opportunities (Task Force on Urban Issues 2002a, 2002b).

2 Development dependencies in urban clusters (UCs) – background studies and research hypotheses

According to Christaller's (1933) Central Place Theory, development processes in neighbouring towns are not necessarily linked. In his view, the centrality of an urban place is determined solely by retailing functions it may contain. Lösch (1939) expressed a similar point of view, arguing that settlement patterns are formed as the 'economic landscape' is divided into non-overlapping 'market areas' which form as a result of competition among independent producers of particular products.

In contrast, more recent studies of urban and regional location emphasize the development linkages among individual towns. Thus, since the early 1950s, the issue of regional growth 'spill-over' has generated a considerable amount of policy debate and scholarly research (see *inter alia* Perroux 1950; Hirschman 1958; Hansen 1975; Hughes and Holland 1994; Parr 1999), including a major colloquium sponsored by the Government of Canada (Wellar 1981) on national and regional economic development strategies. However, there is little evidence to date that a 'growth pole' in a peripheral region has any substantial 'trickle-down' effect on neighbouring towns (Portnov and Erell 2001).

Development links among individual localities are also an important component of the 'core-periphery' dichotomy, which emphasizes the role of urban centres and innovation in the formation of economically advanced regions (Friedmann 1966; Hansen 1975). According to this concept, development originates in a relatively small number of urban centres located at the points of highest potential interaction, defined as the core. Major centres of innovative change are located at this core, which dominates the periphery that is dependent upon the core and upon institutions found in it.

In a recent study of inter-municipal interaction, Pastor et al (2000) found that development processes in central cities and suburban municipalities of the United States are strongly linked. As a result, the poverty and inequality previously experienced in central cities is tending to spread into suburban areas.

Internal migration, long-distance commuting, and trade flows are other important manifestations of interurban linkages that have been examined in urban and region studies (Carvero 1988; Fotheringham 1991; Green and Meyer 1997; Byers et al 2000).

One over-arching development postulate, shared by these background studies, is that as goods, people and information travel from one place to another, events and circum-

stances in one place affect conditions elsewhere (Odland 1988). In this paper we extend that line of reasoning by suggesting that in UCs such a development association may be largely attributed to two factors – hierarchical choices by migrants and location preferences of firms and entrepreneurs, - which are described below as follows.

- Hierarchical choices by migrants. Migrants often choose their destinations hierarchically: first, among clusters of localities, and then among individual localities in a preferred cluster. The reason is that ordinary migrants, as distinguished from those with political, business or other connections, often lack the capability to process information on many possible destinations, and thus treat neighbouring localities as clusters of opportunities (Fotheringham 1991).
- Location preferences of firms and entrepreneurs. In the process of location decision-making, firms and individual entrepreneurs may prefer clusters of towns to small isolated settlements. Within such clusters, they may expect to find a larger pool of skilled labour and consumers than in each stand alone or isolated town. The establishment of a new industrial enterprise in a cluster may trigger a chain reaction leading to further concentration of firms, an effect which Myrdal (1958) termed ‘cumulative causation’.

Since both migrants and entrepreneurs may thus consider clusters of towns as integrated functional units, it can logically be hypothesized that strong association of development processes within such clusters can be expected. And, it can further be assumed that such association necessarily involves spatial limits. Thus, it could be argued that migrants are unlikely to regard a town as a part of a UC if its distance from the rest of the cluster is perceived to be too large. In addition, from the perspective of firms and individual entrepreneurs, the possibilities of hiring skilled employees from neighbouring towns may also be regarded as restricted if inter-town distances are larger than practicable for daily commuting. These hypotheses (viz. development interdependency of individual towns in UCs, and commuting distances as spatial limits of UCs) can be tested using various measures of spatial association.

3 Research method and data sources

3.1 Patterns of urban development in Canada

Like many other countries (Japan, U.K., U.S.A., South-Korea, Norway, Sweden, etc.), Canada has an unevenly spread population. While its three highly-urbanized provinces – Quebec, Ontario, and British Columbia – cover less than 36 per cent of the country's land area, they house nearly three-quarters of its population (Table 1; Fig. 1). In contrast, the combined population of two large northern regions (Yukon and Northwest Territories) amounts to less than 0.4 per cent of Canada's population, whereas the land area exceeds 39 per cent of the country's total (Table 1).

Canada's urban system is dynamic. As Bourne (2000) notes, in the 1980s and early 1990s three new trends emerged: a) a decline of traditional manufacturing centres in the old core regions, while resource-based centres in the periphery were rising; b) the decentralization of specialized service activities through the periphery's urban hierarchy; and c) the diffusion of cultural and educational facilities throughout the urban system. According to Bourne, these trends are adding the south-east of British Columbia (the Fraser Valley, Vancouver and Victoria) and the Edmonton-Calgary corridor to the country's urban core, while shifting all of Quebec, except for the greater Montreal region, to the periphery.

Coffey and Sheamur's (1998) analysis of employment change in 1971-91 also indicates that the resource-based provinces of the Prairie region – Manitoba, Saskatchewan and Alberta – experienced the nation's highest growth rate during the 'resource boom' of the 1970s, reverting to low growth rates during the protracted slowdown of the 1980s. These findings are consistent with those of Ishikawa (1999) that migration into the core provinces of Quebec and Ontario declined in the 1970s and then increased in the 1980s.

3.2 Selection of UCs

Four UCs are included in the analysis. Two of them are located in Canada's highly urbanized areas, and are named after their major population centres – Toronto and Vancouver. Two other clusters – Edmonton and Calgary – are situated in the inland part of the country, in the province of Alberta (Figs. 1-2).¹

¹ The size of the sample (four UCs) was mainly restricted by a limited number of neighboring urban localities of comparable size in peripheral areas of the country. Though two other 'peripheral clusters' -

These UCs differ in respect to the maturity of urban settlement. In the Toronto and Vancouver clusters, urban settlement is both dense and diverse. For instance, the Toronto cluster consists of 14 municipalities with population of 100,000+ residents, six municipalities of 50,000-100,000 residents and of three urban municipalities of smaller size. In the Vancouver cluster, there are six municipalities with populations over 100,000 residents, four municipalities of 50,000-100,000 residents, and nine urban municipalities of smaller size. Moreover, in these clusters urban settlement often forms contiguous urbanized areas.

In contrast, in the Edmonton and Calgary clusters, the majority of the local population (70-90 per cent) is concentrated in the cities of Edmonton and Calgary. Elsewhere in the regions, urban settlement is generally undeveloped, and existing urban localities are small and widely-spaced from each other (Fig. 2).

The inclusion of UCs from regions with both different densities and patterns of urban development is considered to be advantageous for the present analysis. First, it allows us to compare inter-urban interaction in different geographic areas of the country. Second, it may also help to generalize about the nature and role of development links in Canada's urban clusters for national urban strategy purposes (Task Force 2002a, 2002b).

3.3 Selection of localities

Three criteria were used to select localities for the analysis:

1. Minimum population size. To facilitate comparison we excluded very small localities from the study. For the Toronto and Vancouver clusters, the minimum population was set at 10,000 residents, a common threshold for small towns (see *inter alia* Portnov et al 2000). However, for peripheral clusters (Edmonton and Calgary), the inclusion threshold was lowered to 2,000 residents to ensure large-enough samples in these thinly populated regions.²

Regina and Winnipeg – were considered as potential candidates, they were subsequently omitted from the analysis due to the small number of neighboring urban localities of comparable size that they contain.

³Henceforth we refer to the Toronto and Vancouver clusters as centrally-located or 'core' clusters, while defining the Edmonton and Calgary clusters as 'peripheral' ones. Although similar ideas of interregional divides can be found in early works of Myrdal, Lösch, Zipf, McCann, and others, Friedmann's (1966) contribution to this idea involved a major shift from natural regions to city-dominated functional areas.

2. Urban development. The study domain is restricted solely to urban areas. However, census subdivisions (CSDs) in Canada may include both rural and urban localities. Therefore, setting a minimum population threshold does not necessarily guarantee that all localities in the sample are urban. Consequently, only municipalities with a majority of urban population were selected for the analysis.
3. Areal proximity. Since the actual sizes of UCs in different geographic regions of Canada were *a priori* unknown, the criterion of areal proximity was used to identify localities that are likely to belong to UCs. For the core areas this criterion was set at 60 km, and for peripheral areas at 100 km. As indicated by previous studies of inter-urban commuting in Canada (Green and Meyer 1997; Thompson and Mitchell 1998; SC 2001), these distances are likely to capture most (up to 95 percent) of the commuting trips among neighbouring localities in these geographic areas.

3.4 *Development measures and data sources*

Five indicators were included in the analysis as measures of urban development:

- a) POPULATION GROWTH: Overall rate of population growth over five years [percent];
- b) HIGHER EDUCATION: Percent of population with university degrees;
- c) INCOME: Average family income [\$];
- d) UNEMPLOYMENT: Unemployment rate [as percentage of the labour force];
- e) HOMEOWNERSHIP: Home ownership [percent of households].

Though these indicators do not cover all possible measures of inter-town development association (e.g., export-based employment, ratio of manufacturing employment to total employment, housing prices, etc. could be other potential candidates), they do cover the most essential aspects of urban development, viz. population growth and education, employment, and population welfare. Moreover, each indicator in its own right is an important element of urban development, as the following brief comments demonstrate.

High unemployment indicates both economic underdevelopment, and social hardship. Rapid population growth implies attractiveness to both investors and migrants. As often argued (Portnov and Erell 1998; Bourne 2000), a rapidly-growing town more quickly reaches the population threshold ('critical mass') promoting sustainable growth.

Homeownership is a widely-used indicator of urban development, but it can take on very different interpretations. That is, ownership of a home, an expensive and durable commodity, is held to be an important indicator of population welfare (Clark et al 1997; Myers and Lee 1998). However, the reasons behind high homeownership rates can reside in low mortgage rates, lack of rental units, equity-based investment strategies, and societal preferences to own things, whereas a low percentage of homeowners may indicate that a town's dwellers are not committed to staying on as permanent residents (Portnov and Erell 2001).

The data on urban development indicators were drawn from Canada's 1991 and 1996 Censuses of Population: Statistical Profiles of Canadian Communities - Census Divisions (CDs) and Subdivisions (CSDs). The 73 CSDs, grouped into four separate clusters, were included in the analysis (Figs. 1 & 2).

3.5 Analysis of spatial linkages in UCs

As hypothesized, the size of an UC is affected by the location of the urban places whose development is strongly associated. Such association can be investigated using various investigative techniques, including the analysis of interurban commuting and the 'analysis of flows' methodology, each of which is widely used in urban and regional studies (Carvero 1988; Green and Meyer 1997; Casado 2000; Drejer 2000; McNiven et al 2000).

By way of example of this research, Green and Meyer's (1997) analysis of commuting in Canada drew attention to considerable differences between regions: a) the Atlantic provinces (Newfoundland, Prince Edward Island, Nova Scotia, and New Brunswick) are characterized by high rural commuting and low urban commuting; b) the Prairie provinces (Manitoba, Saskatchewan and Alberta) are characterized by extensive urban commuting due to the dominance of a few big cities and to large inter-town distances (see also Wellar 1978); and c) the Central Canada provinces (Ontario and Quebec) are characterized by average rural and intra-urban commuting, and high inter-urban commuting.

In another study of interurban commuting (McNiven et al. 2000), a functional classification of Canada's urban areas, termed 'census metropolitan and census agglomeration influenced zones' (MIZ), was used to delineate urban areas on the basis of minimum commuting thresholds. The MIZ concept focuses on municipalities that are located outside census metropolitan areas (CMAs) and census agglomerations (CAs), but are af-

ected by central municipalities as measured by commuting flows. Unlike the traditional CMA/CA delineations (SC 1997), this classification recognizes multiple sources of attraction rather than a single metropolitan core.

Minimal Flow Analysis (MFA) is another research technique that can be used to investigate functional linkages in UCs. This technique makes it possible to depict production linkages existing between activities, using the algorithm similar to that in the Leontief input-output (IO) tables where activities are interrelated through the purchases and sales of intermediate products. Drejer (2000) used this technique to analyse the structure of National Systems of Innovation (NSI) in different countries -- Germany, Japan, the United Kingdom and the United States. The analysis indicated that the national systems in these countries tend to cluster in two main 'hubs,' one of which is formed around industrial chemicals and pharmaceutical industries, while the other is centred around communication equipment.

However, for the present analysis of development similarities in UCs, neither the analysis of interurban commuting nor the MFA approach may be an adequate research tool. By way of brief explanation, a travel survey may point out that interurban commuting in an UC is mainly centripetal, i.e. directed towards the central city, while direct exchanges between local towns are negligible. The development rates of these towns may nevertheless be strongly linked, perhaps because the towns may share high rates of unemployment or population growth. On the other hand, MFA requires detailed information on production and information exchanges between localities, which is most often not readily available. Moreover, MFA has no spatial dimension. In particular, it does not permit investigating the effect of proximity on the intensity of interurban development association, which a major objective of the present study.

For these reasons, we opted for another research technique known as the analysis of spatial association. This technique has a number of advantages compared to both the analysis of commuting and the MFA methodology. First, the spatial association approach does not require detailed information on interurban exchanges (commuting, material and information flows). Instead, it makes it possible to take advantage of widely available data on socio-economic performance of individual urban localities, such as population growth, employment change, etc. Second, the 'spatial association' approach may help to identify functional linkages between localities, which may not always be detectable by

the analysis of commuting and similar techniques. That is, it may help to identify development association between small localities, even when they do not have heavy exchanges of commuters and goods.

The analysis procedure used to investigate the development linkages among neighbouring towns in UCs was as follows. First, different spatial lags (inter-town distances) were tested. For this study we used the ranges of 5 through 45 km for Toronto and Vancouver clusters, and 10 through 80 km for the Edmonton and Calgary clusters. For each distance band (spatial lag) the value of a given development parameter (e.g., population growth, unemployment, and income), observed in a specific town, was compared with the corresponding values observed in other towns located within a given distance range from the town in question (e.g.: 10-14 km, 15-19 km, 20-24 km, etc.). The procedure was repeated for all towns, and for all the distance ranges covered by the analysis. Then the averages values of the Moran's I measure of spatial autocorrelation were calculated separately for each distance band, and compared with the values expected for a normal distribution of values for a given sample.³ The analysis was performed with the Rookcase add-in to MS Excel, using this program's module for irregular lattice data (Sawada 2000).

4 Results and discussion

Figs. 3-4 contain the results of the analysis for localities having at least three neighbours, to allow for generalization.

As Figs. 3-4 show, the general trends of distance-related change are fairly straightforward: spatial autocorrelation tends to decline as inter-town distances grow. There are, however, discernible differences between centrally-located and peripheral clusters. These differences are examined in the following subsections.

³ Moran's I is a commonly used measure of spatial association that helps to determine whether the values of a particular variable are arranged in space in a systematic manner. The expected value of Moran's I is $-1/(n-1)$. If a calculated value of I is equal to the expected value (within the limits of statistical significance), the value of variable x in a locality i is statistically independent of the values of this variable in other localities. If a calculated value of I exceeds the expected value, this indicates a positive spatial correlation. If a calculated value of I is below $-1/(n-1)$, negative spatial correlation occurs. Under this condition, neighbouring values are not independent but tend to be dissimilar (Cliff and Ord, 1973).

4.1 Group 1: core clusters

As can be seen by inspection of the spatial autocorrelograms in Fig. 3, there are development similarities between neighbouring towns, but most of them stop at the 20-40 km distance range. Beyond this range, the values of Moran's I for nearly all variables in the analysis – population growth, average income, percent with higher education, etc. – drop to the levels to be expected in a normal distribution of observations ($P > 0.05$). In other words, *towns farther away from each other than the 20-40 km distance range no longer exhibit significant development association.*

However, the nature and strength of spatial association varies by cluster. For instance, in the case of population growth spatial autocorrelation is especially strong in the Vancouver cluster (see Fig. 3A), where the values of I reach 0.447 for a 5-10 km distance band ($Z > 2.26$; $P < 0.02$), 0.29 for a 10-15 km band ($Z > 2.29$; $P < 0.01$), and 0.269 for a 15-20 km band ($Z > 3.2$; $P < 0.01$). These values are considerably higher than expected for the normal distribution: -0.056.

Residents with higher education also appear to be distributed across neighbouring towns in a systematic manner. For example, in the Vancouver cluster Moran's I for the higher education variable is statistically significant for the entire 5-45 km distance range (Fig. 3A).

In the Toronto cluster (Fig. 3B) the higher education variable is also autocorrelated for localities up to 35-40 km apart. The homeownership variable behaves similarly: the values of Moran's I are statistically significant for the 6-15 km distance range in the Vancouver cluster, and for the 5-20 km range in the Toronto cluster (Fig. 3).

In contrast, there is no strong evidence that the percent of unemployed and average income have spatially-ordered value distributions. Only in the Toronto cluster do unemployment rates autocorrelate within the 5-20 km range where Moran's $I = 0.20-0.24$ (Fig. 3). However, the probability of this autocorrelation is of low order ($P > 0.05$).

The distinction between two groups of variables-- population growth, percent of residents with higher education, and homeownership that exhibit strong spatial association, versus average income and unemployment rate for which spatial association is weaker-- deserves comment.

In general, this distinction is unsurprising, as it seems to reflect fundamental differences. The first group (population and housing) expresses, both directly and indirectly, the social makeup of an area where people of similar socio-economic and ethnic background settle close to each other (Massey 1985; Morrill 1995). It may result in strong spatial association of values in neighbouring urban localities, as occurs in the present study. In contrast, however, employment-related variables (unemployment, incomes, etc.) may be unrelated to the situation in a given locality and its immediate surroundings. That is, and due for example to inter-urban commuting, low unemployment in a given town may be more an indication of prosperity in the wider region rather than the availability of employment in the town itself.

Further, when opportunities for inter-urban commuting are wide, the spatial association of the values of employment-related variables may indeed become less obvious. Moreover, low unemployment in a given town may be more a reflection of the socio-economic makeup of its population than of its employment situation, and particularly if there is a disproportionately large share of elderly, or a small share of unskilled and other 'employment-disadvantaged' population groups such as ethnic minorities and new immigrants.

4.2 Group II: peripheral clusters

Figure 4 features the results of the analysis of spatial autocorrelation (Moran's I) for two peripheral UCs – Edmonton, and Calgary.

As the diagrams and tables show, the spatial autocorrelation of development levels in peripheral towns extends, in general, over a larger area than that observed in the country's more densely populated and developed regions (see Fig. 3).

For example, in the case of average income, spatial autocorrelation is both strong and statistically significant for towns up to 60 km apart in the Edmonton cluster, and up to 100 km apart in the Calgary cluster (Fig. 4).

Moreover, in the Calgary cluster, unemployment rates also appear to be spatially associated: $I=0.460$ for the 30-40 km distance range; $I=0.338$ for the 40-50 km range, etc. This differs from the situation in centrally-located UCs where, as noted above, average incomes and unemployment rates in neighbouring towns do not autocorrelate significantly (Fig. 3).

This dissimilarity may be explained by patterns of urban development in the periphery. That is, due to the small number of neighbouring towns and longer commuting distances, employment-related variables (unemployment and incomes) may best reflect the employment situation in a given town. Our reasoning here is that opportunities provided by the larger region, outside regular commuting limits, may be less relevant than they are in the core where inter-town distances are small.

5 Development interdependency

Establishing that a high level of spatial association exists does not necessarily mean that the development of neighbouring towns in UCs is an interdependent process. That is, strictly speaking, spatial association of development levels may be caused by parallel but independent changes in neighbouring localities.

In order to ascertain whether spatial autocorrelation observed in UCs reflects interdependency rather than just similarity of development levels, time-series analysis is required. Such an analysis, likely entailing both a larger sample of towns and long-term longitudinal data, is beyond the scope of the present study that uses mainly cross-sectional (1991-1996) data. However, some insights into this aspect of urban clustering may be gained from the data at hand.

The specific research hypothesis posited for testing is as follows:

If development in UCs is transmitted from one urban locality to another, then a higher level of income in the central city of a cluster should subsequently lead to higher income levels in neighbouring towns.

To test this hypothesis, we compared levels of average income in the local towns and central cities of two clusters –Vancouver and Toronto. For the analysis, data from the 1991 and 1996 Censuses of Population were used.

Two separate tests were run using the local Moran's *I* measure of spatial autocorrelation:

Test 1: Average income in the central city (either Vancouver or Toronto) in 1991 vs. incomes in the local towns in 1996.

Test 2: Average incomes in the central cities in 1996 vs. 1996 incomes in the local towns.

Our expectation was as follows: If there is no time-directional linkage between the income levels in the central cities and local towns, then both tests should report similar values of spatial association. However, if there is a time-directional linkage between the income levels in the central cities and the income levels in the local towns, then Test 1, which assumes a time-directional linkage, should indicate stronger spatial association than Test 2, which simply compares present-time incomes.

The results of both tests are given in Table 2. This table reports the values of local I for various distance bands, expanding concentrically from the clusters' central cities at distances of 10 to 50 km.

As Table 2 shows, for nearly all distance bands average incomes in the local towns more similar to the lagged incomes in the central cities (Test 1) than to their present-time incomes (Test 2). This implies that development links in UCs are indeed time-directional. These links are also fast-acting. That is, local towns not only appear to follow the development of the central cities in UCs, but the development links may take effect quickly. In the case of this analysis, the stimulus-response appears to be traceable within a five-year span (1991-1996).

6 Conclusion

Urban clustering has a number of important research and policy facets, including the process of UC formation, the effect of clustering on town development, and socio-economic interactions in UCs. While every facet is an important subject of study, our present inquiry deals with two matters of immediate interest: a) investigating the spatial autocorrelation of development levels in towns within such clusters, and b) ascertaining the physical sizes of UCs in Canada (i.e. the spatial extent of the area of inter-town development association).

The present analysis leads to three general conclusions:

- First, development levels of neighbouring towns in UCs of Canada tend to be closely associated, though the intensity of such a development association generally tends to decline as inter-town distances increase. As argued, this spatial association of development levels may be due to the fact that both private investors and migrants consider UCs as integrated functional units, and make their loca-

tion decisions hierarchically: first, among or between town clusters, and then among or between individual towns in a 'preferred' cluster.

- Second, the effect of clustering on urban growth is not uniform. It is stronger in peripheral UCs (specifically in respect to unemployment and income variables), while in centrally-located ones the development levels of neighbouring towns appear to exhibit fewer similarities. In general, distances within which inter-town development association is sufficiently strong to affect or promote clustering vary with the range practicable for daily commuting, that is, from 20-40 km in the country's core and 60-100 km in its periphery.
- Third, the effect of spatial proximity of towns on their functional linkages differs in respect to different development measures. In particular, as found from our analysis of Canada's core areas, only population and housing variables exhibit strong spatial associations, while the effect of spatial factors on employment-related variables – average income and unemployment rate – is weaker. This dissimilarity represents fundamental differences between these two groups of variables. That is, while population and housing variables may be confidently associated with the clustering of residents in socially homogenous areas, the spatial association of employment-related variables may be influenced by inter-urban commuting. Thus, low unemployment in a town may reflect the availability of employment in the larger region rather than in the town itself, which is an important caution about the care that needs to be taken in correctly selecting and interpreting indicators of urban functionality and growth potential.

Although further studies of the causality of time-related changes in UCs are needed to confirm the generality of the observed trends, and additional measures of urban development (e.g. export-based employment, ratio of manufacturing employment to total employment, housing prices) may also be considered in future studies, the initial findings from this study appear to be informative and instructive for policy purposes.

An important strategic finding of the present investigation is that local towns appear to follow the path of the central city over time, and local towns adjacent to a wealthy city are likely to perform better than those around a less-prosperous central locality. This result indicates that urban growth may spread across individual towns in both core and peripheral UCs, which has implications for urban and regional development policies and

programs at the municipal, provincial and federal levels of government (Wellar 1996; Task Force 2002a, 2002b).

Finally, we should emphasize that this study's findings on the effects of spatial clustering on urban development, and about the physical sizes of UCs, are specific to Canada at this time. However, a similarly strong relationship between urban clustering and growth could occur elsewhere. If it does, then this research may help planners and decision-makers formulate informed regional policies, and especially in countries experiencing severe interregional inequalities and under-population of the periphery.

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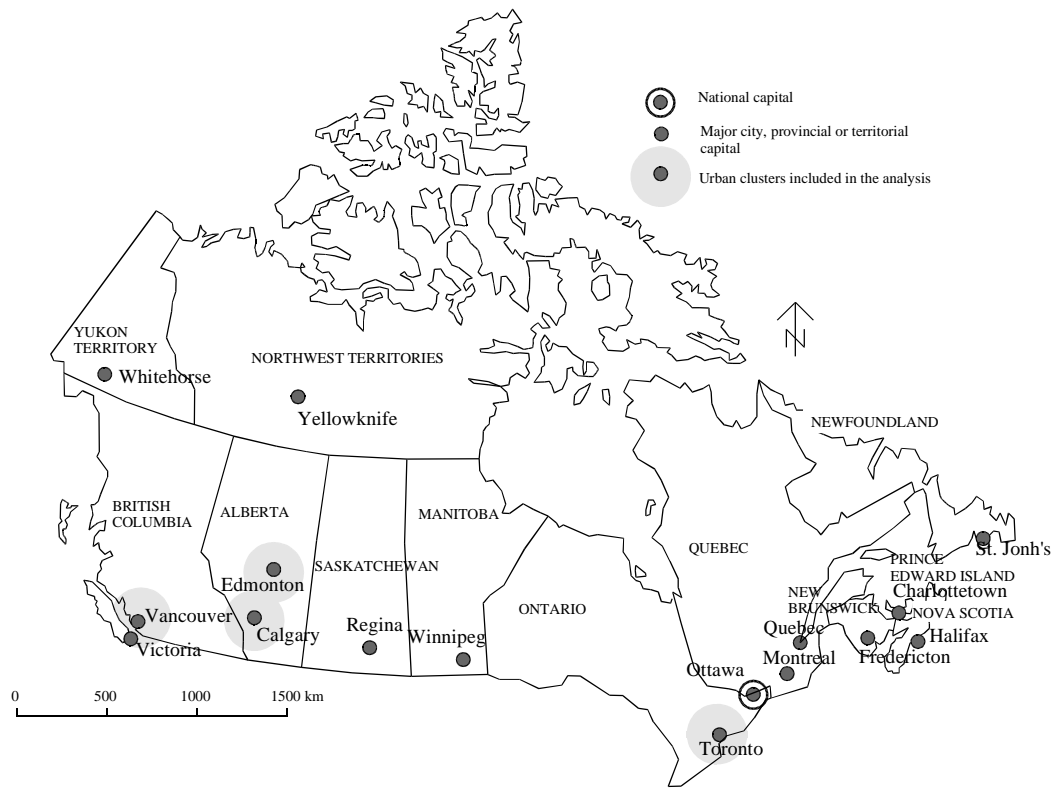


Figure 1 Geographic location of urban clusters included in the analysis

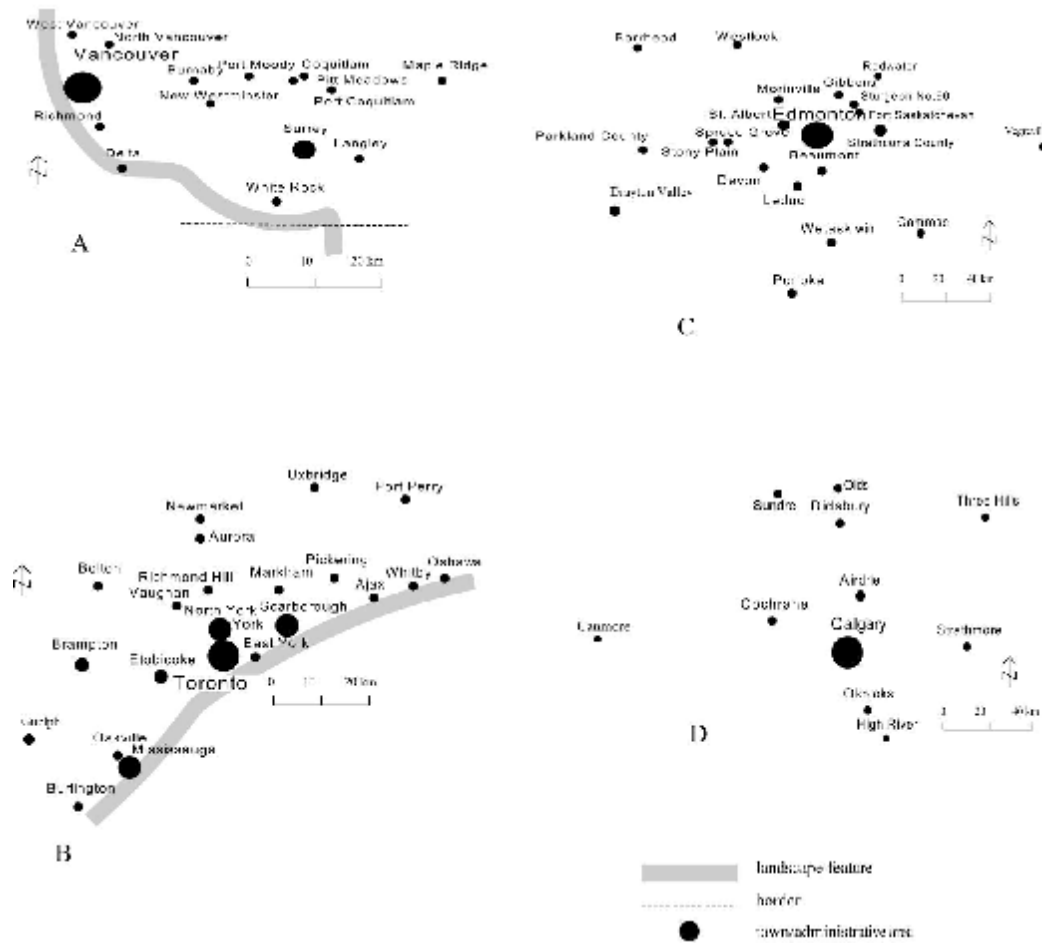


Figure 2 Urban clusters (UCs) included in the analysis

A – Vancouver; B - Toronto; C – Edmonton; D – Calgary.

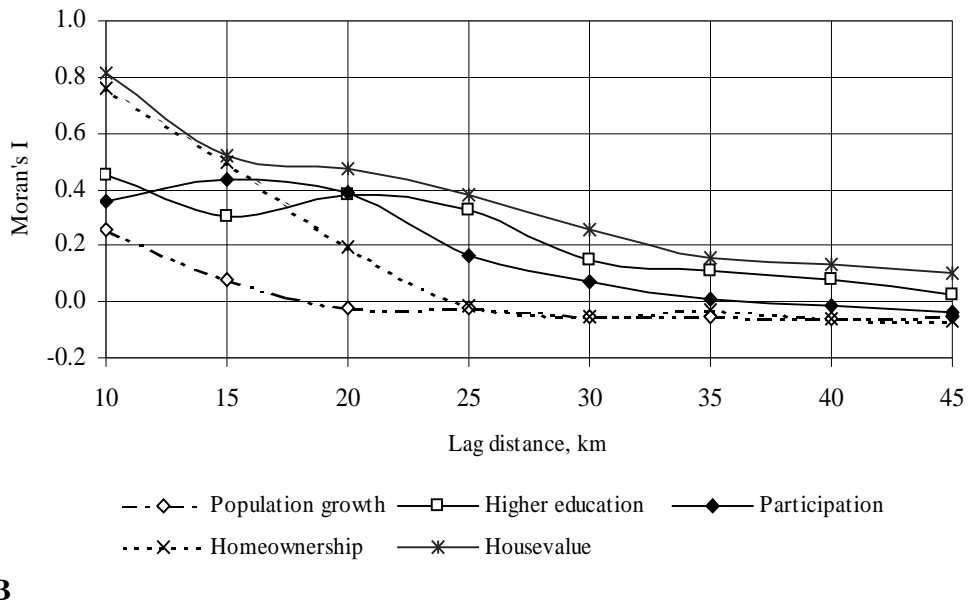
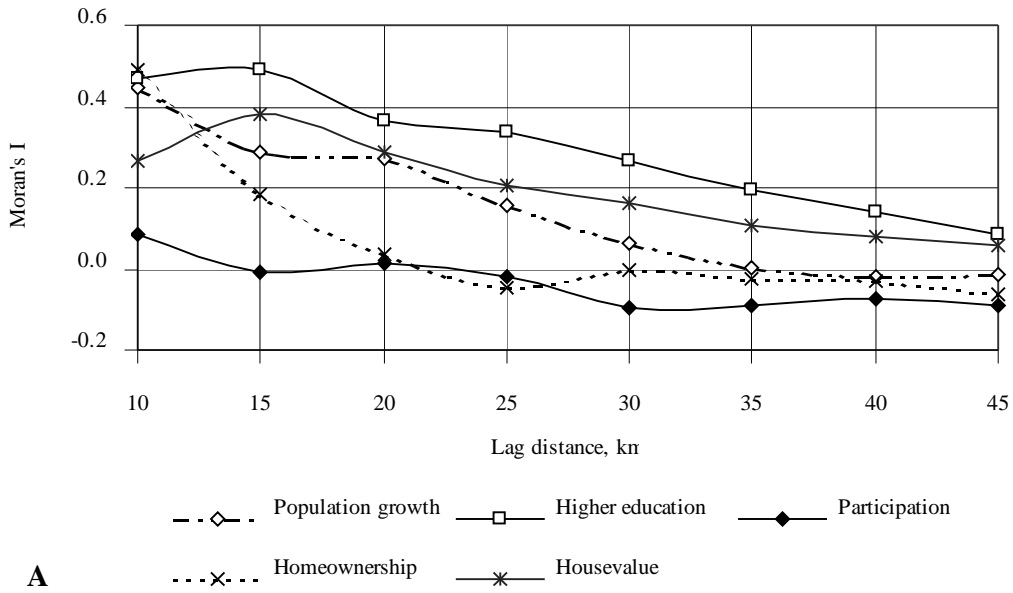


Figure 3 Spatial autocorrelograms for Vancouver (A) and Toronto (B) clusters

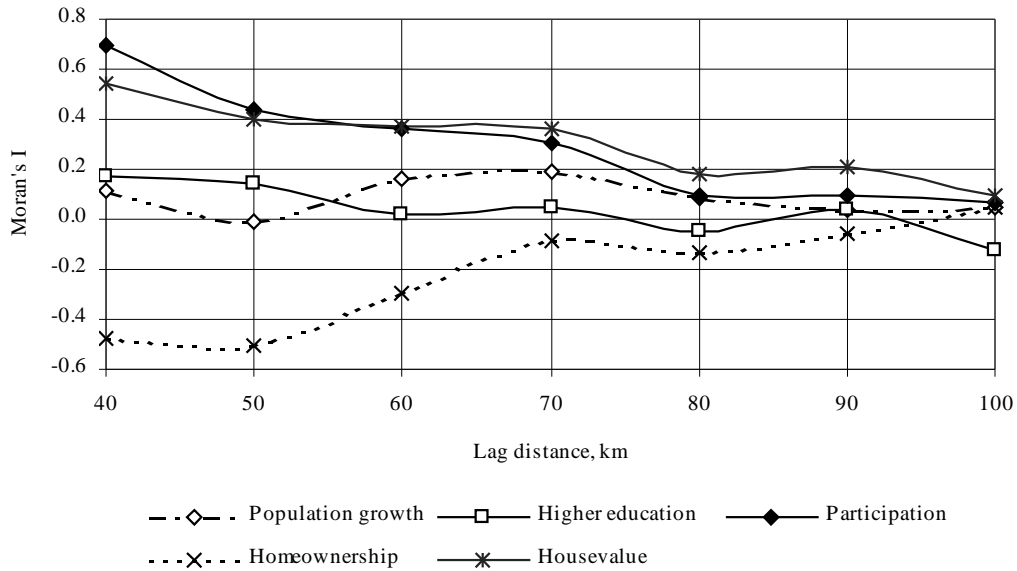
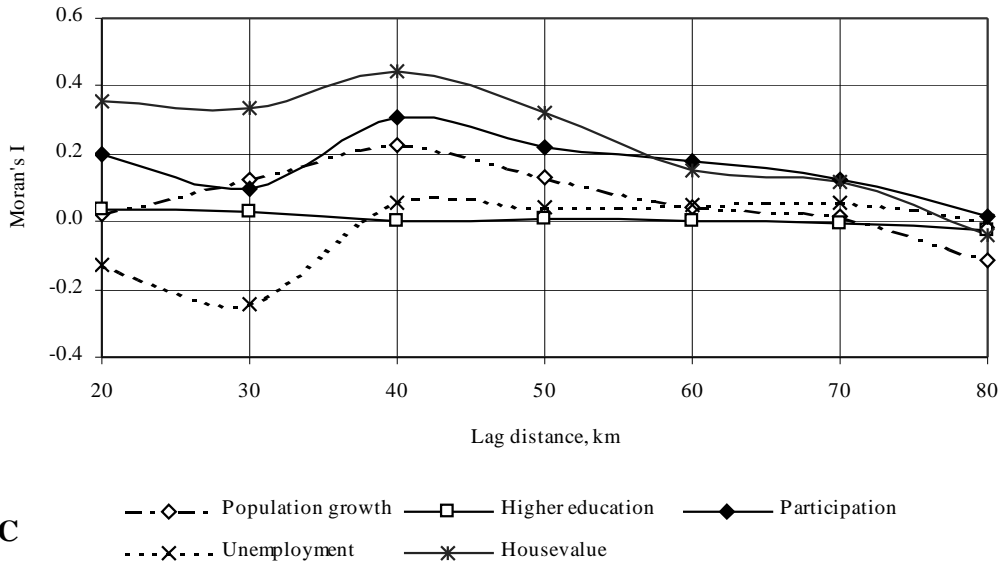


Figure 4 Spatial autocorrelograms for Edmonton (C) and Calgary (D) clusters

TABLE 1

Selected characteristics of provinces and territories

Province/territory	Distribution of population [%]		Land area [% of total]	Urban population [%]	Urban population [% of total]
	1991	1996			
Newfoundland	2.08	1.91	4.06	55.20	1.40
Prince Edward Island	0.48	0.47	0.06	45.82	0.26
Nova Scotia	3.30	3.15	0.55	55.32	2.22
New Brunswick	2.65	2.56	0.73	49.79	1.60
Quebec	25.26	24.75	15.44	81.17	24.92
Ontario	36.95	37.28	10.78	88.83	39.89
Manitoba	4.00	3.86	6.49	73.27	3.56
Saskatchewan	3.62	3.43	6.52	63.42	2.79
Alberta	9.33	9.35	6.63	84.18	9.54
British Columbia	12.02	12.91	9.46	93.15	13.61
Yukon Territory	0.10	0.11	4.83	66.36	0.08
Northwest Territories	0.21	0.22	34.44	47.52	0.12
Canada	100.00	100.00	100.00	82.28	100.00

Compiled from: Population and Dwelling Counts: A National Overview (SC, 1997) and National Resources Canada (GeoAccess Division – Internet Site).

TABLE 2

Spatial autocorrelation of incomes in central cities and local towns

Distance lag, km	Vancouver cluster		Toronto cluster	
	Test 1	Test 2	Test 1	Test 2
10	0.659	0.235	2.116	-0.289
15	1.180	0.442	2.804	-0.387
20	1.582	0.582	3.649	-0.523
25	2.442	0.880	2.812	-0.435
30	3.604	1.271	2.767	-0.448
35	3.515	1.273	-0.113	-0.108
40	0.435	0.345	-0.845	-0.034
45	-1.141	-0.115	-2.812	0.189
50	-1.141	-0.115	-2.812	0.189
Expected <i>I</i> :	-0.056	-0.056	-0.045	-0.045

Test 1: Central city in 1991 - local towns in 1996; Test 2: Central city in 1996 - local towns in 1996.