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EXPLAINING COOPERATION IN
MUNICIPAL SOLID WASTE MANAGEMENT

by

Kelly H. Tiller and William M. Park*

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Corresponding Author: Kelly H. Tiller
University of Tennessee
Department of Agricultural Economics
PO Box 1071
Knoxville, TN 37901-1071
(423) 974-7231
ktiller@agecon2.ag.utk.edu

* Research Associate and Professor, respectively, Department of Agricultural Economics and Rural Sociology, The University of Tennessee. Research support was provided by the Waste Management Research and Education Institute, The University of Tennessee, Knoxville, Tennessee.

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Abstract

As traditional methods of municipal solid waste management (MSWM) become increasingly expensive due to increased regulation, many local governments are considering cooperation as a waste management strategy. A theoretical model of cooperation is developed in which cooperation decisions are made as part of a dynamic cooperation process where individual units use their own characteristics and characteristics of potential cooperating partners to assess the impacts of cooperation on operational costs (characterized by economies of scale), transaction costs, autonomy risk, political risk, service level, and fiscal constraints. The model is then examined qualitatively through several case studies of solid waste regions formed in Tennessee in 1992. Insights gained from the case studies are then applied to the theoretical model to develop a probability model in which the decision Tennessee counties made to form either a single-county solid waste region or a multi-county region to develop comprehensive ten-year solid waste management plans is examined. From the case studies and the statistical model, it is found that cooperation is most likely to be observed when (1) several small entities can join to take advantages of economies of scale in collection, disposal, and recycling, (2) transaction costs are minimized by homogeneity, urban advantages, or institutional structures or individuals that facilitate cooperation, (3) most of the potential members have disposal assurance, minimizing autonomy risk, (4) entities have large decision making bodies to mitigate political risk, and (5) entities are at similar stages of program development and are similarly burdened financially.

KEY WORDS: cooperation, municipal solid waste, waste management, regionalization

Explaining Cooperation in Municipal Solid Waste Management

INTRODUCTION

Municipal solid waste (MSW) refers to a specific portion of the generated waste stream, primarily solid waste generated by residential, commercial, institutional, and some industrial sources. Traditionally, municipal solid waste management (MSWM) has been the responsibility of local governments, with landfilling the most predominant method of disposal. New federal regulations affecting traditional methods of solid waste disposal are increasing the cost by as much as five- to ten-fold. In addition, 44 states have passed recycling laws, or adopted recycling, diversion, or waste reduction goals, and many states have passed comprehensive waste management legislation requiring long-term planning (Steuteville, 1995). As MSWM has grown increasingly complex and expensive, one strategy that some communities have developed to meet new MSWM challenges is multijurisdictional cooperation. Cooperation is a process whereby neighboring cities, counties, or other governmental entities pool resources to address local challenges, taking advantage of the potential economies of scale associated with many aspects of MSWM. Many states have included incentives, provisions, and/or mandates for formation of solid waste regions as an element of MSWM legislation.

As MSWM has evolved over the last decade, there have been numerous examples of successful cooperation in addressing solid waste needs and goals. There have also been numerous cases in which potential economic savings through cooperation existed, but neighboring communities failed to adopt a cooperative strategy. This research develops a theoretical framework that models why and when communities cooperate in MSWM. In addition to potential economic benefits, the model draws upon related social science disciplines including political science and sociology. The theory is then explored through five case studies of solid waste regions formed in Tennessee in 1992. As a complement to the qualitative analysis, statistical models are then developed that examine the decision each Tennessee county made to form a single-county or multi-county solid waste region to develop a ten-year solid waste management plan, as required by state legislation.

THEORETICAL MODEL OF COOPERATION IN MSWM

In developing a theoretical framework allowing examination of cooperation decisions in the area of waste management, it is important to bear in mind that, (1) the theoretical model is intended to provide a formal conceptual framework that allows examination of hypotheses regarding factors influencing the cooperation decision, and (2) the theory, while rigid enough to provide a conceptual framework, should also be flexible enough to allow incorporation of other social science perspectives, such as negotiated order theory, institutional arrangements, and pre-conditions to cooperation, and particularly the dynamic nature of cooperation as a process rather than a static state (Cigler, 1992; Gray, 1989; Oakerson, 1990; Ostrom, 1989; Weiss, 1987).

A random utility model provides a rigorous decision framework, while allowing incorporation of non-monetary variables into the utility function. This theory asserts that individual units compare utility across multiple situations and make decision accordingly. As a first step in developing the random utility model, it is necessary to examine each individual unit's utility maximization problem where each unit selects an optimal level of the choice variables to attain maximum utility. However, in the case of choosing a solid waste regional arrangement, that outcome may not be feasibly available due to either constraints or preclusion of an option due to the simultaneous nature of the decision process. Therefore, a decision making unit compares each feasible arrangement with their utility maximizing optimal arrangement and forms a solid waste region that is (1) feasible, and (2) approaches utility achievable with optimal levels of the choice variables.

UTILITY MAXIMIZATION MODEL

Let each county's[1] preferences be represented by a utility function, U[X, Y, A, Z], where the county receives utility from consumption of a vector of goods and services, X; a vector of solid waste services, Y[2]; an autonomy risk level, A; and a political risk level, Z. The marginal utility of both X and Y is positive, and both X and Y behave as normal goods.[3] Let A be a continuous

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[1] For simplicity, the theoretical model assumes the base jurisdictional unit to be a "county", although applicable to other forms of jurisdictional division.

[2] Y may include services such as landfilling residential, commercial, or inert wastes, incineration at a WTE facility, curbside recycling, drop-off recycling, backyard composting, or collection services or education services, which may be publicly or privately provided.

[3] The assumption of normality of Y refers only to how the level of Y changes as income (county revenue) changes. If county revenue increases, ceteris paribus, then the county will demand more, not less, solid waste services.

variable representing the level of risk a county faces from a loss of autonomy, where autonomy risk is a measure of a county's ability to prevent undesirable solid waste management practices from occurring within its borders. Let Z be a continuous variable representing the level of political risk a county faces, which is a measure of the probability of intense political conflict within the county or between counties. While autonomy risk focuses on a risk perception on the part of all citizens collectively, political risk focuses on the contribution to county utility (disutility) contributed by the perception of risk on the part of a small subgroup of elected political leaders, decision makers, or other interested political figures. The marginal utility of both A and Z is negative.

Define $A(C \mid C^0)$ and $Z(C \mid C^0)$, where C^0 is an (nx1) vector of characteristics of the individual county and C is an (nx1) vector of characteristics associated with the one or more contiguous counties that represent potential partners for formation of a multi-county solid waste region. Let each element of C, C_i, be a continuous variable corresponding directly to individual characteristics of each potential cooperative county. Further, let each C_i be defined such that $\frac{\partial A}{\partial C_i} > 0$ and $\frac{\partial Z}{\partial C_i} > 0$, i.e., the levels of autonomy risk and political risk are increasing in C_i. The vector C might include elements such as population, per capita income, per capita revenue, assessed value, disposal assurance, past cooperation experience, presence of a cooperation entrepreneur, distance, highway infrastructure, tenure of legislative and executive elected officials, bureaucratic structure, or the state of the current MSW management system. For a county with a characteristic vector $C^0=[C_1^0,C_2^0,...,C_n^0]$, every alternative arrangement of the characteristic vector of contiguous counties, $C=[C_1,C_2,...,C_n]$, may be mapped to a corresponding rank of A and Z.

A county allocates expenditures among X and Y, such that $P^X X + P^Y Y = M$, where P^X is the price of X, and M is total revenue from all sources. P^Y is the price of Y, and is also a function of the characteristics of alternative region arrangements, given the county=s own characteristics, where $P^Y [E(C| C^0), T(C| C^0)]$, and E represents the average operational costs of providing solid waste services, characterized by economies of scale, and T represents transaction costs associated with organizing and administering a decision making unit for the provision and management of solid waste services. The price of Y is increasing in operational costs, such that $\frac{\partial P^Y}{\partial E} > 0$, and the price of Y is increasing in transaction costs, such that, $\frac{\partial P^Y}{\partial T} > 0$. In general, characteristics that reduce average operational costs tend to increase transaction costs. Note that while each element of C is defined such that autonomy risk and political risk are increasing in C_i, the impact of a change in C_i on E and T is indeterminate; that is, $\frac{\partial E}{\partial C_i} \gtreqless 0$ and $\frac{\partial T}{\partial C_i} \gtreqless 0$. Thus both the direction and the magnitude of the impact of a change in C_i on operational costs or transaction costs are indeterminate, and the impact of a marginal change in a characteristic on the price of Y is indeterminate: $\frac{d P^Y}{d C_i} = \frac{\partial P^Y}{\partial E} \frac{\text{partialE}}{\partial C_i} + \frac{\partial P^Y}{\partial T} \frac{\partial T}{\partial C_i} \gtreqless 0$. The hedonic price function for Y may then be substituted into the expenditure function, such that $P^X X + P^Y [E(C| C^0), T(C| C^0)] Y = M$. While the level of Y is a choice variable for the county, Y may be constrained to be above a predetermined minimum level by mandate or by state or regional planners, in which case, Y becomes further restrained to the following condition: $Y \geq R$, where R is a vector of minimum service requirements for solid waste services. When provision of solid waste services is unrestricted, R=0.

The objective of the county is to maximize utility, subject to budget and service constraints:

$$\text{MAX} \quad U(X, Y, A(C| C^0), Z(C| C^0))$$

$$\text{s.t.} \quad P^X X + P^Y [E(C| C^0, T(C| C^0)] Y = M$$

$$\text{s.t.} \quad Y \geq R$$

which may be written as a LaGrangian function:

$$\_ = U(X, Y, A(C| C^0), Z(C| C^0)) + \lambda(M - P^X X - P^Y [E(C| C^0), T(C| C^0)] Y) + \mu (R - Y)$$

Since a county may maximize utility by choosing not to consume at least one good, a corner solution is feasible. Thus, the Kuhn-Tucker first order conditions for maximizing the LaGrangian function are:

A. $\frac{\partial\_}{\partial X} = \frac{\partial U}{\partial X} - \lambda P^X \leq 0$

B. $\frac{\partial U}{\partial X} X = 0$

C. $\frac{\partial\_}{\partial Y} = \frac{\partial U}{\partial Y} - \lambda PsupY [E(C), T(C)] - \mu \leq 0$

D. $\frac{\partial U}{\partial Y} Y = 0$

E. $\frac{\partial\_}{\partial C_i} = \frac{\partial U}{\partial A} \frac{\partial A}{\partial C_i} + \frac{\partial U}{\partial Z} \frac{\partial Z}{\partial C_i} - \lambda [\frac{\partial P^Y}{\partial E} \frac{\partial E}{\partial C_i} + \frac{\partial P^Y}{\partial T} \frac{\partial T}{\partial C_i}] \leq 0$

F. $\frac{\partial U}{\partial C_i} C_i = 0$

Equation E is the condition by which the decision making county chooses an optimal level of each of n elements of C. Through careful definition of each C_i, $\frac{\partial A}{\partial C_i} > 0$ and $\frac{\partial Z}{\partial C_i} > 0$. We also know that $\frac{\partial U}{\partial A} < 0$ and $\frac{\partial U}{\partial Z} < 0$, thus $\frac{\partial U}{\partial A} \frac{\partial A}{\partial C_i} < 0$ and $\frac{\partial U}{\partial Z} \frac{\partial Z}{\partial C_i} < 0$, so that $\frac{\partial U}{\partial A} \frac{\partial A}{\partial C_i} + \frac{\partial U}{\partial Z} \frac{\partial Z}{\partial C_i} < 0$. Joining a multi-county solid waste region with a given set of characteristics may lower utility by increasing the autonomy risk and increasing the political risk. So why would a county choose to join a multi-county solid waste region? Recall that the sign of $\frac{\partial E}{\partial C_i} \overset{>}{\underset{<}{=}} 0$. In some cases, joining a region may cause this sign to be negative. That is, by joining a solid waste region with particular characteristics, average operational costs may decrease, causing a reduction in the price of Y. As noted earlier, $\frac{\partial Y}{\partial P^Y} < 0$ and $\frac{\partial U}{\partial Y} > 0$. Thus, utility is actually increased when the characteristic is negatively related to operational costs, through the resulting impact on the price of Y and the resulting level of Y. So a county will only choose to cooperate when the characteristics of a region arrangement potentially reduce average operational costs. The utility gain from choosing a characteristic level that decreases average operational costs, however, is partially or fully offset by a concurrent utility reduction from an increase in autonomy risk, political risk, and transaction costs resulting from choosing a positive level of any characteristic C_i. So from equation E, one should note the tradeoff a county experiences in choosing a positive level of any characteristic. By this condition, a county will optimally choose a positive level of each characteristic only if the marginal gain from lowering average operational costs outweighs the marginal loss from increasing transaction costs, autonomy risk, and political risk.

UTILITY DIFFERENCE MODEL

Solution to first order conditions A-F yields the demands for the choice variables, X, Y, and C_i, as a function of the exogenous variables, P^X, C^0, M, and R. Optimal levels of each choice variable may be denoted X*, Y*, C_i*. A set of n optimal characteristic elements comprises an optimal characteristic vector C*. By substituting these optimal demands into the original utility function, one may obtain an indirect utility function, $V\ (X^*,\ Y^*,\ A(C^*\,|\,C^0),\ Z(C^*\,|\,C^0)\ )$. When optimal levels of each choice variable are chosen, this indirect utility function yields the maximum achievable utility. The *optimum* level of C, however, assumes that a county may choose any level of a characteristic. But an arrangement with these characteristics may not be a feasible consideration for the decision making county. The indicator Afeasible@ refers to a limitation of the choice set, as limited by legislated requirements, decision maker preferences, or norms and values.

So the county begins the second stage of the decision process where the characteristic levels chosen as optimal then become the characteristic Awish list@ for the county. The county would receive maximum utility from choosing to cooperate with another county(s) possessing these characteristics. However, these optimal characteristic levels may not be available, given the characteristics of counties that may feasibly serve as cooperation partners. The second task of the decision making county thus is to compare the utility outcomes of feasibly available alternatives with the maximum utility level of the ideal partner(s) and choose the alternative that minimizes the difference between the ideal outcome and available outcomes.

In the second stage, the decision making county evaluates the level of indirect utility achievable under every feasible alternative regional arrangement, $V\ (X^i,\ Y^i,\ A(C^i\,|\,C^0),\ Z(C^i\,|\,C^0)\ )$, where i=1...n and n is the number of feasible alternatives. For example, if the decision making county is surrounded by four neighboring counties (counties sharing a border with the decision making county), and they limit their feasible choice set to alliances with counties with which they share a border, then they may consider 14 possible alternatives (one single-county arrangement, four two-county alliances, four three-county alliances, four four-county alliances, and one five-county alliance), so that n=14. The county then subtracts the achievable utility for each of n alternatives from the maximum achievable utility:

$$V(X^*,\ Y^*,\ A(C^* | C^0),\ Z(C^* | C^0)\ ) - V(X^i,\ Ysupi, A(C^i | C^0),\ Z(C^i | C^0)\ )$$

Assuming a linear functional form, the objective of the county then becomes to choose the alternative from n available alternatives that minimizes the utility difference:

$$\Delta V\ [(X^* - X^i),\ (Y^* - Y^i),\ (A(C^* | C^0) - A(Csupi | C^0)),\ (Z(C^* | C^0) - Z$$

COOPERATION NEGOTIATION

Once a county chooses an alternative that is feasible and minimizes the difference between optimal utility and achievable utility, they may pursue that alternative, but cannot unilaterally choose that alternative if it involves a cooperative strategy. They may, however, use potential gains to offset some of the costs a cooperation strategy would impose upon potential partners. As a simple example, suppose there are only two counties, A and B, and each county has only two alternatives: to form a single-county region or to join the other in forming a two-county region. Suppose the utility difference from the optimal level for each alternative is as follows:

	Single	Multi
County A	5	15
County B	25	10

A=s utility would be maximized by forming a single-county region and B=s utility would be maximized by forming a two-county region with A. But if A forms a single-county region, then B has no alternative but to also form a single-county region, and B=s utility would be 15 units lower. However, from an outcome of two single-county regions, a move to one two-county region would benefit B by 15 units, while only *costing* A 10 units. If B could use this potential gain to offset A=s loss, then both may be able to minimize their utility difference by forming a two-county region. If B were able to achieve a utility difference gain for A of at least 10 units by agreeing to an arrangement that reduces A=s transaction costs or risk at a *cost* to B of no more than 15 units, then such a negotiation would result in a potential Pareto improvement for both parties.

This type of matching and negotiation is assumed to take place among all potential partners until all potential Pareto improvements are exhausted and an optimal feasible arrangement emerges. The characteristics of counties in the feasible choice set influence a county=s decision in two ways. First, they directly influence the autonomy and political risk a county would face and the price a county would pay for solid waste services under a cooperative arrangement. Thus, they indirectly influence a county=s utility. But all counties undergo the same decision process simultaneously, and cooperation requires willingness on the part of all participants. So the characteristics of other counties also impact the final outcome through their influence on other counties= utility maximizing preferences and the implications of these preferences for their willingness to cooperate and their leverage in negotiating a cooperative arrangement.

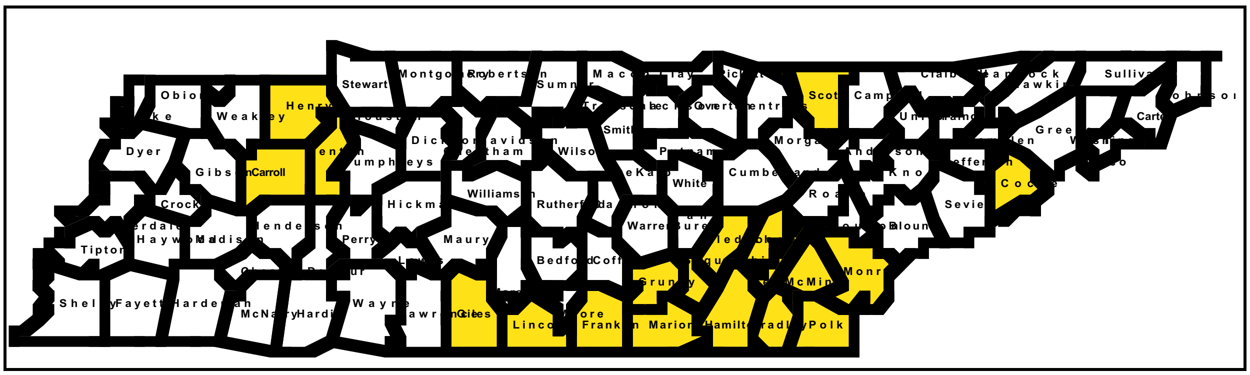
APPLYING THE THEORETICAL MODEL

DATA AND METHODS

Tennessee passed a comprehensive Solid Waste Management Act in 1991 requiring each county to form a solid waste region to develop a ten-year MSWM plan. As a first step in plan development, each county was required to form a solid waste region, with a single county the minimum acceptable size. Statutory language, monetary incentives, and technical advisors all encouraged counties to form multi-county regions. The Tennessee case provides a natural experiment in which the regionalization decision may be examined. Given the complex and specific nature of cooperation in solid waste management, a logical first step is to approach the problem through analysis of individual cases. Thus, implications of the theory are explored through five in-depth case studies of solid waste regions formed in Tennessee in 1992. The theory and insights gained from the case studies are then applied to development of a statistical model designed to predict the decision by Tennessee counties regarding region size.

CASE STUDIES

Five Tennessee solid waste regions were identified for in-depth study, as indicated in Figure 1. Two of the five cases are single-county regions, one is a three-county region, one is a ten-county region, and one was a three-county region that has split into a two-county region and a single-county region. The cases were selected in an effort to ensure diversity of the cases and further the understanding of the regionalization process and its outcomes, and thus they vary widely in composition, characteristics, past experience in solid waste, and outcomes. In addition to looking at the process by which regions were formed, the case studies also provide further insight into the management of solid waste under alternative regional arrangements. For brevity, this



section summarizes the findings of the individual cases as they relate to the theoretical model and other contributions from the broader literature.[4]

In all cases, operational costs played a significant role in the decision process, and in the resulting management of MSW. However, the way in which individual cases assimilated cost information into the decision process varied greatly. The cases provided evidence that the manner in which operational cost projections are communicated to decision makers, the source from which they are communicated, and the degree of acceptance on the part of decision makers have direct implications for the decision process. For decision makers to embrace cooperation as a waste management strategy, potential operational cost savings due to economies of scale in disposal or collection or education must be not only available, but also effectively communicated and widely accepted.

Several elements of the individual cases contributed toward an understanding of how

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4 An extensive discussion of the case study findings may be found in Tiller, 1996.

transaction costs influence the decision making process and resultant solid waste management practices. A history of cooperation among potential partners, even if the outcome was less than satisfactory, aids in reducing transaction costs associated with region formation, by building relationships of trust and comraderie. They also reveal goals, norms, and values of potential cooperative partners, which lower transaction costs. An individual(s) serving as a cooperation entrepreneur(s) reduces transaction costs by taking charge of the tempo of the decision process and serving as a focus point for new interest. Similarly, transaction costs are minimized in the presence of an institutional arrangement in place that serves as a cooperation cornerstone, with the resources required to evaluate options, coordinate meetings, establish cooperation rules, and resolve conflict, while maintaining full trust and confidence of members. Homogeneity among potential participants, or perception of homogeneous problems, also reduces transaction costs. Conversely, if the institutional structure for decision making is restricted to a narrowly defined framework, transaction costs are higher.

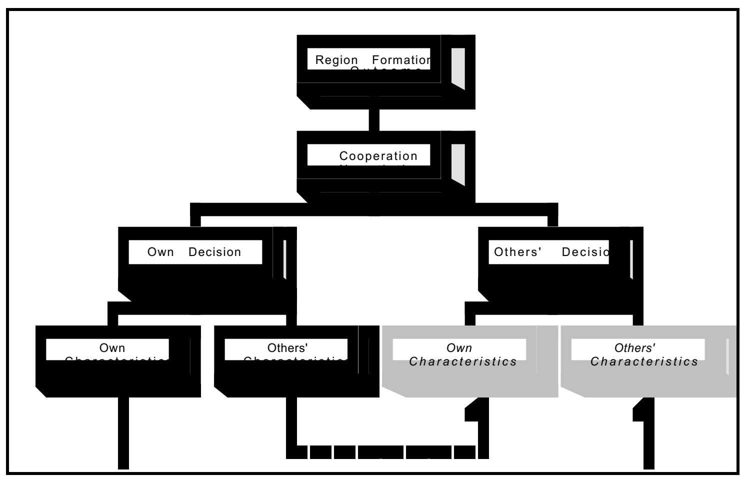
The formality of the legal bond among partners may influence transaction costs in different ways. Higher initial transaction costs may be required to develop a formal legal commitment, but in the long run, existence of a tight bond may actually reduce transaction costs associated with re-education, continuity, and conflict resolution. The initial investment in transaction costs associated with establishing an agreement were negatively related to the transaction costs required in the long run in several cases. Thus, a temporal tradeoff appears with respect to transaction costs invested is establishing formal ties. High transaction costs invested early, whether the arrangement is for a tight or loose bond, may reduce future transaction costs associated with conflict resolution, education, and continuity. The private sector influences transaction costs associated with the decision process and management of MSW, although the role of the private sector may be to either increase or decrease transaction costs. In one case, the private sector reduced transaction costs by serving as a neutral third party facilitating informal cooperation while in another, the private sector actually increased transaction costs by attempting to lure individual entities involved in a cooperative arrangement into breach of contract.

One factor that appears to minimize political risk associated with cooperation is past experience in a successful cooperative effort, whereby decision makers gained confidence and trust in the intentions and abilities of potential partners, reducing political risk. While use of a formal commitment to establish regional arrangements may increase political risk in the short run, it reduces political risk in the long run. Conversely, where little risk was accepted initially, i.e., no formal binding commitments were made to regional agreements, the long run result was overwhelming political risk when the boundaries of the region's authority were called into question among heated debate on sensitive issues. The perception of equitable representation on solid waste boards, and equitable distribution of costs and benefits among entities under a board reduces political risk. Homogeneity among potential partners and institutional arrangements that spread political risk over a large number of individuals also appear to reduce risk levels.

Individual entities perceive autonomy differently and value autonomy differently. The flexibility of regional arrangements may also influence the perception of autonomy, where in one case, member counties perceived that the loose agreement they negotiated ensured autonomy for *individual* interests while in another case, member counties perceived that the tightly-constructed agreement they negotiated ensured autonomy for the *authority* as a whole. A binding service level constraint can encourage multi-county cooperation. If potential member counties perceive a similar problem, they may recognize potential gains in negotiating a joint solution to the problem. If significant changes are required to bring an existing solid waste service program into compliance with service requirements, such a constraint may foster a cooperative solution. Similarly, a binding budget constraint was also shown to influence cooperation decisions. In one case, cooperation was only considered (informal cooperation brokered by a private firm) when fiscal strain became significant, and it appears that the value placed on political and autonomy risk is a function of the degree to which the budget constraint is binding.

STATISTICAL ANALYSIS

Upon completion of a county-by-county assessment of the current state of solid waste management in Tennessee, each county was given approximately ten weeks to decide whether they would form a single-county solid waste region or whether they would join neighboring counties to form a multi-county region. According to the theoretical model, cooperation decisions are made based on (1) characteristics of the county, and (2) characteristics of surrounding counties, both of which influence the ultimate outcome in two ways, as illustrated in Figure 2. These characteristics were hypothesized to influence the utility outcome in several ways, including impacting (1) operational costs characterized by economies of scale, (2) transaction costs, (3) autonomy risk, (4) political risk, (5) a binding budget constraint, and (6) a binding solid waste service provision constraint. Variables identified to capture these influences, their



descriptions, means, standard deviations, and minimum and maximum values may be found in Table 1.[5] These variables are then used to specify a binary choice model, in which the dependent variable is formation of a single-county region or formation of a multi-county region.

The variables POP and POPCC are designed to capture potential operational cost savings due to economies of scale, where POP measures a county's own population in 1991 and POPCC measures the population of the largest neighboring county. While the expected sign for POP is unambiguously negative, the logic for POPCC is less clear. While a small county may look favorably on partnership with a larger neighboring county, the larger the neighboring county, the less likely they are to desire cooperation, since they are more able to take advantage of economies of scale in operational costs independently (DeBoer, 1995). Thus the expected sign on the variable POPCC is negative.

Weighing against potential economic benefits of cooperation are transaction costs required to develop and maintain a cooperative relationship. Not only are transaction costs likely to be negatively related to the number of counties cooperating, but they are likely to be increasing at an increasing rate with the number of members (Kahn, 1995). A high degree of homogeneity may make coordination of a cooperative arrangement less costly in terms of defining goals and priorities. One measure of homogeneity is INCDIFF, which measures the absolute difference between a county's per capita income and that of its most similar contiguous county. The expected sign of INCDIFF is thus negative.

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[5] Counties were required to make their region decisions by December 12, 1992, so the most recent economic and solid waste data they had available to them was from 1991. Unless otherwise noted, all data are from 1991. Data were supplied by the Tennessee Department of Environment and Conservation, Division of Solid Waste Assistance.

It is also reasonable to expect that transaction costs may be minimized if a county has a well-developed networking and communication link with other counties, and if they have administrative personnel specializing in the management of solid waste, which may be characteristics of more urban counties. The variable %URBAN measures the percentage of the county classified as urban, and is hypothesized to be positively related to the decision to join a multi-county region. The degree to which neighboring counties are classified as urban may be an indicator of their ability to absorb transaction costs, as well. Thus, the variable %URBCC measuring the percentage urban of the most urban neighboring county is expected to have a positive sign as well.

Based on several studies indicating that significant economies of scale in operational costs are available up to a population of approximately 100,000, the variable MINPOP measures the minimum number of contiguous counties required (including the observed county) to reach a combined population of 100,000 (Barkenbus, et al., 1991; Renkow and Keeler, 1995; Dooley at al., 1994).[6] In addition, technical advisors initially suggested "rational waste sheds" for forming multi-county regions, where one of the base criteria was a combined population in the range of 100,000. One would expect a negative sign for such a variable, based on the notion that the smaller the number of partners required to exploit the bulk of economies of scale available, the lower transaction costs would be.

The variable SUBDLF is a dummy variable indicating whether or not a county has (1) a Subtitle D-compliant landfill in existence, (2) a permit

[6] MINPOP excludes the four largest counties from calculation since the population of the fourth largest county is more than double that of the fifth, based on the assumption that these four outliers are significantly different enough from the remaining 91 counties that other characteristics may outweigh potential economies of scale cooperation advantages.

application on file to upgrade an existing landfill to Subtitle D standards, or 3) a permit application on file for a new Subtitle D landfill. It is expected that if any of these conditions are met, a county may be less likely to join a solid waste region perceiving that cooperation may force acceptance of out-of-county waste, increasing autonomy risk. The variable %CCLF is an attempt to measure the autonomy risk threat imposed by other counties by indicating the percentage of neighboring counties that have a Subtitle D landfill in place, or firm plans to construct or upgrade to a Subtitle D facility. The expected sign is positive, since a higher value would indicate that a larger percentage of neighboring counties have their disposal problem "solved", and thus they would be less of an autonomy risk threat.

The variable COMM, which indicates the number of elected county commissioners in that county, attempts to measure the degree of political risk associated with forming a multi-county solid waste region. It is expected that as the number of commissioners increases, political risk is shared and each individual elected official bears less of the risk burden, making cooperation more likely. Large commissions are more likely to use a committee structure in which committee members have more expertise in a particular area. It seems less likely that a few politically powerful commissioners can dominate a large commission. The variable COMMCC attempts to measure the risk associated with potential regional partners by indicating the number of county commissioners in the neighboring county with the largest commission, and for the same reasons as above is expected to have a positive sign.

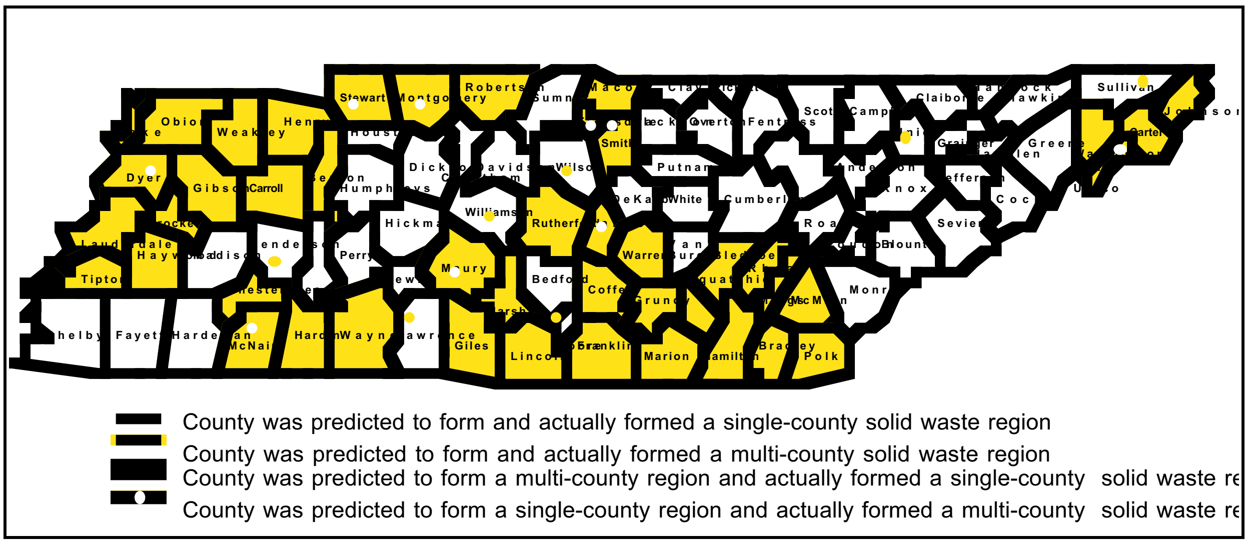
As was discovered in the case studies, risk (both autonomy and political) and transaction costs were reduced in some cases where (1) institutional structures were in place that facilitated cooperation, such as an aggressive, pro-active development district, (2) potential partners had successful past experience with cooperation, or (3) a cooperation entrepreneur was willing to shoulder individually much of the effort required to reduce risk and lower transaction costs. Ideally, one would like to capture the impacts of these influences in a statistical model. However, no variables were available to measure these occurrences.

The more effort required on the part of a county to meet state-mandated requirements for collection, recycling, disposal, and education, the more likely they may be to join a solid waste region since marginal benefits of cooperation are likely higher for counties with immature MSWM systems than for those with well-developed systems. The variable %UNMAN is intended to capture this influence by measuring the percentage of county waste currently produced that is unmanaged and is expected to have a positive sign. It seems reasonable to expect that counties that are at a similar stage with their MSWM system may benefit from cooperating. The variable CCUNMAN measures the absolute value of the difference between the percentage of unmanaged waste in a county and that of its most similar neighboring county, thus a negative sign is expected. The greater a county=s fiscal stress, the more likely they may be to look favorably at cooperation. The variable PCAPREV, per capita total revenue, is included to capture this effect, and a negative sign is expected. The variable PCREVCC is a measure of the per capita revenue of the neighboring county with the lowest per capita revenue, and it is included to capture the desire of surrounding counties to cooperate. It is expected that PCREVCC and cooperation would be inversely related.

Results of the probit estimation may be found in Table 2. In the first specification, only variables indicating own county characteristics are included. According to the theoretical model, counties assess characteristics of other counties as a function of their own characteristics, and then assign these characteristics values based on their own characteristics. All variables in the first specification display the expected sign and all are statistically significant at the 10% level or lower, except POP. Counties that are more urban and have larger county commissions are more likely to form a multi-county region for solid waste management. If a county has a Subtitle D landfill and currently manages a high percentage of their potentially generated waste, then they are less likely to join a multi-county region, as are counties with a higher level of per capita revenue. This specification predicts 66% of counties forming a single-county region correctly, and predicts formation of a multi-county region with 64% accuracy.

The other probit model specified predicts formation of a multi-county region as a function of the same own county characteristics, and also characteristics of other counties. In this specification, variables that are significant at 10% or lower level are POPCC, %URBAN, %URBCC, SUBDLF, and %UNMAN, and each exhibits the expected sign. The larger the population of the most populous neighboring county, the less likely a county is to be part of a multi-county region. This emphasizes the dynamic nature of the final outcome, that while a county might prefer to cooperate with another county with a large population to take advantage of operational cost savings, the other potential partners must also make that same decision for cooperation to be observed. An urban county is more likely to be observed cooperating, as before, and also the measure of "urban-ness" of contiguous counties is positive and significant. This indicates that the more urban at least one neighboring county is, the more likely it is to observe cooperation, perhaps because of lower transaction costs. Cooperation is more likely to be observed in cases where a county has a large political decision making body and where they do not yet have a well-developed MSWM system in place. Presence of a landfill reduces the likelihood of observing cooperation. Overall, this model predicts 72% of the responses correctly, with 74% of single-county regions predicted accurately and 69% of multi-county regions predicted accurately.

The marginal effects of a one standard deviation change in variables significant in the second specification are also reported in Table 2. Overall, the probability of forming a multi-county region was found to be 46%. By far, the variable contributing the most to the join decision is the presence of a landfill. If a county that does not have a Subtitle D landfill



sites a landfill in their county, the probability of joining a multi-county region would decrease from 61% to 29%, a decrease in probability of 32%.[7]

The model attempts to capture the influences of other counties' decisions on the final cooperation outcome by including characteristics of surrounding counties as a factor in a county's decision. However, an examination of predicted versus actual outcomes provides evidence that the model is not able to fully capture this dynamic aspect of the decision, as

[7] Since SUBDLF is a binary variable, marginal impacts are calculated at both SUBDLF=0 and SUBDLF=1 levels to allow probability comparison.

seen in Figure 3. If the model were able to fully account for decisions made by other counties, counties predicted to form multi-county regions would have to occur in clusters. But the model predicted a cooperative outcome for three counties for which every contiguous county was predicted to form a single-county region (Robertson, Overton and Union). The opposite outcome occurred three times, where a county was predicted to form a single-county region while all contiguous counties were predicted to form multi-county regions (Dyer, Hamilton, and Unicoi). With full information regarding other counties it would appear that if all contiguous counties desired cooperation, then the central county would likely face lower costs of cooperation.

POLICY IMPLICATIONS

This research is important in identifying conditions under which cooperation in MSWM is feasible, factors that contribute toward successful cooperation, and policies and institutional arrangements that facilitate cooperation. First, it is important to note that cooperation is not an efficient solution in every situation, and thus policies designed to impose cooperation upon local governments based purely on fiscal considerations will not necessarily produce optimal results for the management of solid waste. Secondly, there are certain characteristics of local entities that may reduce transaction costs, political risk, or autonomy losses associated with cooperation, including past experience cooperating in MSWM or other issues, presence of a cooperation entrepreneur, and homogeneity among potential partners. Finally, another aspect of cooperation facilitation is having policies and institutional arrangements in place that encourage cooperation by clearly communicating benefits of cooperation and reducing transaction costs, political risk, or autonomy risk associated with cooperation. Such policies may include sufficient time for decision maker education and exploration of alternatives, flexibility in region formation options, and establishment of an efficient communication link between local decision makers and policy makers. To the extent possible, taking the decision making process out of the political realm may also facilitate cooperation. Policies and institutions sensitive to the conditions required for successful cooperation can lead to more efficient provision of solid waste management services, and can also facilitate cooperation in addressing issues other than MSWM.

Table 1. Variable means, standard deviations, minimum and maximum values, and definitions.

VARIABLE	DEFINITION	MEAN	STD DEV	MIN/MAX
JOIN	1=formed multi-county region; 0=formed single-county region	0.47	0.50	0/1
POP	County population (in thousands)	51.35	105.5	4.6/826
POPCC	Population of largest neighboring county (in thousands)	144.6	168.3	17/826
%URBAN	Percentage of county classified urban	28.8	24.3	0/99
%URBCC	Percentage of county classified as urban for the neighboring county with the highest percentage urban	59.5	20.8	20/99
MINPOP	Minimum number of counties required to reach a combined population of 100,000	3.1	1.7	1/9
INCDIFF	Absolute value of per capita income difference between a county and its most similar neighbor	716.44	894.35	17/4577
COMM	Number of county commissioners	17.7	5.0	9/31
COMMCC	Number of county commissioners in the neighboring county with the largest commission	22.6	3.6	11/31
SUBDLF	1=existence of Subtitle D landfill; 0 otherwise	0.43	0.50	0/1
%CCLF	Percentage of neighboring counties with a Subtitle D landfill	45.2	24.6	0/100
%UNMAN	Potential percentage of waste stream unmanaged	30.9	24.1	0/78
CCUNMAN	Absolute value of the difference between the potential percentage of unmanaged waste in a county and its most similar neighbor	8.3	9.3	0/37
PCAPREV	Per capita total county revenue	$726. 1	133.5	322/1351
PCREVCC	Per capita revenue of the neighboring county with the lowest per capita revenue	$604.6	102.8	322/755

Table 2. Probit estimation results. (dependent variable: JOIN)

VARIABLE	Own Characteristics Specification	Own & Others= Characteristics Specification	Marginal Effects
INTERCEPT		-0.59 (-0.30)	
POP	-0.005 (-1.31)	-0.005 (-1.12)	
POPCC		-0.003* (-1.86)	-.2142
%URBAN	0.02** (2.18)	0.03** (2.14)	.2466
%URBCC		0.03** (2.32)	.2827
MINPOP		0.15 (1.02)	
INCDIFF		0.00003 (0.14)	
COMM	0.05* (1.65)	0.08** (2.06)	.1575
COMMCC		-0.07 (-1.35)	
SUBDLF	-0.91** (2.82)	-0.86** (-2.38)	-.3270
%CCLF		0.35 (0.44)	
%UNMAN	0.02** (2.65)	0.02** (2.18)	-.1567
CCUNMAN		0.007 (0.37)	
PCAPREV	-0.002* (-1.70)	-0.002 (-1.39)	
PCREVCC		-0.0006 (-0.32)	
Log-Likelihood	-53.36	-49.35	
% 0's Correct (of 50)	66% (33)	74% (37)	
% 1's Correct (of 45)	64% (29)	69% (31)	
Correct Predictions (of 95)	65% (62)	72% (68)	

Numbers in parentheses represent the ratio of a coefficient to its asymptotic standard error.
* denotes significance at α = 0.10.
** denotes significance at α = 0.05.

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