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Regional Population Size and the Cost of Municipal Environmental Protection Services: Empirical Evidence from Ontario

Michael Jerrett and John Eyles
School of Geography and Geology
McMaster Institute of Environment and Health
McMaster University
1280 Main Street West
Hamilton, ON L8S 4K1

Christian Dufournaud
Department of Geography
University of Waterloo
Waterloo, ON N2L 3G1

With the passage of *City of Toronto Act*, the Government of Ontario created a 'megacity' by amalgamating six lower tier municipalities with the upper tier Regional Municipality of Metropolitan Toronto. The controversy over the megacity bill and similar proposals for amalgamation in other Ontario regions has rekindled a debate over whether larger city-regions supply services at a lower cost per capita than smaller regions. Through numerous public pronouncements and television advertisements, the Government argued that larger city-regions reduce political and administrative overlap, operate more efficiently, and subsequently reduce municipal government expenditures. The savings result in lower property taxes, making amalgamated communities more attractive locations for new business investment. Despite considerable public debate, neither the Government nor its critics say much about the potential environmental consequences and related environmental protection expenditures resulting from amalgamation.

As in many jurisdictions, environmental protection represents a major area of program spending for municipal governments in Ontario. These outlays absorb approximately 18 % of total municipal expenditures across Ontario, with some municipalities that have high per capita expenditures such as the District of Muskoka spending as much as 26 % of their total budget (Ministry of Municipal Affairs (MMA) 1993a). If the 'bigger is better' argument holds for environmental programs in Ontario, some economy of scale should be present in the existing expenditure data. In this context we pursue two research objectives. First, we review the literature on the relationships between population size and environmental costs to provide a rationale for the research. Second, we analyse the empirical relationship between environmental expenditures and population size in Ontario to inform current policy debates and contribute empirical evidence to the scholarly discourse.

The next section contains the literature review and conceptual framework. This is followed by a description of the data and methods. Presentation and discussion of the results follow this section. The paper concludes with a summary and recommendations for future research.

Population Size, Environmental Costs and Protection Expenditures: Is Bigger Better?

In his work on ‘garden cities,’ Howard (1902) argued the population size of a city and the disamenities of industrialisation are positively linked. He proposed the development of new garden cities with a population of about 32,000 to alleviate the environmental costs and social alienation associated with urban agglomerations. With his garden city solution, Howard implied a diseconomy of scale in city population size. While a ‘scale’ hypothesis has been around for a long time, surprisingly little empirical research has investigated this question.

Most scholars writing on environmental accounting and urban planning agree that urbanisation causes many types of environmental degradation and that it also leads to a collective response in the form of policies and programs designed to protect or defend environmental quality (Mumford 1961; O’Riordan 1981; Leipert 1986; Hall 1988; Daly and Cobb 1989). Beyond this general agreement that cities cause environmental stress requiring higher protective or defensive expenditures, little is known about what size and type of city generates the greatest environmental impacts and expenditures (O’Riordan 1981; White and Whitney 1992). Some have called the search for an optimal city size futile, as much of the “relevant data are either unavailable, noncomparable, or subject to so much value judgement as to be worthless” (O’Riordan 1976: 132). The same problems appear relevant today and can be extended to debates on ‘correct’ urban density and form. Assessing economies of scale and other factors that influence the environmental impacts of urban areas remains difficult. But it is still worth pursuing because empirical evidence can inform not only scholarly debates on regional planning, but also the more politically charged amalgamation and other regional restructuring debates.

Previous work on land use variables that contribute to urban disamenities and pollution suggests these effects result from a combination of density, urban morphology, population size, the age of the settlement, and the placement of the urban area in relation to natural features and processes (O’Riordan 1981; Button and Pearce 1989; McHarg 1992; Hough 1995). Population size and density are relatively easy to measure and to operationalise, while urban morphology, age of settlement, and urban placement present considerable conceptual and measurement challenges. Given the recent political proposals for municipal amalgamation, this paper focuses specifically on the evidence and arguments surrounding population size, while controlling for other variables that may influence environmental expenditures.

Early empirical research on the determinants of municipal spending in the US found population size exerted either no effect or raised per capita servicing costs (Brazer 1959; Bahl 1969). O’Riordan (1981) cites British studies showing that a population of 50,000 is a critical threshold beyond which the cost of supplying urban services, including those traditionally defined as environmental, increases substantially. More recent empirical work suggests a positive relationship between population size and municipal expenditures in major US central cities (Ladd and Yinger 1989). Ladd (1992) points out that the degree of pureness in the public goods supplied by government influences the economy or diseconomy of scale in provision of services. Public goods are defined as those goods that display non-rivalry in consumption and non-exclusiveness in provision (Bird and Slack 1993). Given the extreme case of pure public goods, the per capita cost of providing a specific level of goods will vary inversely with the size of the population. For example, programs to improve air quality where one agent’s use of the air does not affect the ability of others to use the air (non-rivalrous) and where exclusion of use would be extremely difficult (non-exclusive) would fall into this category in Canada where no explicit property rights have been assigned to airsheds. As Ladd (1992: 278) notes, “the more people among whom the fixed costs of a given level of pure public good can be spread, the lower are the per capita costs of the good”.

White and Whitney (1992) discuss World Bank studies on the provision of services and infrastructure in India. The evidence from India suggests substantial economies of scale in cities up to a size of 150,000. They note there may be a point where economies disappear, but it has not yet been determined. Newman and Kenworthy (1989) found no statistically significant relationship between the size of a city and its dependence on automobiles. Given that higher levels of automobile use are associated with higher environmental impacts (Elkin et al 1991), this evidence can be viewed as contrary to the 'diseconomies of scale' argument. This interpretation relies on the assumption of a linear relationship between automobile use and environmental impacts such as air and water pollution. Such linearity may not exist, and in these cases, environmental impacts may increase at a greater rate than population.

From a global perspective, Satterthwaite (1997) suggests environmental problems do not necessarily worsen as cities grow larger. He points out that many of the world's largest cities reside in the world's largest economies, and wealth gives them increased capacity to address environmental problems. Another important point from his analysis relates to the need to categorise environmental problems when comparing different cities or the same city over time. He identified five categories of problems:

- Environmental hazards within the human environment such as inadequate sanitation and drinking water;
- High levels of use of resources that are only renewable within finite limits (i.e., critical zone resources such as groundwater);
- High levels of use of non-renewable resources such as fossil fuels;
- High levels of generation of non-biodegradable wastes; and
- Overuse of the renewable sink beyond the capacity of ecosystems to break down biodegradable waste.

Within a relatively small area, such as a province or state in a developed country, probably few differences exist in the first category. Yet differences may exist among cities of different sizes in the other four categories, although there is insufficient empirical evidence to determine the pattern of influence that scale may exert on each.

The question of whether increased wealth in certain regions influences their ability to supply services in Ontario was partly answered by Jerrett (1999). In his study, Jerrett used a more comprehensive measure of environmental expenditures known as 'defensive expenditures'. These expenditures are defined as those needed to prevent, abate, and remediate adverse environmental change thought to be caused by human activities. He found these expenditures to be positively associated with 'ability to finance' variables such as property taxes per capita and grants per capita. Household income was also positively related to per capita defensive expenditures. Thus, within Ontario, there is some support for Satterthwaite's contention that wealth generated in large urban areas can lead to increased capacity for environmental protection.

A consultant's report commissioned by the Government of Ontario to support its amalgamation proposal for Toronto (KPMG 1997) suggested cost savings on environmental services resulting from the Toronto amalgamation would be in the range of $26.0 to $46.5 million annually, with $5 to $7 million attributable to positions eliminated through consolidation and $21 to $39.4 million through vaguely specified efficiency improvements such as 're-engineering to achieve efficiencies'. The report shows that among the lower tier municipalities with comparable responsibilities, East York, the one with the smallest population, had the lowest environmental expenditures per household. In assessing the 'cost drivers' for expenditures, the report assumed that external cost factors including density and population lie outside the control of a municipal government and should be excluded from the analysis. Contrary to this contention, these factors are influenced by municipal governments through planning and land use regulations. Site densities are usually tightly controlled by planners, and population size is sometimes constrained by lack of adequate infrastructure for sewage and water treatment.

Intuitively there are reasons to expect a diseconomy of scale in environmental service expenditures. Municipalities with larger populations usually need more sophisticated and costly sewage treatment systems than smaller places that rely on private septic systems and wells. In addition, in the early 1990s many smaller municipalities had not implemented waste recycling systems, and they still relied on less costly open dumps instead of sanitary landfills. Smaller places also probably spend less on stormwater management because low population densities result in smaller areas of impervious surfaces, which reduces the need for costly engineering interventions.[1]

This review of the literature suggests that two important questions remain unresolved. First, do regions with larger populations exert larger environmental impacts per capita, with the subsequent need to spend more per capita on environmental protection services? Second, do administrative efficiencies allow larger regions to supply services at a lower cost per capita than smaller ones? Some of the empirical studies point to diseconomies of scale, while others suggest the opposite. Thus, a need exists for research on the relationship between the population size of a region and its related environmental expenditures, especially in the context of recent amalgamation initiatives in Ontario.

Conceptual Framework for Analysis

We adopt a framework developed by Jerrett (1999). Under this framework, government policies and programs are operationalized through budgetary allocations (Figure 1). Once implemented, the policies and programs can have both intended and unintended effects on the behaviour of individuals, firms, and other levels of government. Here government is seen as the authority that sets the playing field for societal actions. (We recognise that other societal and economic forces influence government actions.) Such actions can and do exert impacts on the environment, and these impacts accumulate in time and space, especially within a regional context, to reduce the environmental services or functions valued by humans (i.e., resource supply such as drinking water, waste assimilation such as sewage treatment, and spiritual and recreational fulfilment such as beach use). When the loss of these services becomes large enough to prompt policy action, political and administrative structures may reallocate budgetary expenditures to maintain or restore these lost environmental functions.

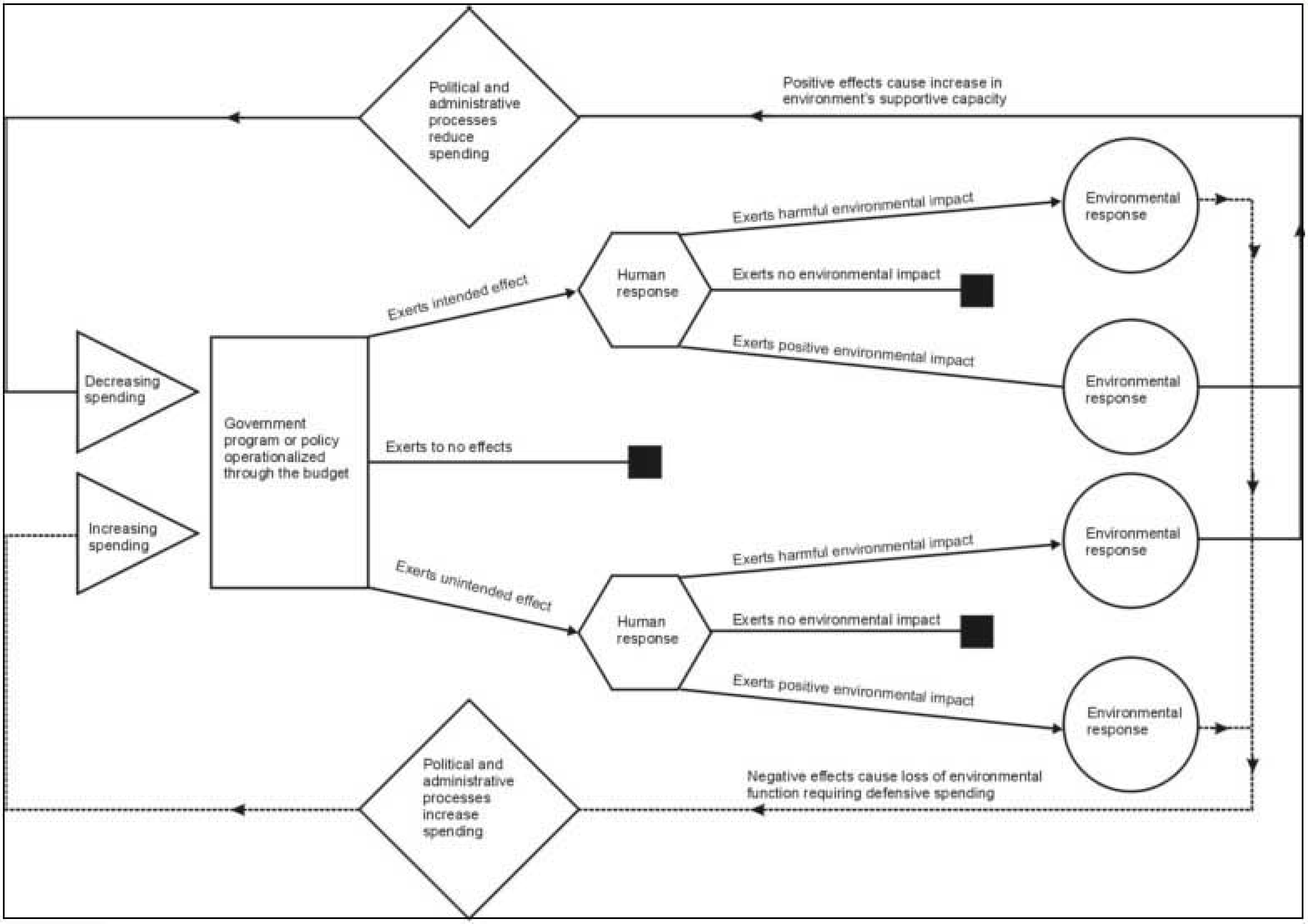

FIGURE 1 Conceptual Framework

Extending this framework to specific variables that influence the environmental expenditures made by municipalities, four broad categories of variables exist. Those that:

- Increase the pressure on the environment,
- Indicate deteriorated environmental conditions,
- Influence the demands for environmental quality, and
- Influence the ability to pay for environmental services.

Population size falls into the first category as a variable with the potential to increase pressure on the regional environment, but it is also important to incorporate variables from the other categories into models that attempt to assess the determinants of environmental expenditures. In the next section we formulate a regression model that includes representative variables from these categories, and we comment on those that we would have liked to include, but were unable to because of data constraints.

Data and Methods

Most of the recent work on the economics of urban form in Ontario rests on assumptions about hypothesized, archetypal urban structures (Blais 1996; IBI Group 1990). These studies rely on numerous simplifying assumptions. As a result, the findings of such studies, while useful, must be viewed with some skepticism. Comparative regional analysis using regression modelling supplies another way of exploring the possible impact of administrative and planning changes on municipal spending (Ladd 1992). This method allows for testing of, say, whether variation in the level of environmental expenditures is associated with variation in possible explanatory variables such as population size. Blais (1996) argues such studies establish relationships that lack the detail necessary to detect the 'real causes' behind those relationships. Her assessment downplays the potential benefits of this type of research. Regional regression analysis can play a useful role in stimulating new hypotheses about suspected relationships and augment findings from hypothesized settlement studies with information on relationships between *real* municipal expenditures and *real* populations.

Our modelling strategy relies on two separate, but complementary analyses. Each approach is designed to compensate for potential limitations inherent in the other. The first strategy uses a fully-specified per capita expenditures model. In developing the per capita model we included variables that influence the environmental expenditures of a given region. Returning to our conceptual model, we organised the available variables into the categories of pressure on the environment (population size, pollution output, per capita water use), demand for environmental quality (average household income, environmental interest groups), and ability to finance (property taxes, provincial grants). Data on some important variables such as the age of settlement and ambient environmental quality are unavailable. The per capita model is laid out below:

$$1\text{n}\ Y_i = b_o + b_1 (\text{liX}_{1i} - 1\text{nX}_l) + b_2 (X_{2i}^{.5} - X_2^{.5}) + b_3 (1\text{n}X_{3i} - 1\text{n}X_3) + b_4 (1\text{n}X_{4i} - 1\text{n}X_4) + b_5 (1\text{n}X_{5i} - 1\text{n}X_5) + b_6 (X_{6i} - X_6) + b_7 (X_{7i} - X_7) + b_8 (X_{8i} - X_8) + u_i$$

where

Y_i = Municipal environmental protection expenditures per person, in 1991 Canadian dollars, in the *i*th region;

X_{1i} = Population size in the *i*th region;

X_{2i} = Environmental interest groups per capita in the *i*th region;

X_{3i} = Municipal water use per person, in cubic metres per day, in the *i*th region;

X_{4i} = Total pollution output, in metric tonnes per year (1993), in the *i*th region;

X_{5i} = Median income per household, in 1991 Canadian dollars, in the *i*th region;

X_{6i} = Manufacturing employment location quotient for the *i*th region;

X_{7i} = Provincial transfer payments for environmental expenditures per person in the *i*th region;

X_{8i} = Property tax per person in the *i*th region; and

u_i = Disturbance term in the *i*th region.

To test the economies of scale hypothesis in the provision of environmental protection services, data were extracted from the Municipal Financial Information Database (MFID) of the MMA (1993a). Environmental protection expenditures include waste water treatment, drinking water treatment, solid waste collection and disposal, some types of stormwater management, and associated approvals and public education costs. (See MMA (1993a) for a full description of these expenditures.) This definition is fairly narrow in comparison to other measures such as defensive expenditures (Jerrett 1999). Many public health, recreation, transportation, police, and planning programs arise either from past environmental degradation (e.g., public health programs to prevent the spread of infectious disease through water, provision of parks to compensate for loss of natural greenspace) or, in the cases of police emergency response and planning substainable communities, attempt to prevent future damage. We have chosen this narrower, conventional measure to provide estimates that are easily understood by policymakers and to avoid the contentious issues about what should count as an environmental expenditure. The statistical population is the 832 upper and lower tier municipalities of Ontario for 1991. These municipalities are aggregated into the 49 upper tier regions, counties, and districts (called 'regions' for convenience). This aggregation ensures administrative commensurability among municipalities (i.e., each unit of the population of 49 holds roughly similar responsibilities and delivers roughly the same services). It also ensures that all expenditures made within the geographic region are taken into account. We can test whether population within these units of analysis affects the cost of supplying environmental services.

This study area provides almost complete geographic coverage of the expenditures made by municipal governments in Ontario, with the exception of a few unorganised territories. These territories account for only 150,000 out of a population of 9,053,939 or about 1.6 % of the total population (MMA 1993a).

Per capita environmental expenditures are mapped in Figure 2.[2] Based on the map, it appears considerable variation exists in the dependent variable, although no clear spatial pattern is evident. A Moran's *I* test revealed no significant spatial autocorrelation in per capita expenditures (I = -0.13, normal 2-sided p-value = 0.2033).

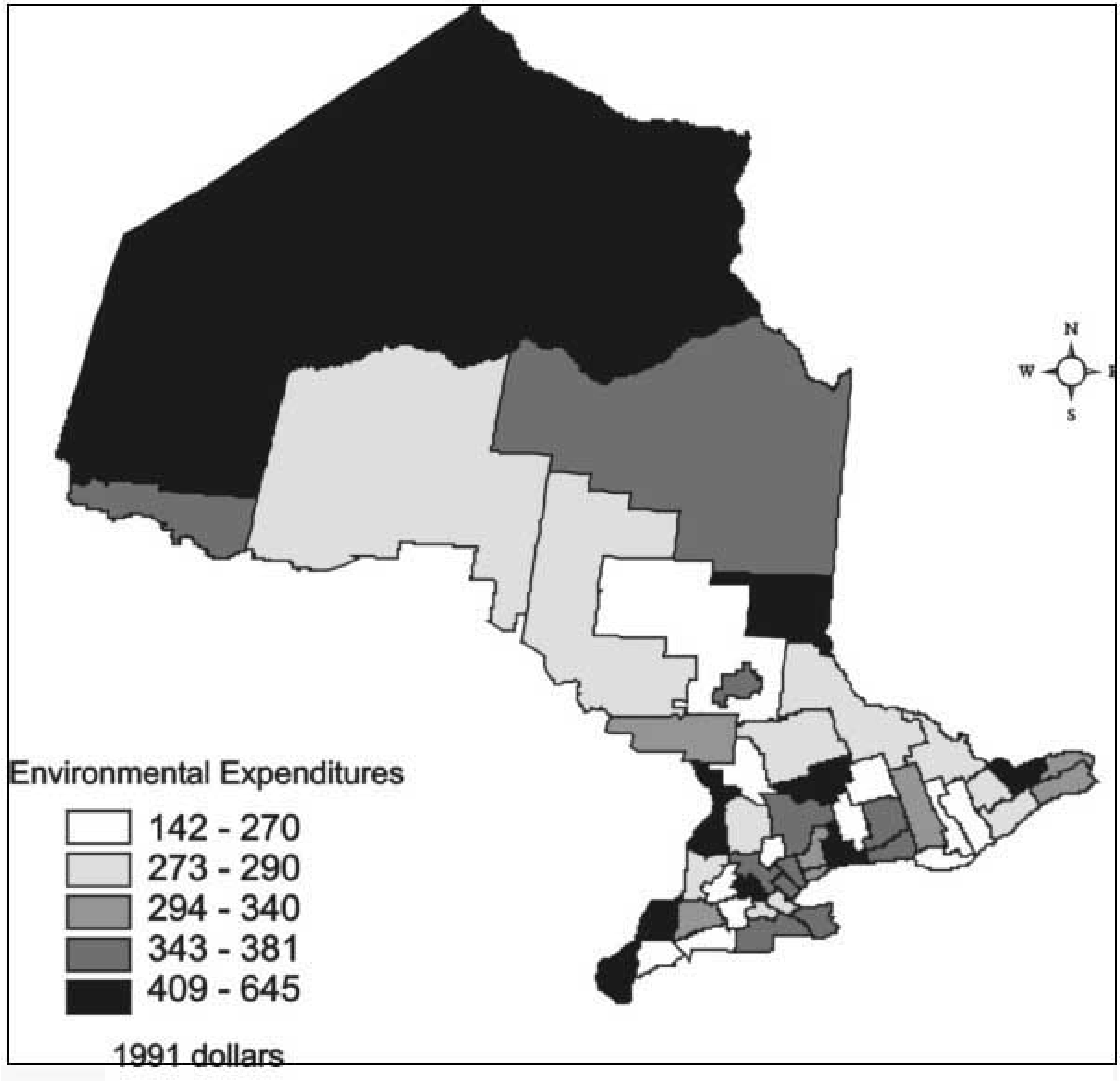

FIGURE 2 Per Captiva Environmental Protection Expenditures by Region

Although the sample covers the entire population of expenditures made in the 49 regions, inferential statistics are still appropriate. For populations with distributions subject to stochastic processes, it is appropriate to use significance tests even when the sample covers the entire population. Spatial sampling is always subject to stochastic variations within the population. Following this logic, most geographical data should be treated as a sample, and it is reasonable to apply inferential statistics (Cliff and Ord 1981; Norcliffe 1982). Therefore, the expenditure data from the entire population are treated as a sample.

The data are gathered by the MMA through surveys that every municipality must complete before receiving provincial transfer payments. These surveys are known as Financial Information Returns (FIRs) and are subject to audits by the MMA (MMA 1993b; Goojha 1995). The FIRs force municipalities to use standardised functional accounting categories, which allow for comparison across different municipal jurisdictions. Given the large amounts of money involved (more than 18 billion dollars in 1991), the rigorous auditing procedures used, and the long period over which these data have been collected (more than 20 years), there is good reason to believe that the data are accurate and reliable.

With 49 cases and eight predictors, this model results in a ratio of 6.1 cases to each potential predictor. While this is less than optimal, it meets the minimum requirements of regression analysis (Tabachnick and Fidell 1989). Financial and population data are taken from the MFID. Data on household income and manufacturing comes from the 1991 Census of Canada. Data on water use are supplied by Environment Canada (1991). The pollution data are extracted from the National Pollutant Release Inventory (NPRI) (Environment Canada 1993). (See Jerrett et al (1997) for a discussion of the aggregation methods used to compile the pollution data). Some variables were transformed to approximate Gaussian normality to avoid problems with outliers and heteroscedasticity. Model selection for this analysis proceeded with a best subsets selection process that used adjusted R,sup>2, Mallow's Cp, and the standard error of model prediction to derive the final model, which is reported in the next section.

Introducing population as a predictor variable raises statistical problems in a model with *per capita* expenditures. Specifically, statistical complications arise when correlating a ratio (for example, x_1 environmental protection expenditures per region over x_2 population of persons per region) with one of its own terms (x2 population per region). Schuessler (1974) and Uslaner (1976) demonstrate how such correlations may prove spurious. The central question is whether x_1/x_2 tends to vary inversely to x1 due to restrictions on the variation of the components x_1 and x_2 and the covariance between them. The answer depends on the relationship between the relative variance of x_1/x_2 and x_2^2. If the former is greater than the latter, the relationship will be negative and no significance can be given to the absence of a positive relationship (Schuessler 1974). Schuessler supplies methods for assessing how the shared components can result in spurious correlations. More recently, Williams (1984) and Kanaroglou (1995) have given examples and formulas for assessing this problem. These can be applied when significant correlations are found between per capita expenditures and population size, although they only determine whether the problem is present and not how much of the association is attributable to the shared elements.

Our second model, which avoids shared components, attempts to supply another strategy for dealing with this problem. A bivariate regression model with total environmental expenditures regressed on total population shares no components. If the null hypothesis holds, we expect to see no significant relationship between total environmental protection expenditures and total population. If the alternative hypothesis holds, the slope coefficient is significantly different from 0 or some non-linearity in the model's regression coefficient is present or both. This approach suffers from potential bias in the parameter estimates, although it provides useful information to corroborate the per capita model. The model is laid out below:

$$1n\ Y_i = b_o + b_1\ (liX_{1i} - 1nX_l) + u_i$$

where

Y_i = Total municipal environmental protection expenditures, in 1991 Canadian dollars, in the *i*th region;

X_{1i} = Total population size in the *i*th region; and

u_i = Disturbance term in the *i*th region.

With the bivariate log-log model, we can interpret the change in the response variable as a percentage change in the predictor variable, i.e., as an elasticity (Gujarati 1995). These models are run with three response variables:

- Total expenditures,
- Operating expenditures, and
- Capital expenditures.

This disaggregation was undertaken for two reasons. First, it controls for the potential impact of lumpy.[3] capital expenditures on the results. Lumpy expenditures can inflate the values of the dependent variable in some municipalities and unduly influence the model. Second, it allows for an assessment of whether capital, operating or both types of expenditures drive the observed relationship.

Results

Results from the per capita model, shown in Table 1, suggest four variables have significant positive relationships with per capita environmental protection expenditures: total population, total pollution emissions, per capital property taxes, and provincial grants for environmental protection. The adjusted R^2 value for the model is 44.2% ($p < 0.0001$). The Mallow's Cp statistic of 3.9 indicates the model does not suffer from significant bias when assessed against a model containing all the original variables. In the bivariate model with total variables, population size is a powerful predictor of total environmental protection expenditures ($R^2 = 95.7\%$, $F = 1070.017$, $p < 0.0001$). Diagnostics suggested the models conform reasonably well to the underlying assumptions and requirements of the regression model. A Moran's I test on the residuals shows no significant autocorrelation ($I = -0.1006$, normal 2-sided p-value = 0.3847).

TABLE 1 Results from the Multiple Regression of Per Capita Environmental Expenditures on Total Population, Pollution Output, Provincial Grants and Property Taxes

Source	SS	df	MS	
Model	1.83678	4	.45919	N = 49 F(4,44) = 8.45 Prob > F = 0.000 R^2 = 0.488 adj. R^2 = 0.442
Residual	1.92558	44	.04376	
Total	3.76236	48	50295	

Variable	Coefficient	Std. Error	t	$Prob>\|t\|$	Var. Inflation Factor
Population	0.08520	0.04413	1.93	0.060	2.4
Pollution Output	0.02559	0.01494	1.71	0.094	1.9
Environmental Grants	0.0038990	0.000808	4.82	0.000	1.4
Property Taxes	0.0008382	0.000339	2.47	0.017	1.6
Constant	5.72893	0.03610	158.7	0.000	

Note:1. Mallow's Cp Statistic = 3.9 based on best subsets selection that began with the original eight variable.

Interpretation of the Regression Coefficients

Due to multicollinearity with the constant term, the variables in both models were centred or transformed into a deviation from the mean form (see Montgomery and Peck (1982) for a discussion of this technique). It follows that interpretation of the log-log coefficients must be undertaken with reference to the mean value. This suggests that each 1 % increase above the mean of the population variable is associated, on average, with a 0.1 % increase in per capita environmental expenditures. Similarly a 1 % increase in total pollution output above the mean is associated with a 0.02 % increase in environmental expenditures. For property taxes and grants, interpretation is slightly different. For these variables, the regression coefficient is placed as the exponent of the base of the natural log (i.e., $e^{b(\Delta X - \Delta X)}$). The resulting coefficient indicates that a 1 dollar increase in the property tax variable above its mean is associated with an average increase in environmental expenditures of 1.0008 dollars. For environmental grants the equivalent figure is 1.0003. In other words, a 1 dollar increase above the mean of either property taxes or grants is associated with about a 1 dollar increase in environmental expenditures.

With the log-log model using the total variables, we expect to see a clear, linear relationship between total environmental protection expenditures and total population with a slope coefficient roughly equal to 1 if the null hypothesis holds. If the alternative hypothesis holds, we expect to see a slope coefficient significantly different from 1 (equivalent to different from zero in a non-log model) or some non-linearity in the model's regression coefficient or both. For example, if the diseconomy of scale in the provision of environmental services holds, we would expect to see the relationship show a form similar to the one illustrated on curve A of Figure 3 (i.e., a slope greater than 1). Alternatively, the economy of scale hypothesis leads to a form similar to curve B. Curve C suggests the absence of economies or diseconomies of scale (i.e., constant returns to scale). Curve D indicates constant returns to scale until some population level where diseconomies of scale appear.

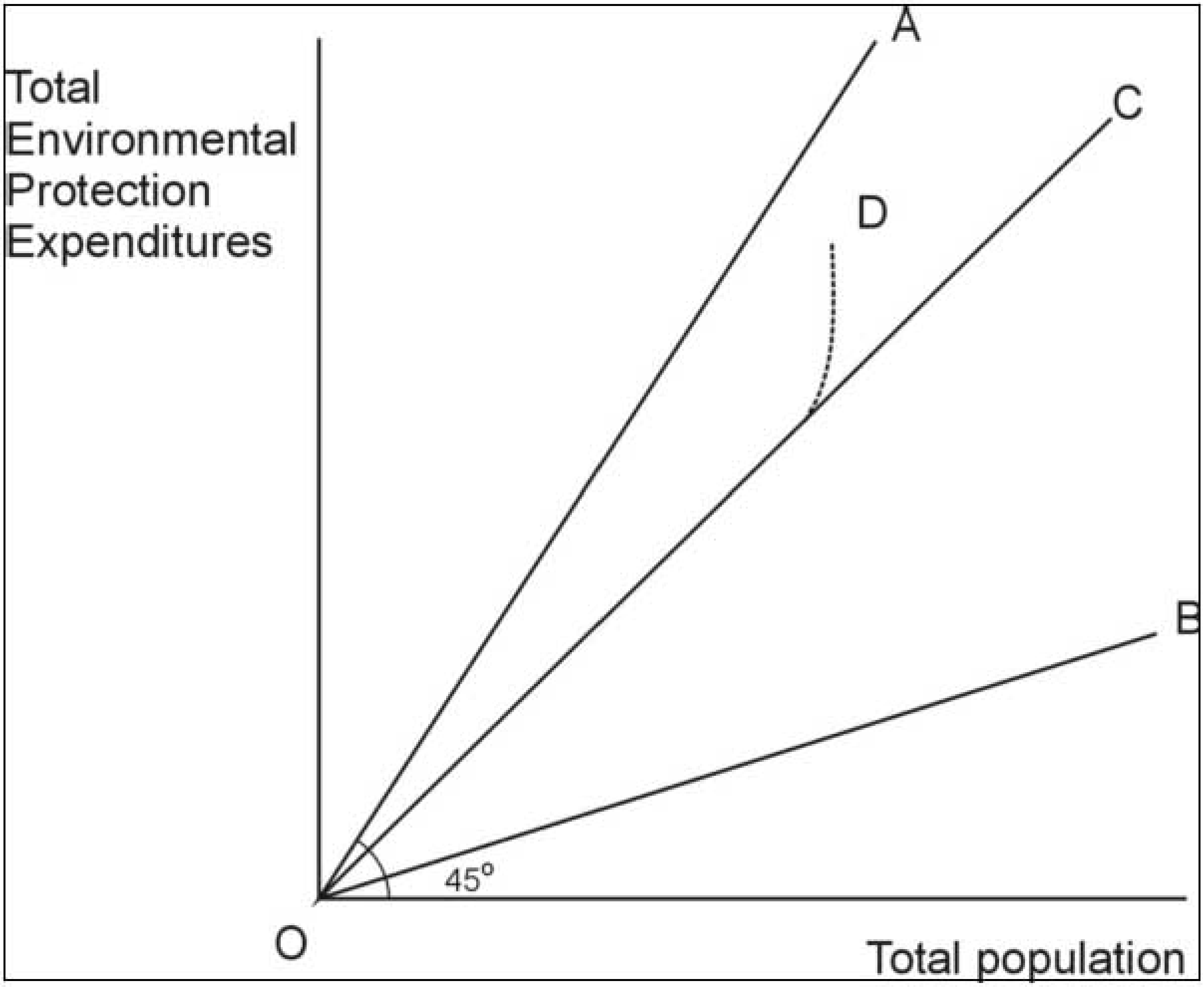

FIGURE 3 Illustration of the Different Hypothesis on the Relationship Between Total Environmental Protection Expenditures and Total Population in a Log-Log Model.

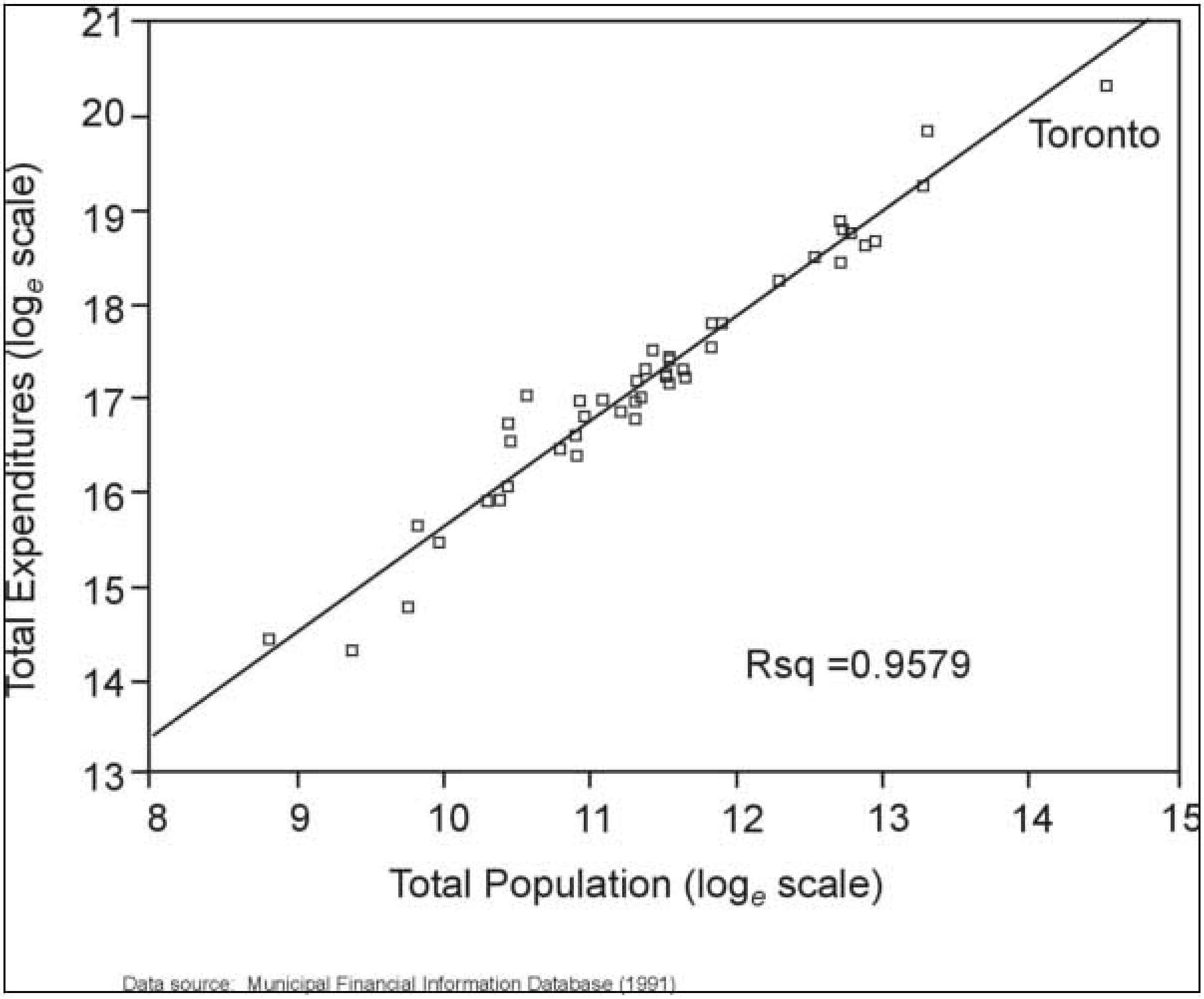

FIGURE 4 Total Environmental Protection

Figure 4 shows the bivariate relationship of total environmental expenditures regressed onto total population, which displays an extraordinarily strong relationship. The prediction equation for this model is as follows:

$$\text{LOGTENEXP} = 17.222 + 1.102\,\text{LOGTPOP}$$
$$t = (465.784) \quad (32.711)$$

Since the regression coefficient for this model takes the form of an elasticity, it suggests that for every 1 % increase in total population above the mean, total environmental expenditures will increase by 1.10 %. The 95 % confidence interval ranges from 1.03 % to 1.17 %.

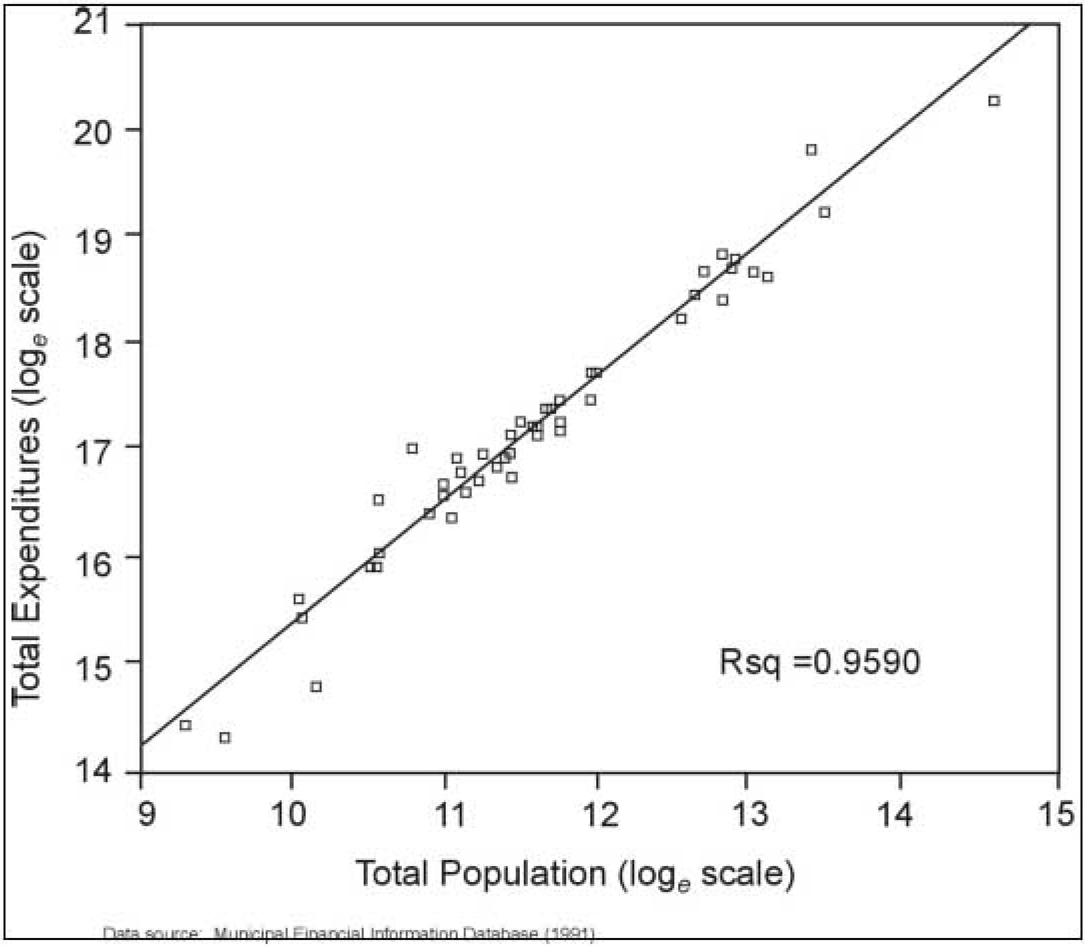

FIGURE 5Total Environmental Protection Operating Expenditures on Total Population

Results from the operating and capital expenditures models suggest that the strong relationship observed in the total expenditures model is driven mainly by operating expenditures. This is evidenced by the close resemblance of the operating model to the total model (Figure 5). Similar to the total model, the operating model achieves high predictive power (R^2 = 95.9 %, $p < 0.0001$), with a similar regression equation:

$$\text{LOGTENEXOP} = 9.877 + 1.152\,\text{LOGTPOP}$$
$$t = (279.928) \quad (35.837)$$

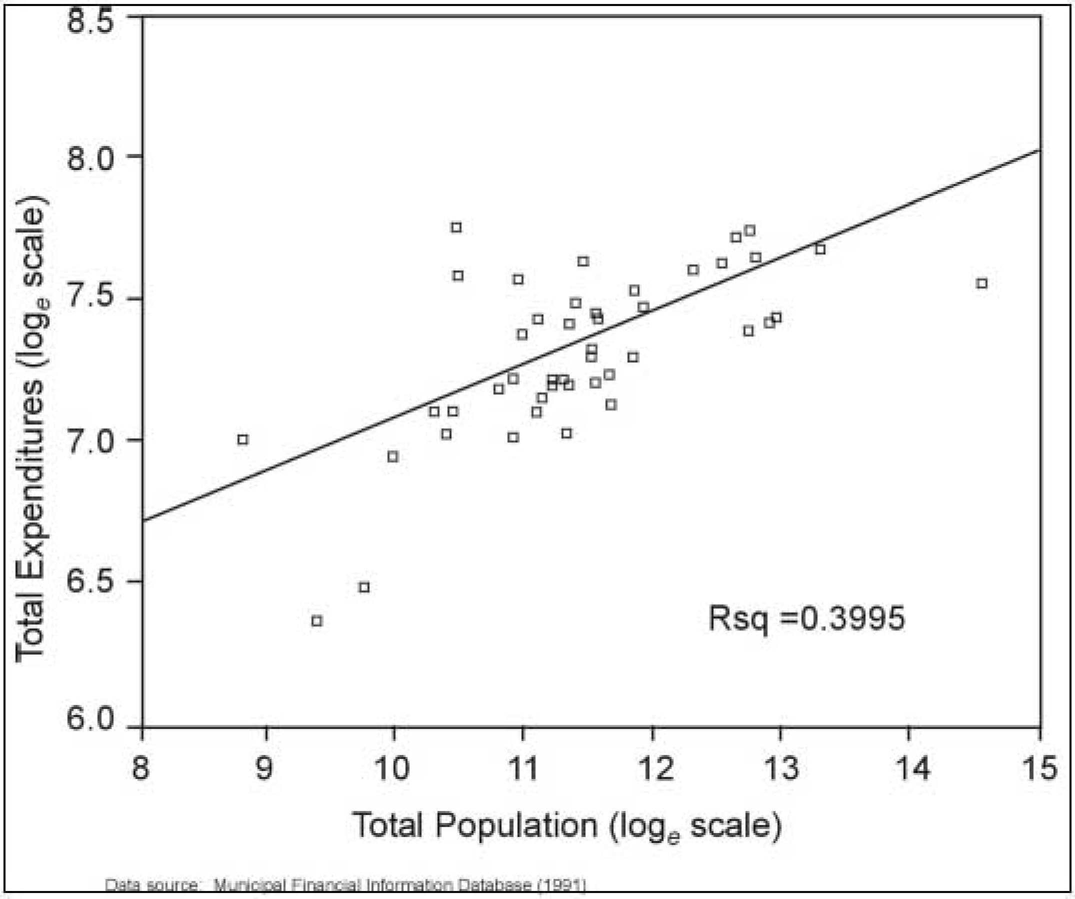

FIGURE 6 Total Environmental Protection Capital Expenditures on Total Population

As illustrated on Figure 6, the capital expenditures model shows a far lower proportion of the variance in expenditures associated with population size (R^2 = 39.9 %, $p < 0.0001$). The regression equation for this model is shown below:

$$LOGENEXCAP = 7.360 + .189 LOGTPOP$$
$$t = (198.264) \quad (5.591)$$

Unlike the total and operating models, the capital model shows the presence of a significant economy of scale.

Even with this finding of a mild diseconomy of scale in the provision of total environmental services, the possibility of financial savings in other areas exists. We tested for this possibility by regressing total expenditures (i.e., operating plus capital) with environmental expenditures netted from them onto total population, both in log form. This model also achieves a very high adjusted R^2 value of 96.9 %, $p < 0.0001$. The regression coefficient is 1.027, and the 95 % confidence interval ranged from 0.97 to 1.08. This finding is equivocal, and we cannot rule out the possibility of a small economy of scale, although there is a higher probability of a diseconomy.

Discussion

The results from both models suggest regions with larger populations tend to spend more per capita on environmental services than regions with smaller populations. While the findings remain tentative due to data limitations discussed below, they indicate that diseconomies of scale may exist in the provision of environmental services. It appears the recent amalgamation of Toronto and similar amalgamation efforts may increase the per capita cost of providing environmental services.

The exception to this conclusion is environmental capital expenditures, which constitute a relatively small portion of total environmental expenditures (about 30 % on a province-wide basis). Capital expenditures are the only portion of the total environmental expenditures that show an economy of scale. This finding suggests that some form of cost sharing among municipalities for larger capital projects may provide financial savings. Moreover, this suggests a need for flexibility in the administrative arrangements associated with the provision of capital-intensive environmental services, along the lines of the flexible arrangements advocated by Ostrom et al (1961) in their classic work on the organisation of government in metropolitan areas.

It is worth tempering the conclusions with caveats about the limitations with this type of analysis. By so doing, we also highlight opportunities for future research.

The finding of an economy of scale in capital expenditures may have been influenced by lumpiness in the expenditure stream. Capital expenditures are accounted for on an annual basis, and in accordance with governmental accounting practices, these are not amortised over the lifetime of the facility, but are counted in the year they are spent. Yet this is tempered by the incremental nature of most budgetary processes (Wildavsky 1986). Earlier studies by Jerrett (1999) in Ontario showed no significant difference between the coefficients generated for operating and capital expenditures. In future studies, five-year moving averages and other methods for smoothing potential lumpiness could be considered. Given that the data had to be extracted by hand from over 832 individual financial information returns to avoid the problem of netting user fees, it was not possible to perform this smoothing analysis here and control simultaneously for possible confounding due to different user fee structures.

The relatively low R^2 of 44.2 % in the per capita model suggests other significant variables may help explain the variation in environmental protection expenditures. Some of those highlighted in the literature review such as age of settlement may exert a significant influence on the environmental protection expenditures of a region, although the most likely influence arises from variation in regional environmental quality. Of the variables tested, pollution, grants, and property taxes showed similar relationships, although with less explanatory power, than in earlier analyses focused on predicting a more comprehensive measure of environmental expenditures (Jerrett 1999). Our findings here corroborate these earlier findings and suggest that, while other variables may be missing, those found to be significant seem to be consistent in both analyses.

Spatial variations in environmental quality represent a key confounder in this analysis. As noted in the discussion of the conceptual model, this category of variables can exert a significant influence on defensive expenditures. This issue presents less of a problem when considering aspects of the environment for which municipalities must apparently comply with provincial standards, such as drinking water quality. Other aspects of environmental quality such as access to green space and water recreation or air quality below standards display considerable differences among regions. Many cities in Ontario still flush untreated or partly treated sewage into already polluted lakes and rivers, suffer from regular incidents of unacceptably high air pollution, sit on contaminated soils, lack a coherent network of green space, and suffer noise impacts from automobile use. (See Hough (1995), Button and Pearce (1989), Elkin et al (1991), and Mcharg (1992) for general discussions of these urban environmental problems, and the Government of Canada (1991) and the Royal Commission on the Future of the Toronto Waterfront (Crombie 1992) for specific reference to Ontario.) Recent studies on pollution emissions at the regional level show considerable variation exists in the distribution of pollution in Ontario (Jerrett et al 1997).

These variations appear due to both the willingness of the citizens or their political representatives to accept different levels of environmental quality in different regions and to the historical legacy of economic development. Differences in patterns of economic development influence the initial endowment of environmental quality that current regional decision-makers inherit. Few would disagree that Muskoka S the centre of 'cottage country' S possesses a higher quality natural environment than Toronto. So when Muskoka spends more per capita than Toronto on environmental expenditures, does this difference result from the smaller size of the settlement and possible economies of scale in Toronto? Or alternatively does it result from a collective desire to maintain a higher level of environmental quality in Muskoka than Toronto due to its reliance on natural beauty as a tourist attraction for the regional economy? The possibility of either explanation or some combination of both cannot be ruled out. Controlling for variations in environmental quality among regions was not possible in this study. One solution to this problem relies on the construction of a sophisticated environmental index or group of indicators to measure environmental quality in each region (see Maclaren (1996) for a review of these approaches). Such an index could be entered into the regression model as one or more independent variable(s). The significant positive association with the pollution variable emphasised the potential influence of environmental quality on protection expenditures. Controlling for environmental quality through the construction of indicators appears essential for understanding the relationship between population size, other relevant variables, and the costs of providing environmental services.

The NPRI pollution estimates we used are the only direct measure of potential impacts to the biophysical environment. In our analysis, we relied on toxic emissions to all media from large polluters who emit more than 10 tonnes per year. (In 1994, NPRI only required reporting for polluters emitting 10 tonnes or more per year of a priority-listed toxic substance.) Some of these emissions, particularly those emitted into the air, lie outside municipal responsibility. We used total emissions for two reasons. First, we view NPRI data as a proxy for polluting activities within a region. These estimates were intended to serve as a general indicator of environmentally damaging activity, and we would argue that they are indicative of other costs such as contaminated storm water that runs off of roads in industrial areas and does have to be dealt with by municipal governments. Second, even emissions into the air eventually contaminate the land and water, which are within the realm of municipal responsibility. Although useful for this initial analysis, more sophisticated indices on the state of the environment are needed.

Environmental indices would also have to control for external costs and benefits. For example, some municipalities may pollute the waters of downstream communities, and this would increase the cost of protecting environmental quality in the community bearing the external cost, while reducing it the region that generated the cost. Likewise, residents of a municipality with low expenditures may be able to 'free ride' on those that spend more on services supplied by amenities such as parks. White and Whitney (1992) propose an extension of interregional environmental accounting for goods and services traded through the global economy. This proposal represents an ambitious agenda for future research.

The contrasting urban and rural character of the regions in the sample presents another problem. At least three distinct types of regions can be identified and broken out of the population. The first type are large, urban regions. These consist mainly of concentrated urban areas and related urban fringes (e.g., Metro Toronto). The second type are the counties that consist largely of smaller cities and towns and an agrarian-based rural economy (e.g., Peterborough County). The third type are the northern districts that also possess smaller urban areas and towns and rely on primary industries and tourism (e.g., Kenora District). This is a crude classification, but discriminating enough to highlight how they might differ with respect to environmental programs. As mentioned earlier, larger urban areas rely on public municipal services for items such as sewer and water supply. Smaller urban areas and towns rely more on private wells and septic systems, while the rural areas rely almost completely on private services. These variations confound attempts to compare the environmental protection expenditures in different regions. Yet, these differences serve to highlight how urban agglomerations associated with the modern industrial structures are induced to spend more on 'regrettable necessities,' such as environmental protection (Hueting 1980). Those areas relying heavily on private services may represent examples of regions remaining within their carrying capacity or, in the worst case, may represent areas where cumulative effects with time lags have not begun to exert an adverse impact. Future research should control for these regional differences by using pooled, time-series data on each type of region.

Another question remains unaddressed in the literature: does the administrative structure of a city-region actually influence the type and extent of the impacts on the environment? Larger administrative units may promote more regional scale expressways and larger industrial areas which, in a smaller city, would be considered beyond financial means or too large for a smaller population. Although it is difficult to generalise about the impacts from larger facilities, we note that larger administrative structure could lead to more (or less) severe environmental impacts. Alternatively, administrative amalgamations may not change the type and scale of projects that could generate environmental impacts. The only scope for economies or diseconomies of scale under this scenario are those that result from the administrative efficiencies. Investigating these potential relationships would require detailed historical research or future research on the newly amalgamated cities in Ontario. We have not addressed this question directly in this paper, but note that it is an important area for investigation.

Conclusion

The results from this analysis indicate a diseconomy of scale in the provision of environmental services. Our results also suggest no economy of scale in other municipal services. If these relationships apply to newly created or amalgamated municipalities, it is reasonable to conclude that the amalgamation of existing cities into larger ones will result in few, if any, savings in the provision of environmental services. More research using control variables for environmental quality differences and a time-series perspective will help to overcome the possible confounding effects discovered in this paper. While the findings remain tentative due to limitations with the regional regression method of analysis in the context of the available data in Ontario, they suggest policymakers should proceed with caution when considering amalgamation initiatives.

The lack of cost savings in environmental expenditures and probably in other municipal expenditures raises another important question: if not for cost savings, why would the Government of Ontario amalgamate municipal governments? This question enters more into the political-economy of provincial-local relations, and it seems that the underlying rationale could have more to do with political benefits and provincial downloading than with cost savings. The political benefits arise in the form of emasculated local participation (based on the assumption that smaller political systems are more accessible and responsive to the local citizenry), giving the provincial government greater leeway to implement contentious policies without facing effective local opposition. In the case of downloading, some capital intensive services such as commuter transit, public housing, and highway operation would be more difficult to download onto smaller municipalities. The Government of Ontario recently abandoned future plans to amalgamate municipalities, probably due to mounting political costs from opponents of amalgamation or because the next amalgamations would have affected its core voters in the ‘905' suburbs of Toronto, but perhaps also because a lack of real financial savings, as we evidenced in our empirical findings.

Endnotes

1. We thank an anonymous reviewer for this useful addition to our analysis.

2. Data published by the MMA on environmental protection expenditures have revenues collected from users fees such as water billings netted from the total. To avoid invalid comparisons resulting from different user fee structures, the environmental protection expenditures reported here have been extracted directly from the Financial Information Returns (FIRs) before the netting for fees was done. Because these expenditures data have not had user fees netted from them, they are slightly higher than those published by the MMA.

3. Here ‘lumpy’ refers to expenditures that can vary significantly from one year to the next. The periodic nature of capital projects often means that capital expenditures often show greater variation from one year to the next than operating expenditures.

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