Too Big, Too Small, or Just Right?

Cost Efficiency of Environmental Inspection Services in Connecticut

Jeffrey P. Cohen, Ph.D.
(corresponding author)
Department of Finance
School of Business
University of Connecticut
2100 Hillside Road
Storrs, CT 06269
860-486-1277
Jeffrey.Cohen@business.uconn.edu

Patricia J. Checko, Ph.D.
Consultant
Connecticut Association of Directors of Health
101 Oak Street
Hartford, CT 06106
860-221-8888
pjchecko@comcast.net

Abstract

Objective: To assess optimal activity size/mix of Connecticut local public health jurisdictions, through estimating economies of scale/scope/specialization for environmental inspections/services.

Data Sources/Study Setting: Connecticut's 74 local health jurisdictions (LHJs) must provide environmental health services, but their efficiency or reasons for wide cost variation is unknown. The public health system is decentralized, with variation in organizational structure/size. We develop/compile a longitudinal dataset covering all 74 LHJs, annually from 2005-2012.

Study Design: We estimate a public health services/inspections cost function, where inputs are translated into outputs. We consider separate estimates of economies of scale/scope/specialization for four mandated inspection types.

Data Collection/Extraction Methods: We obtain data from Connecticut Department of Public Health databases, reports, and other publicly available sources. There has been no known previous utilization of this combined dataset.

Principal Findings: On average, regional districts, municipal departments, and part-time LHJ's are performing fewer than the efficient number of inspections. The full-time municipal departments and regional districts are more efficient but still not at the minimum efficient scale. The regional districts' elasticities of scale are larger, implying they are more efficient than municipal health departments.

Conclusions: LHJs may enhance efficiency by increasing inspections and/or sharing some services.

Keywords: Environmental Inspections, Economies of Scale/Scope

Introduction

Environmental health inspections are mandated in Connecticut, and are crucial to public health and safety. We focus on the cost efficiency of inspection services in all 74 local health jurisdictions (LHJs) in Connecticut, over the time period 2005-2012. Cost efficiency implies getting to the “right” level of services – and not providing too many or too few services. This can be examined in the form of the quantity of total inspection services performed; as well as by determining whether it is cost-reducing for jurisdictions to perform different types of inspections together, or to specialize in a small number of inspections.

In Connecticut, LHJs may be full-time[1] or part-time[2] municipal health departments, or multi-town regional health districts.[3] While all Connecticut LHJs provide state-mandated environmental services, there is no known research about the influence of organization structure and size on environmental services costs. The state’s Department of Public Health had been compiling a longitudinal database on local public health services and costs for several years, however there had not been any known studies utilizing this data for analyzing the determinants of costs. This approach was attractive because it was an alternative to research involving more time intensive and costly surveys of a subset of the LHJs. The diversity of and variation in organizational structure of local health in Connecticut makes the state an ideal “petri-dish” for evaluating the role of these variations on costs.

Previous research has shown that variations in public health systems performance depends on funding and staffing levels (Gordon, Gerzoff and Richards, 1997; Kennedy and Moore, 2001) but can also be influenced by the population served (Mays, Halverson and Baker, 2004; Turnock, Handler and Miller, 1998). As suggested by Santerre (2009), public health systems may be more cost-efficient if they serve larger populations. Others examine whether consolidation of services into centralized departments is more/less efficient (Mukherjee, Santerre and Zhang, 2010), but more research is needed in this area. LHJs in Connecticut vary in jurisdictional type, funding levels, staffing and serve a range of population sizes, which allows us a unique opportunity to further this research.

We analyze the scale/scope of the four required environmental health services provided in Connecticut[4] and the differences in associated costs incurred by LHJs that may arise from differences in size and structure of LHJs. These services are: food protection[5], private water wells[6], subsurface sewage disposal[7], and child lead poisoning prevention/control. [8, 9] Specifically, we address the question of whether or not local health departments could lower their average (i.e., unit) costs of providing these services by providing more or fewer inspections. Second, we examine how the incremental costs of a particular service are impacted by providing it together with another type of service. We examine differences in these effects for municipal health departments, regional health districts, and part-time LHJs[10].

We use regression analysis to estimate a semi-translog total cost function for providing four types of public health inspection services. We compile longitudinal data for annual cost of providing inspection services, average wages of personnel, average price of physical capital, number of inspections, number of establishments, mix of inspection sites, and characteristics of various local health departments. Subsequently, we use the regression estimates to estimate economies of scale and scope/specialization for each LHJ in Connecticut during 2005-2012.

Our contribution in this research is several fold: we estimate a cost function for local public health services with a model grounded in economic theory of the production process where inputs are translated into outputs; we consider separate estimates of economies of scale and scope for several categories of environmental inspections; and we leverage a comprehensive data set that we compile from various sources covering all 74 LHJs in Connecticut, annually from 2005-2012. To our knowledge, such an analysis of rich data using a rigorous economic framework is unique.

Background and Literature Review

In choosing input combinations to use in their production process, we assume LHJs compare the incremental benefits obtained from hiring another worker against the incremental benefits from renting or purchasing more physical capital (equipment, machines, real estate, etc.). If the extra “output” per dollar spent on workers is greater than (less than) the extra “output” per dollar spent on capital, the LHJ should choose to hire more (less) workers and use less (more) capital. With this balancing act, the LHJ will hire the efficient[11] amount of both inputs when the extra output per dollar spent on each input is equal. The cost function we estimate for local public health services embodies this balancing process, and for this reason it is an ideal tool for estimating economies of scale and scope since it assumes LHJs are doing their best in choosing inputs to balance the benefits of using all inputs.

Cost Function Analysis is a technique from the Industrial Organization literature in the field of economics, which has been applied to many different industry studies. It has been used for a variety of different sectors and industries, including transportation, manufacturing, and health care[12], among others,[13] to aid in decisions of how many firms, how much of each input each firm should use, and what firm size is optimal in an industry. This approach can help with decisions of whether it is more efficient for many small firms to produce small amounts, or fewer large firms to produce large amounts, of a product/service. Cost functions have also been widely used to understand if it is less costly for production of two or more distinct products or services with each occurring separately in different firms, or together in one firm. Underlying cost functions is the production process, where “inputs” are converted into “outputs”. A crucial point is that this approach helps determine how much of a product “entities” should produce, and what input combination they should use to produce it, in order to operate “efficiently”. When LHJs are not using the optimal input mix, this is inefficient and some people/groups may not get services they need. While it may seem like a trivial problem to solve, it is complex since there are many other variables affecting a LHJ's decision of how to produce its output(s). It is necessary to control for these factors with regression analysis.

In the literature on local public health services costs, Honeycutt et al (2006) outline a process for analyzing the costs of public health services. This relatively comprehensive guide includes discussion of the need to identify "outcomes" for cost effectiveness studies. But cost effectiveness studies are different from our goals – that is, to assess the optimal size of LHJs. Our approach controls for other factors that affect costs, and it is a promising way to help LHJs analyze the scale/scope of services to provide.

Mays (2013) studies scale/scope economies for 20 public health services across 360 communities in 3 years (1998, 2006, 2012). He estimates a "semi-translog" cost function, where "scale" represents the population size, "scope" represents availability of 20 public health services, and "quality" represents "perceived effectiveness of each activity". The functional form is a semi-translog opposed to a translog, because Mays includes linear and quadratic terms but omits interaction terms. He finds costs increase as scale rises; costs increase as scope rises; and costs decrease as perceived effectiveness increases.

Singh and Bernet (2014) analyze the costs of local public health services in Florida. They consider economies of scale and scope. Their ad-hoc specification, with scale and scope variables similar to Mays (2013), is a contribution to the literature on costs of local public health services because it is among the very small number of studies in this emerging literature that have estimated a cost function.

Research methodology and approach

In order to examine economies of scale/scope for LHJs, the first step is to estimate a semi-translog cost function of providing various types of public health inspection services using data from Connecticut's LHJs. As described above, the semi-translog total cost function is a flexible functional form that allows for nonlinear relationships between the dependent variable (total costs) and the explanatory variables (the "input" prices, the "outputs" or services, and other shift factors). Our estimation of a total cost function is guided by neoclassical microeconomic cost theory. Details of the cost function approach are described in Appendix 1. Figure A1 in Appendix 2 graphically depicts the concept of economies of scale.

Data

A contribution of our research is our unique data synthesis from several state agency sources in the context of local public health services. Our focus on economies of scale and scope for environmental health services as the area of analysis reflects the reality of Connecticut's local public health system. Connecticut is a state with a population of 3.5 million with 169 towns. There is no county system in Connecticut, and only 4 municipalities with populations above 100,000. The 169 towns are served by 74 local health departments or regional health districts (and we have been referring to all 74 of these as "local health jurisdictions", abbreviated as "LHJs"). The 21 regional health districts serve anywhere from 2 to 20 towns. The remainder of the state's residents is served by municipal departments which can be either part-time or full-time. While part-time municipal departments are decreasing there are still 24 towns that do not have a full-time Director of Health and their health departments may be served by a single sanitarian. These communities account for only 6% of the Connecticut population. There are 29 towns with full-time municipal health departments. Tables A1 and A2 in Appendix 2 present the population ranges for each type of LHJ. Over the period of our analysis (2005-2012), there was one pair of towns that merged to form a regional health district, and therefore we have omitted this district from our analysis. Otherwise, the LHJs were stable in size and type over the observation period.[14]

In our analysis, we are interested in determining how total costs for a LHJ change as inspections change – in other words, our objective is to answer the question: are there economies of scale and/or scope for environmental health inspections services? Data limitations preclude an analysis exclusively focusing on the environmental health subsections of the LHJs as separate entities. While a substantial proportion of all CT LHJ's place their focus on environmental health services, many full-time municipal departments and regional districts provide a broader range of public health measures that were not captured in this data. Due to the limitations of the cost data available for the LHJ's only total budgetary costs were available for use, as opposed to an estimate of environmental cost centers. Therefore, the cost function could appear inflated for those municipal departments and regional districts providing a wider array of public health services, since we only had access to environmental health data.

Total LHJ expenses include personnel expenses, contractual expenses, legal expenses, operations expenses, and miscellaneous expenses. The latter two expenses categories encompass overhead costs. We deflated expenses with the Consumer Price Index from Table B-3 of the 2013 Economic Report of the President (and converted to a base year of 2005). Wages were calculated as personnel expenses divided by full-time equivalents (these include all employees in the districts or municipalities; some municipalities and districts have primarily environmental health employees, while some other include other types of public health employees). Capital prices were obtained from the Capital Equipment Producer Price Index in Table B-65, 2013 Economic Report of the President.[15]

The outputs that we include in our regressions for equation (2) in Appendix 1 are:

- Private water wells: the total number of private and public water well permits issued
- Food Services: the total number of food establishments (Classes I-IV) inspections and temporary events
- Septic Services: the total number of new permits, repair permits, lots tested and B-100[16] application reviews

- Lead: total number of childhood lead blood level investigations

Our approach of analyzing a Department of Public Health data set obtained from official reports is in contrast to that of some of the other ongoing cost studies that engage in primary data collection for a subset of jurisdictions through survey instruments. Our data are obtained from the 2005-2012 LHJ Annual Reports from the Connecticut Department of Public Health. Unfortunately, expenditure data from municipal departments were neither required nor consistently collected by the Connecticut Department of Public Health during the study period. This resulted in considerable missing expenditure data from municipalities. Substantial effort was expended to obtain expenditure data for all municipal LHJs. In some cases financial information is available on-line on the town websites. In a few instances we obtain expenditure data from the local health director and/or the finance director.[17] We subsequently clean/merge the data.[18] These data are combined with additional data from the publicly available State of Connecticut's childhood blood lead surveillance reports, to provide a rich data set for the purpose of estimating cost functions and economies of scale for the local health organizations. Table 1 includes summary statistics.

In addition to the variables discussed, we control for LHJ efforts and services outside of environmental health. Nurses and health educators are the most commonly employed health care workers by LHJs outside of environmental health personnel.[19] We also control for urban/rural designation. In other words, this dummy variable equals 1 if a LHJ is in an urban or rural area, and 0 otherwise (e.g., in a suburban area; this enables us to distinguish suburban areas from other areas).[20]

Table 1 - Costs, wages, environmental health inspections and rural-urban status by LHJ type

Variable	Overall for All LHJ's	Full-Time Municipal Departments	Regional Districts	Part-Time Jurisdictions
Total Expenses				
Mean	$1,541,909	$3,013,206	$1,173,964	$193,655
Median	$565,453	$846,184	$978,331	$ 44,291
Average Annual Salaries				
Mean	$33,341	$41,327	$42,082	$17,585
Median	$36,832	$42,387	$41,537	$ 7,773
Number of Wells Inspected				
Mean	40	20	84	29
Median	15	11	48	12
Lead Inspections				
Mean	22	46	11	4
Median	1	2	2	1
Food Inspections				
Mean	434	565	665	111
Median	269	398	562	47
Septic Inspections				
Mean	257	161	559	130
Median	140	112	459	82
Rural or Urban				
Mean	.835	.835	.820	.845

The final semi-translog model includes average wage, average capital price, food inspections, water inspections, lead inspections, sewer inspections, rural/urban dummy variable, nurse staff dummy, child cumulative lead blood level over 10, and dummies for whether or not the LHJ is a full-time municipality or a district. The semi-translog total cost function regression results (using White robust standard errors) are in Table 2.[21]

The model is a reasonably good fit, with R-squared of 0.64.[22] Several inspections parameter estimates are statistically significant at the 5% or 10% levels, although many interaction terms are insignificant.[23] Many other control variables are highly statistically significant, including whether nurses are on staff; whether the municipality is urban or rural (negative and significant effect on total costs, implying more money is spent in other municipalities – i.e., suburbs); and number of children tested with blood levels of at least 10. Also, regional districts and municipal health departments tend to spend more money than part-time LHJ's.[24]

It is noteworthy that a complete set of linear and quadratic and interaction terms are often included in cost function analyses. However, as described above, Mays (2013) is one example of a recent cost function study that omits some interaction terms. We chose to omit some terms here because the high degree of multicollinearity that inflates the standard errors led to fewer significant parameter estimates[25] (as well as some differences in the parameter estimates when we included the full set of terms). Retaining the interaction and quadratic terms while eliminating the linear terms enable us to reduce multicollinearity while at the same time allowing for the possibility of curvature in the cost function.

In addition, there may be concerns about autocorrelation in longitudinal data. Autocorrelation affects the standard errors (and t-statistics). This autocorrelation has no effect at all on the actual parameter estimates we use to calculate the elasticities (and, therefore, no effect on the elasticities), which we confirm with a Heteroskedasticity and Autocorrelation Consistent (HAC) adjustment to our cost function regression. Accordingly, we present results from the HAC estimation procedure in order to avoid the autocorrelation concerns that can lead to statistical insignificant parameter estimates, and this does not alter the actual values of the parameter estimates.

Table 2 – Least Squares Regression Results, Translog Total Cost Function (equation (2))

VARIABLE NAME	Coefficient **P-Value**
CONSTANT	-49.1485 **0.8353**
LOG(WAGE)*LOG(CAPITAL PRICE)	0.0655 **0.5623**
LOG(WAGE)^2	0.0043 **0.0868**
LOG(CAPITAL PRICE)^2	0.6240 **0.9423**
(LOG(WATER INSPECTIONS))^2	0.0375 **0.1640**
(LOG(LEAD INSPECTIONS))^2	0.0178 **0.2709**
(LOG(FOOD INSPECTIONS))^2	0.0179 **0.0259**
(LOG(SEPTIC INSPECTIONS))^2	0.0375 **0.0468**
LOG(SEPTIC INSPECTIONS)*LOG(WATER INSPECTIONS)	-0.0624 **0.1617**
LOG(SEPTIC INSPECTIONS)*LOG(LEAD INSPECTIONS)	-0.0085 **0.7215**
LOG(SEPTIC INSPECTIONS)*LOG(FOOD INSPECTIONS)	-0.0231 **0.1767**
LOG(WATER INSPECTIONS)*LOG(FOOD INSPECTIONS)	0.0072 **0.7510**
LOG(WATER INSPECTIONS)*LOG(LEAD INSPECTIONS)	0.0482 **0.1639**
LOG(LEAD INSPECTIONS)*LOG(FOOD INSPECTIONS)	-0.0190 **0.1735**
DUMMY FOR NURSE(S) ON STAFF	0.4367 **0.0000**
DUMMY FOR RURAL OR URBAN JURISDICTION	-0.2969 **0.0083**
YEAR	0.0299 **0.7997**
DUMMY FOR MUNICIPAL HEALTH DEPARTMENTS	1.5681 **0.0000**
DUMMY FOR HEALTH DISTRICTS	1.5686 **0.0000**
CHILDREN WITH BLOOD LEAD CUMULATIVE STATS OVER 10	0.0134 **0.0000**

Included observations (N):	529
R-squared:	0.6412
Adjusted R-squared:	0.6278

Note: Data are annual (2005-2012), for 74 jurisdictions (missing values reduces sample size to N=529)

Note: P-Values calculated based on White heteroskedasticity-consistent standard errors & covariance

Note: the "base" is part-time districts and/or departments,
for the two dummies for full-time municipal departments and full-time health districts

Table 3 reports descriptive statistics for the economies of scale estimates. The largest value is 0.38, while the lowest is 0.025. The mean of all elasticities is 0.19. These categories demonstrate the number of LHJs with elasticities of scale in each of 4 arbitrarily-chosen ranges, and they provide some details about the specifics of the elasticities. Among the 74 total LHJs, 47 had mean elasticities between 0.1 and 0.3. The mean for each LHJ is taken over the years 2005-2012. The standard deviations for each category are small relative to the mean of each category, implying a reasonable degree of confidence.

Table 3 – Descriptive Statistics for the 74 LHJ Elasticities of Scale Estimates

Descriptive Statistics for Elasticity of Scale. The elasticity for each LHJ is evaluated at the mean of data for each LHJ over all of the years 2005-2012 (there are 74 LHJ's total in our sample)
Categorized by values of Elasticity of Scale

Included observations: 74

Elasticity of Scale	Mean	Max	Min.	Std. Dev.	Obs.
[0, 0.1)	0.0611	0.0936	0.0246	0.0220	16
[0.1, 0.2)	0.1497	0.1930	0.1168	0.0235	26
[0.2, 0.3)	0.2577	0.2988	0.2030	0.0245	21
[0.3, 0.4)	0.3565	0.3887	0.3227	0.0247	11
All [0, 0.4)	0.1919	0.3887	0.0246	0.1012	74

We find that on average, Connecticut's LHJs have elasticity of scale less than 1.0. When separating these into the various types of LHJs, we find the part-timers have elasticity of scale estimates of closest to 0. This implies these part-time departments may be performing too few inspections. In contrast, the full-time municipal health departments and regional health districts are closer but still not at minimum efficient scale, since their elasticity of scale is greater than the part-timers but still less than 1.0. The elasticities of scale for the districts are larger on average than for the full time municipal departments, implying the districts are closer to being efficient than the municipal health departments. A histogram of the 74 elasticities of scale estimates are shown in Figure A2 in Appendix 2.[26]

Figure A2a shows the distribution of the 74 LHJs elasticity of scale estimates. Figures A2b, A2c, and A2d break these out by whether they are a municipal, district, or part-time.[27] For the part-timers, there are 20 with elasticities less than 0.20, while for the (full-time) districts there are 15 jurisdictions with elasticities greater than 0.20. The municipal health departments have the mode economies of scale estimate, which is 0.26. As described above, many of these municipalities are concentrating on many activities in addition to environmental health, which can potentially explain the scattered observations across the low end of the economies of scale distribution. As can be seen in Figure A2, the elasticities are fairly uniformly distributed throughout for the full-time municipal health departments and the part-timers. The elasticities for the districts are skewed to the right, which implies that those elasticities were slightly closer to 1.0 (the minimum efficient scale). We explore graphically the relationships between economies of scale estimates and several other variables that are representative of the size of the LHJ. These size variables include population, full-time equivalents, total cost, and total output.[28] There is a positive relationship between economies of scale and each of these size variables, as can be seen in Figure 1.

<INSERT FIGURE 1 HERE>

These positive relationships between economies of scale and each of the size variables imply that “larger” LHJs tend to have larger economies of scale estimates. In other words, smaller LHJs tend to be less cost efficient than the larger ones. Interestingly, the “smaller” LHJs tend to be part-timers.

This notion of consolidation and shared services is closely related to, yet distinct, from the notion of economies of specialization and scope.[29] Specifically, based on the results of our regression analysis in equation 2, we find economies of scope for four pairwise combinations of inspections. In other words, incremental costs fall with the production of water and septic inspections together; food and septic inspections together; food and lead inspections together; and lead and septic inspections together. On the other hand, we find economies of specialization for two pairwise combinations of inspections. That is, there are higher incremental costs when water and lead inspection services are done separately; and when water and food inspections are done separately. These results are presented in Table 4.

Table 4 – Economies of Scope/Specialization Estimates

Inspection Pairs	Estimate
FOOD and LEAD	-0.018977
FOOD and_SEPTIC	-0.023105
LEAD and_SEPTIC	-0.008518
WATER and_FOOD	0.007207
WATER and_LEAD	0.048250
WATER and_SEPTIC	-0.062385

These estimates of economies of scope/specialization in Table 4 above are for the entire sample of 74 jurisdictions during the period of our sample (2005-2012). Due to the nature of the semi-translog cost function, these estimates are equal across all LHJs. A negative value indicates economies of scope, while a positive number implies economies of specialization.

Limitations

There are a number of potential limitations of our study. The greatest are the data available to us. One major contribution is our development and use of the Connecticut Department of Public Health Annual Report data for each jurisdiction over a period of 8 years for a cost function estimation. We initially had assumed the data set was complete for all LHJs.[30] But there are many data issues that we have detected. Some jurisdictions are missing values of some variables for one or more years, necessitating interpolation in a small number of instances.[31] In a few cases, some data seem to be implausible, possibly a result of keystroke errors when the data were entered into the system with the initial Department of Public Health surveys. Other jurisdictions are simply missing data for some years, which we have determined when contacting Connecticut Department of Public Health to try and follow up.

Another potential limitation is the economies of scale policy implications. The interpretation of the economies of scale results is intended to apply to small changes in output. These estimates tell us how efficiency would change when there is a small change in output (number of inspections). If two reasonably large districts or municipalities are to share services, the significantly large jump in “output” might lead to unit costs that are too large because of the inefficiencies associated with a large organization. However, these results do not necessarily imply that a part-time LHJ should not join a regional district, since there still may be cost savings for both.

In terms of economies of scope, our methodology allows for pairwise comparison of two types of inspections, whereas in reality most jurisdictions perform more than two types of inspections. Therefore, we cannot address the question of whether or not it is less costly for one district to perform all 3 or 4 types of inspections, or if it is more efficient to have 4 different jurisdictions with each specializing and performing only one of these types of inspections.

Many full-time municipal departments and regional health districts provide a broader range of public health services for which we do not have data.[32] Therefore, since we control for the 4 environmental health outputs but the costs include all other types of outputs, some of the elasticities of scale may be understated.[33] This implies that some LHJ's are likely to be closer to the minimum efficient scale (i.e., elasticity of scale closer to 1.0) than we have estimated. For those LHJ's that provide a diverse set of services (such as communicable diseases), the cost per service may be somewhat exaggerated.[34] Nevertheless, in some situations, especially in larger LHJ's, it may be difficult to distinguish how much of a particular employee's time is dedicated to environmental health inspections versus other activities, whereas their entire salary may be included in total operating expenses. This is an example of another reason why care should be taken in jumping to policy conclusions from these results, and why there should be a push to acquire and maintain more reliable data on environmental health costs and their components.

Finally, cost is not the only consideration in determining the appropriate local public health jurisdiction for the provision of environmental health services.[35] As we discuss above, the mix of services is also different in the various types of LHJ's, so there may not be much cost savings by merging the LHJ's that provide very different types of services.[36]

Conclusion/Discussion

There are several potential policy implications of our research. First, analyses of scale and scope may be a valuable tool to determine efficiency of LHJ services and to evaluate the benefits of sharing specific services. Despite the data limitations, our methodology is a valid approach that is deserving of applications to Connecticut's and other states' Environmental Health costs.[37] As noted above, two small, part-time LHJs may elect to share some inspection services (or consider merging) to move closer to full utilization of environmental health staff and reduction of fixed costs. Specialization economies may imply that it is more efficient for some LHJs to focus on the services they can do best (e.g. a part-time LHJ to contract with a municipal LHJ to provide lead services). On the other hand, some services are done together quite naturally. For instance, water testing as an environmental service is relatively simple, lower cost, and involves minimal worker time to perform. It is the least complex of the 4 mandated services. It is also done nearly in conjunction with septic work for new dwelling or repairs of existing septic systems and it is reasonable that providing both services would imply economies of scope. For the same reasons, it follows that the combination of either water and lead or water and food would produce higher incremental costs, because of the complexity of the inspection process as well as the time involved in the inspection/investigation. On average, a food service inspection may require up to two hours to complete as well as the administrative time for completion of forms and reports. In terms of specialization, lead investigations require special training and perhaps certification, are very complex and may require weeks to months of follow up, if remediation is required.

Second, more research utilizing existing LHJ financial and service data deserves attention. These include: limitations in working with available LHJ service delivery data that may not be broken down to specific types and/or components; the lack of clear definitions for outputs (i.e., what we count) and whether a standard "routine" set of activities will be adopted for inclusion in economies of scale and scope analyses. Adoption of the appropriate outputs for analysis is critical.[38]

Third, developing and encouraging a national standard for financial data would strengthen this research. LHJs and states have essential roles in developing and executing more standardized data systems. States that provide funding to LHJs could establish required standardized report forms that incorporate the categories and types of information that would allow for analysis of data over time. A National Clearing House could also be established to gather and maintain state and local financial and service data, sponsored by organizations such as the Robert Wood Johnson Foundation or a federal agency. National associations, such as National Association of County & City Health Officials, and/or Association of State and Territorial Health Officials could play a lead role or become this repository.[39]

Fourth, public health training for administrators in governmental agencies should include more on financial management and application of business models to the management of LHJ finances. Few, if any, have the ability or expertise to determine true unit costs for public health services. This can be addressed through a number of mechanisms. Modular, on-line courses, training through national associations, Public Health Training Centers, and other appropriate national organizations, and incorporation into existing public health school curriculums, are specific suggestions for how this additional education and training might occur.

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Endnotes

[1] Municipal health departments are part of the local town government infrastructure and function as a department. Any town with a population of at least 40,000 must have a full-time municipal health department, i.e. employ a full-time Director of Health. Full-time municipalities with more than 50,000 population receive a state appropriation of $1.18 per capita. Regional health districts must serve at least 50,000 or serve ≥ 3 municipalities regardless of their

combined population to receive a $1.85 per capita appropriation (Connecticut Office of Legislative Research, January 29, 2016).

[2] Part-time municipal departments must provide the equivalent of at least one FTE employees and are administered by a part-time Director of Health. They receive no payments from the state. While some part-time health departments have at least one full-time sanitarian on site, others provide minimal regulatory services and utilize contracted employees to provide them. Their focus is primarily on food protection inspections.

[3] Regional health Districts are full-time LHJ's formed by two or more municipalities and governed by an independent Board of Health composed of representatives appointed by the member municipalities. It operates as an independent entity of government. Districts with a population of 50,000 or more, or serving three or more towns, regardless of population, are eligible for a state appropriation of $1.85 per capita.

[4]The four services selected for evaluation in our analysis are recognized as essential responsibilities and services of governmental public health authorities by the public and by local and state lawmakers. These four services have also been selected because LHJs must report annually to the State of Connecticut Department of Public Health on these indicated programs.

[5] We measure the "output" of food services protection by the number of inspections.

[6] Whether or not a LHJ will actually provide inspections and permits for private wells and residential septic systems is a function of place. All urban and most suburban areas have public water and sewers. So the need to have staff certified to perform such services is determined by the new homes being built that require well and septic or repairs of existing wells or septic systems.

[7] Septic and private well water services may represent a significant amount of sanitarian time in many LHJs, Only three (4.2%) jurisdictions reported no subsurface activities in 2012 and all but six (8.5%) reported some level of well permitting. These were primarily the large urban areas with public water and sewers.

[8] Childhood lead poisoning is a rare condition in Connecticut. Whether or not an individual local health jurisdiction will need to respond to an elevated blood level is a function of geography and aging housing. Connecticut Department of Public Health produces lead surveillance reports on an annual basis. In 2012 a blood lead level of ≥20μg/dL was the required level for a full environmental and epidemiologic investigation. A total of 73,785 children ≤6 of age were

tested and 522 were ≥10μg/dL (0.7%). Of these tests, only 107 were ≥20μg/dL(0.15%) , triggering a full scale lead response. Only 41 of 169 towns (24%) had at least one case of lead poisoning during the year, and only six reported 31-36 blood levels of ≥15μg/dL. Thirty LHJs reported no lead inspections. Among Connecticut LHJs, 45% reported having HUD, CDBG or LAMPP funding to support the lead program in their jurisdictions.

[9] For purposes of this study we used the number of lead inspections done as an output variable. Lead surveillance data was also used in the analysis with any blood level ≥10μg/dL being considered positive (i.e. actionable).

[10] Those without a full-time director of health.

[11] It is worth noting that we are describing technical efficiency (with these details explained more in Appendix 1). This is in contrast with allocative efficiency, where the marginal benefit to consumers equals the marginal production cost.

[12] Early studies in the general literature on hospital cost estimation, for instance, simply regressed costs on a list of variables (*ad hoc* or behavioral cost functions, such as Lave and Lave, 1970), without considering the conditions the function needs to satisfy to be a relevant representation of cost minimization. In later empirical work, regularity conditions for the cost function in terms of output(s) were accommodated, but not relationships with input prices (such as Granneman, Brown and Pauly, 1986, and Vitaliano, 1987). Recognition of such input price relationships is necessary, however, for appropriate measurement of scale economies and scope economies. More recently, researchers have been using flexible cost functional forms that allow for the representation of more “factors of production” and interactions underlying actual health costs for empirical analysis of hospital costs. Cowing and Holtman (1983) and Vita (1990), for example, used translog (second order approximation in logarithms) functional forms with multiple outputs, which facilitate the estimation of scope (diversification) economies. Bilodeau, Cremieux and Ouellette (2000) also assumed a translog form, and tested for required regularity conditions to establish whether hospitals are actually minimizing costs. Li and Rosenman (2001) used a generalized Leontief form (second order approximation in square roots), because they found that it was theoretically justified, but the translog function was not, for their data on hospitals in Washington State.

[13] Along with the move toward functional forms more supported by microeconomic foundations, the literature has also increasingly tended to rely on longitudinal data (for a group of hospitals over time) rather than cross-sectional (at one time period) data (see, for example, Bilodeau, Cremieux and Ouellette, 2000). The importance of this was emphasized by Carey (1997) who showed that scale economies may be evident from panel data even if cross sectional data fail to reveal these economies.

[14] A helpful referee suggested we include population as a control in the cost function estimation. We attempted including population as a control, and there was no difference in the signs of the coefficients and minor differences in the magnitudes. This implies that the elasticities of scale and scope are essentially unchanged when we include population as a control. There is also little variation over time in the population for the regional health districts in Connecticut. For all of these reasons, and also because it is atypical in most cost function studies to include population as a control, we chose to present the results without population as a control.

[15] This producer price index, similar to the consumer price index, is based on national-level prices. Local-level price indexes for individual towns in Connecticut not available.

[16] A "B-100" is needed for properties served by septic systems, where there are additions to the property. A determination needs to be made as to whether these properties will continue to satisfy public health code after the addition is made.

[17] Again, the level and detail of the data is limited and in the final analysis, only total annual expenditure data is obtainable. As a result we are limited in our ability to separate the cost of only environmental health services from those of the entire LHJ. While the outputs represent only environmental health services efforts, in most cases the costs reflect the entire operation.

[18] A detailed list of which years and LHJ's were not included in the State of Connecticut Department of Public Health reports, and therefore required further follow-up search for us to obtain, is available from the authors upon request.

[19] For 2012, 45% of LHJs reported employing any nurse and 34% reported employing any Health Educator.

[20] This utilized the U.S. Census classification of Connecticut municipalities as urban or rural, and Humprhies (2012) employed a similar measure for her study of revenues of Connecticut LHJ's.

[21] Table 2 indicates results for 529 observations, even though there are 600 observations over the time period and across jurisdictions in our analysis. This disparity is due to the fact that there is missing data for total costs for some jurisdictions in some years. Some of these missing values were coded as "0", so we added the sample condition that the total cost variable needed to be greater than 1 in order to be included in the regression sample.

[22] We also perform a joint test of significance, and we reject the null hypothesis that all variables are jointly insignificant (P-value<0.001).

[23] This insignificance arises due to multicolinearity, which inflates the standard errors although does not bias the parameter estimates, which justifies using them to calculate the elasticity estimates.

[24] A helpful referee suggested we estimate separate total cost functions for each LHJ type, and test whether they differ by type. We agree this would be a sensible approach if the sample size is substantial for each type. But there are 74 LHJ's overall, among which there are 21 districts, 29 full-time municipal health departments, and 24 part-time LHJ's. By estimating separate cost functions for each of these 3 types, this would necessitate our reliance upon a very thin cross-section of jurisdictions in each category, which would be difficult to justify statistically. For this reason, the results in Table include dummy shift variables for the municipalities and the districts, with the part-time LHJ's as the "base". We are more comfortable with "controlling" for the variations in the type of district by this approach, than we are with estimating 3 separate cost functions that have weak statistical power due to the very small number of LHJ's in each of the 3 categories.

[25] The focus of our analysis is on both significance testing and the scale and scope economies. The scale and scope economies estimates are based on the cost function regression parameter estimates. If these cost function parameter estimates are all statistically insignificantly different from zero, then all of the inputs into the scale and scope elasticities would effectively be zero. This would preclude our ability to examine the scale and scope elasticities. For this reason, both the significance of the cost function parameter estimates, and the scale and scope elasticities, are the focus of our paper. Accurate and reliable parameter estimates are needed to then obtain the scale and scope elasticities.

[26] A table listing each of the 74 elasticity estimates is available from the authors upon request.

[27] There are several issues to consider in these figures. First, a jurisdiction classified as part-time may be either a part-time jurisdiction, or a full-time municipality with a part-time Director of Health. Second, Southington (municipality) merged with Plainville (municipality) during the time period covered by our analysis. In addition to some other data availability issues, we report the elasticity of scale estimate for Southington only.

[28] The size variables are the data from the year 2005, while the elasticity of scale represents the estimates presented above in Figure 1.

[29] It is noteworthy that this concept of economies of scope/specialization can only be applied to pair-wise comparisons of efficiency of inspection services. So, for instance, it is not possible to address the question of whether or not it is less costly to produce 3 inspection services in the same district or separately.

[30] In fact, other researchers, such as Santerre (2009) had used some of the data in an analysis on jurisdiction size and local public health spending, and Humphries (2012) had studied revenue streams.

[31] An anonymous referee suggested we perform sensitivity analyses to explore whether the missing values are a major issue. While this would be a valid exercise for a simple regression model if there had been a substantial

number of interpolated data points, there are fewer than 1% of the observations that were interpolated out of the total 529 observations in our sample. These were for very small LHJ's and dropping these observations has virtually no impact on our results. Also, since the main goal of the paper is to interpret the elasticities of scale and then interpret them, such a sensitivity analysis would not be possible for the LHJ's that had missing values because their data is necessary in order to calculate an elasticity for those observations.

[32] In addition, the municipal departments are not required to report their total expenses to the state, but in some cases they report it anyway. This is one reason why we did not find expense data for all municipalities in the state database.

[33] In other words, ε = MC/AC = $[\partial TC/\partial Q] \times [Q/TC]$ falls as Q falls and TC rises. Since the Q for municipalities includes fewer activities than are actually undertaken, and the TC includes more costs than merely environmental health, the estimate of ε that we obtain may be understated. In other words, the elasticity estimates presented should be considered lower-bounds.

[34] For example, one regional health district provides school nurses, and a dental program in addition to a robust communicable disease program. These services are responsible for almost half of the annual budget and have the effect of inflating the cost per service in the analysis.

[35] An anonymous referee pointed this out, along with his/her suggestion that some regions might prefer local control.

[36] An anonymous referee suggested these examples are reasons why we should consider estimating different cost functions by type of LHJ. But, as discussed in footnote 29, the small number of jurisdictions in each type would result in a very weak statistical power if we were to separately estimate 3 cost functions, each with approximately 20 to 29 jurisdictions. Therefore, we are much more comfortable with our approach of controlling for differences across LHJ's by controlling for LHJ type. Then, we obtain unique estimates of economies of scale for each LHJ in each year, underlying which is our analysis that controls for differences in LHJ type.

[37] A helpful editor pointed out several additional issues worthy of mention. First, businesses and residents incur costs of inspections, in addition to the LHJs. In fact, this could be an additional limitation, however it is beyond the scope of our research to evaluate these costs. Second, these inspections generate benefits for firms and residents, which would be a relevant consideration in a benefit-cost analysis (however, our study is limited to consideration of costs). Finally, the frequency of inspections, and which residents/businesses are inspected, also have impacts on the costs and cost efficiency of environmental health inspections.

[38] For example, in the case of lead poisoning, it is the elevated blood lead level (BLL) that drives the LHJ response to investigate so, the number of investigations is the output of interest.

[39] The many issues involved in how to collect the appropriate data for a cost function study is beyond the scope of this paper, but deserving of additional research.