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THE PROVISION OF MUNICIPAL SANITATION SERVICES BY PRIVATE FIRMS: AN EMPIRICAL ANALYSIS OF THE EFFICIENCY OF ALTERNATIVE MARKET STRUCTURES AND REGULATORY ARRANGEMENTS

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I. INTRODUCTION

CONCERN about productivity in local government is encouraging city officials to look closely at private market alternatives to the direct provision of municipal services by local government. One important issue concerns the question of which are the most efficient market structures and regulatory arrangements for the provision of such services. There is presently little hard evidence available to guide city officials.[1] The present study seeks to remedy this deficiency by empirically analyzing the alternative market structures and regulatory arrangements used in 77 cities in the United States for the provision of residential refuse collection service by private firms. Refuse collection services constitute an important municipal expenditure. In the fiscal year 1975–76 all municipal governments in the United States spent $13.85 per person on sanitation services other than sewerage. This expenditure constitutes about 9% of basic municipal service expenditures (police, fire, highways, sewerage, parks and recreation, and sanitation).[2]

II. ALTERNATIVE MARKET STRUCTURES AND REGULATORY SCHEMES

There exist several types of structural and regulatory arrangements for the collection of residential solid waste. At one extreme is public provision of collection services, where municipalities directly provide such services to all households and pay for them out of general tax revenues. At the other end of the spectrum is what we call the 'unregulated' arrangement, in which private refuse collectors have complete freedom to enter and leave the industry and where collectors and households are free to negotiate

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[1] Earlier studies of refuse collection are Dennis Young [6] and Werner Hirsch [2].

[2] US Bureau of the Census [5, p. 2].

whatever refuse service arrangements they wish. In between there are three general regulatory schemes for private collection: contract, franchise, and license. Since the focus of this study is on private collection systems, a detailed description of these arrangements follows.[3]

In contract arrangements, the city selects and directly pays a collection firm to provide refuse collection services to all residents in a given geographic area. Each collector, therefore, is the sole collector of refuse in a particular area. The typical contract between the city and the collector specifies the level of service to be provided (e.g. frequency of pickup, the point of pickup, and the types of refuse to be collected), the payment for each of the services, and the duration of the agreement. Households are given no choice regarding the level of service they will receive or the price they will pay—whether payment is via a user charge or part of general taxes. This is not true of the other private collection systems. In addition, the contract also frequently specifies rate adjustment procedures in the event of changes in the firm's cost, variations in the population served, or increases in some specified price index, and often contains an option to renew the contract if there is 'acceptable performance'. Among contract cities the most important distinction is whether the city assigns collection contracts by competitive bidding or by simply negotiating directly with would-be collectors. In the empirical work later in this paper we attempt to determine whether this difference is important in practice.

Franchise arrangements are similar but not identical to contract arrangements. The city again gives collection firms an exclusive right to provide service in a specified area for a given period of time, usually sets collection prices, and may or may not utilize competitive bidding (in our sample only three franchise cities made use of competitive bidding). There are, however, two important differences. First, franchised collectors negotiate service levels with households and bill them directly, rather than receiving payment from the city as under the contract arrangement. Thus, franchised collectors bear the costs associated with billing and their collection prices must reflect these additional costs. Second, in some franchise cities it is not mandatory for households to take (and pay for) refuse collection, while in others service is mandatory, as in contract cities. In non-mandatory franchise cities households may self-haul if they are dissatisfied with the collection service being provided, whereas in contract cities self-hauling is not a viable option because all households must pay for collection service whether or not they use it. In our empirical analysis we assess the practical significance of this self-hauling option. Except for billing costs, therefore, mandatory franchise cities are identical to contract cities, while non-mandatory franchise cities differ because of the self-hauling option.

Under all other private collection arrangements there is no legal agreement between the collector and the municipal government, although

[3] For a theoretical analysis of these alternatives schemes, see Edwards and Stevens [1].

some regulation may still exist. In general, these arrangements are characterized by a high degree of competition, easy entry, non-exclusive collection territories, and freedom to set prices and service levels through direct negotiation with service recipients. Two kinds of regulation may exist in these cities. In some cities collection firms are required to obtain a hauling license; and in some there is 'bureau' price regulation. Since it is possible that a licensing requirement may impose an important barrier to entry, in our empirical analysis we distinguish between a 'license' city and all other non-contract, non-franchise cities—which we refer to as simply 'unregulated' cities. Finally, we analyze the effectiveness of price regulation (both by 'bureau' and by contract) in all of the arrangements.

In sum, the efficiency of six distinct schemes for the provision of the residential refuse collection service are analyzed: contract with competitive bidding; contract without competitive bidding; mandatory franchise; non-mandatory franchise; license; and unregulated. In addition, the effectiveness of price regulation is analyzed. Of these schemes, the first four are alternative forms of collective action while the last two are 'free-market' or 'independent market adjustment' schemes.

III. EFFICIENCY OF THE ALTERNATIVE COLLECTION SCHEMES

This section investigates the empirical issue of which structural arrangement for refuse collection is the most efficient in practice. We focus on the prices that households pay for a given refuse collection service under different collection arrangements. The lower the price, the more 'efficient' the regulatory scheme is judged to be. Alternatively, we consider a regulation to be ineffective if it does not affect the price that households pay, or if it does not change 'efficiency'.[4]

1. Prices Under Independent Market Adjustment: the Basic Price Equation

To examine the relative efficiency of the various structural arrangements and the effectiveness of the different regulatory devices, we first develop a basic model of the determination of collection prices under independent market adjustment (or assuming no government intervention). Since prices in competitive markets depend upon supply and demand conditions, we begin by specifying demand and supply equations for collection service and then solve these equations for the equilibrium market price to obtain our basic estimating equation. The city is the unit of observation in our empirical analysis.

Like most commodities, a household's demand for a given refuse collection service (e.g. once-a-week, curbside service) is a function of the price of the

[4] Even when important externalities are present, under certain assumptions the prices that households pay for refuse collection will accurately reflect the social as well as the private costs of this service. See Edwards and Stevens [1, Section D].

service, the price of substitute services, and the household's level of income. Total market demand, therefore, is obtained by aggregating over all households. Similarly, the aggregate supply schedule is a summation of firms' marginal cost curves. In competitive markets, each firm produces up to the point where its marginal cost equals the market price, so that the equilibrium quantity supplied is a function of the variables that determine the position and shape of firms' marginal cost schedules. A firm's marginal cost will be determined by cost factors outside the control of the firm, and, if economies of scale exist, on the level of its output. In particular, marginal cost will be higher when factor prices are high, when population density is low (since travel time between households is greater), and when the climate is warm and rainy (because the refuse pickup is heavier). The basic aggregate demand and supply equations, therefore, are:

$$Q_d = f_d(P, PS, Y) \tag{1}$$

$$Q_s = f_s(S, P, W, r, \text{DEN}, \text{RF}, \text{TEMP}) \tag{2}$$

$$Q_d = Q_s \tag{3}$$

where Q_s, Q_d = quantity of collection service supplied and demanded;
P = price of collection service per year, for once-a-week curbside collection;
S = size of collection firm measured by number of trucks;[5]
Y = total income in the metropolitan area;
PS = price of alternative means of refuse disposal, or implicit price of self-hauling;
RF = average annual rainfall in the metropolitan area (SMSA), in centimeters;
TEMP = mean July temperature in the SMSA, in degrees centigrade;
r = cost of capital;
W = the monthly basic wage (exclusive of overtime and fringe benefits) paid by local collectors, expressed in dollars per month;[6] and,
DEN = household density.

Solving equations (1)–(3) for the equilibrium price yields the following reduced-form equation:

$$P = f_p(\overset{-}{S}, \overset{+}{PS}, \overset{+}{Y}, \overset{+}{W}, \overset{+}{r}, \overset{-}{\text{DEN}}, \overset{+}{\text{RF}}, \overset{+}{\text{TEMP}}) \tag{4}$$

[5] S is measured as the total number of collection vehicles owned by the firm, not the total number of collection vehicles used only for residential refuse collection. This measure will be an unbiased estimate of scale only if scale economies are common to all types of refuse collected (e.g. better maintenance).

[6] We assume that this wage rate is independent of the particular structural arrangement. Use of the (less appropriate) 'manufacturing wage rate' for the SMSA did not change our results, however.

where the hypothesized signs of the coefficients are indicated above the variables.

2. Prices When Government Intervenes

When government intervenes to assure that refuse collection service is provided to all residents in the city (as is the case in 'contract' cities), there are two possible sources of cost reduction: the ability to make collectors' routes more contiguous; and the ability to capture scale economies that are not being fully exploited under independent market adjustment arrangements. Alternatively, if collection firms are able to achieve whatever scale economies exist by operating simultaneously in more than one city, so that they always operate at an efficient scale, government intervention may still lower collectors' costs by enabling them to operate at an efficient scale without having to operate in more than one city. There are, presumably, some transaction costs associated with having to operate in several cities. In general, therefore, we might expect government intervention to reduce costs (and therefore prices) by more in small cities than in large cities. All cities should be subject to savings arising out of economies of contiguity, while only small cities should be subject to economies-of-scale savings. (The available evidence indicates that economies of scale vanish when collectors reach a size where they are servicing about 40,000 people.)[7]

There may also be negative aspects to government involvement: it may result in certain cost inefficiencies, and may bestow (consciously or inadvertently) monopoly power on private collection firms, both of which will cause prices to be higher. Whether the potential cost savings will dominate or be dominated by these potential inefficiencies is an empirical issue.

Thus, in order to obtain an empirical estimate of the net effect of these competing considerations, we add to the reduced-form price equation (4) a set of structural and regulatory variables (Z).

$$(5) \qquad P = f(Z, PS, Y, W, r, \mathrm{DEN}, \mathrm{RF}, \mathrm{TE\ MP}, S)$$

Estimation of equation (5) will provide estimates of the impact that each type of government intervention has on prices in the refuse collection industry, and will provide an estimate of the net benefits (or cost) of collective action. More specifically, by estimating equation (5) we can determine the impact of the various structural and regulatory schemes on collection prices (or $\partial P/\partial Z$), holding all other factors constant, including the size of the firm S. Assuming that S adequately accounts for scale economies, therefore, the coefficient of $\partial P/\partial Z$ indicates the effect of the structural schemes independent of scale effects. Or, it measures the net effect of the economies of contiguity and the possible cost inefficiencies associated with government involvement. Alternatively, to the extent that the size of firm

[7] See, for example, Stevens [4], McFarland [3], and note 25 *infra*.

S is itself a function of the structural scheme Z, the $\partial P/\partial Z$ coefficient will understate the impact of Z.[8]

3. *Sample, Data Characteristics, and Institutional and Regulatory Variables*

We utilize data on private collectors operating in 77 cities using some form of private collection system.[9] These data were compiled for the year 1975. In 37 of the cities a contract collection system is used, in 17 cities a franchise system is used, in eight cities a hauling license is required, and in 16 cities not even a hauling license is necessary, although in one of these cities rates are regulated. Thus, in the sample of 77 cities, private collectors are regulated in all but 15 cities.

The sample is derived from an extensive mail and telephone survey. In specific, 128 contract cities were surveyed, 65 franchise cities, and 125 'non-contract/non-franchise' cities, some of which turned out to be license and some unregulated cities. To qualify for inclusion in the sample two factors were required: collectors in the city must have provided once-a-week, curbside service, and both collectors and cities must have supplied complete data for all the variables requested. This means that both the firm providing service and the city government had to respond to questionnaires. The former requirement was imposed so that we could test our hypotheses in the context of standardized prices (what households pay for a given, homogeneous, service), thereby avoiding the thorny empirical problems associated with analyzing a heterogeneous output. This requirement reduced our sample considerably. Nevertheless, the sample represents the total survey fairly well. For example, 4% of the non-contract and non-franchise cities in the sample regulate rates, whereas 6% of all such cities in the complete survey reported rate regulation.

Lastly, the 77 cities in our sample can be classified into nine structural and regulatory classifications: U, L, CCB, COTH, FMAND, FOTH, RR, RRC, and RRB. These variables are defined below, and the number of cities falling into each is given in Table I.

U = cities in which the collector is unregulated, which takes the value of one where the city is not a contract or franchise city and does not require a hauling license, and zero otherwise;

[8] The omission of S has only a trivial effect on the $\partial P/\partial Z$ coefficients. The issue of separating economies of scale effects from economies of contiguities effects is discussed more fully later.

[9] With the exception of the four mandatory franchise cities, these cities also are fairly evenly dispersed across the northeastern, northern, and western regions of the country. None is located in the south. In particular, for each type of structural arrangement, at least 8% of the observations are present in each of the three regions noted above. However, all four mandatory franchise cities are located in the west. Our estimating equations include variables to capture economic differences among regions relevant to solid waste collection, such as the 'annual rainfall' in each city.

TABLE I

NUMBER OF CITIES IN EACH STRUCTURAL AND REGULATORY CLASSIFICATION

Institutional and regulatory classification	*Price regulation (RR)* Fixed in contract (RRC)	Bureau administered (RRB)	*None*
U (16)	0	1	15
L (8)	0	3	5
CCB (12)	12	0	0
COTH (24)	23	1	0
FMAND (4)	1	3	0
FOTH (13)	9	4	0

L = cities that require collectors to obtain a hauling license, which takes the value of one where the city is not a contract or franchise city but does require a hauling license, and zero otherwise;

CCB = competitive bidding contract city, taking the value of one for all contract cities which reported more than two bidders on each contract, and zero otherwise;[10]

COTH = all contract cities other then CCB cities, taking the value of one for such cities, and zero otherwise;

FMAND = mandatory-collection franchise cities, taking the value of one for all franchise cities in which self-hauling is not permitted, and zero otherwise;

FOTH = all franchise cities in which self-hauling is permitted, taking the value of one for such cities, and zero otherwise;

RR = cities in which collection prices are set either in the collection agreement or by a regulatory bureau, taking the value of one for such cities, and zero otherwise;

RRC = cities in which collection prices are set in the collection agreement, taking the value of one for such cities, and zero otherwise; and,

RRB = cities in which collection prices are set by a regulatory bureau, taking the value of one for such cities, and zero otherwise.

As can be seen from Table I, there are six mutually distinct categories, and three that cut across several categories (RR, RRC, and RRB).

4. The Final Estimating Equation

To obtain the final estimating equation, the foregoing structural and regulatory variables are added to equation (4) as in equation (5) above. Also, variables *PS* and *r* are omitted from the equation. The cost of capital *r* is omitted primarily because it is not measurable, although a reasonable

[10] We also investigated an alternative CCB variable defined as any city that simply claimed to be a competitive bidding city. The empirical results were the same.

argument can be made that it does not vary much by region since its major component—the level of the interest rate—is determined in a national financial market. Variable *PS*, the cost to the household of disposing of their refuse by self-hauling (the only alternative to organized collection service), is omitted because it is unobservable and attempts to proxy it were unsuccessful. In particular, *PS* should arguably be a function of the hauling time required in the city and the household's opportunity cost of time. When we measured the latter by the level of income per capita in the city, and the former by both city size (number of households) and traffic congestion (household density), and included these variables in the estimating equation, none of our estimates changed (nor were these variables significant).

In summary, making the further assumption that the structural demand and supply equations are multiplicative in form,[11] the final estimating equation for equilibrium collection prices under all types of collection arrangements is:

$$\ln P_h = \ln a_1 + a_2 \ln S + a_3 \ln Y + a_4 \ln \mathrm{RF} + a_5 \ln \mathrm{TEMP} + a_6 \ln \mathrm{DEN} + a_7 \ln W + a_8 Z + \alpha \tag{6}$$

where P_h is collection price per household,[12] S is the size of collection firm, Y is aggregate income of all households in the city, *RF* is annual rainfall, TEMP is mean July temperature, DEN is household density, W is wage rate of sanitation workers, Z represents the various structural and regulatory variables, and α is a random error-term.

This procedure, of course, assumes that the parameters a_2, a_3, a_4, a_5, a_6, and a_7 are stable across the alternative structural and regulatory groupings. Although the data were not sufficient to test the validity of this assumption for every case, we did estimate appropriate versions of equation (6) for the four separate groupings of contract, franchise, license, and unregulated cities The. null hypothesis of parameter stability could not be rejected. Thus, the assumption of stability across the structural and regulatory classifications was adopted.

5. *Empirical Results*

With six distinct collection schemes plus the possibility of price regulation it is clear that there are a large number of alternative hypotheses to be tested—15 structural arrangement hypotheses and two price regulation hypotheses.[13]

To present the results for all possible hypotheses, we felt the most illuminating expositional device was to estimate (by least-squares regression

[11] Alternate functional forms were tested. The logarithmic form was selected as providing the best fit.

[12] Precisely, annual price per household, net of all disposal fees and franchise fees. In franchise cities 'revenue-raising fees' are often imposed on collectors by the city.

[13] With six distinct structural arrangements, there are 15 possible pairings of such arrangements.

techniques) alternative versions of equation (6) for the entire sample, omitting a different structural arrangement variable each time. These results are reported in the first seven equations of Table II, which together permit the use of the reported *t*-statistics to test directly any of the 15 structural arrangement hypotheses.[14]

The estimates shown in Table II yield the following conclusions:

(*a*) The structural arrangements fall into two distinct groups: CCB and COTH constitute one group, and FOTH, L, and U constitute the other.[15] Collection prices in the latter cities are significantly higher than in the former group of cities, implying that the contract arrangement is the most efficient collection system.[16]

(b) The structural arrangement FMAND cannot be distinguished from either of the two above distinct groupings at an acceptable level of statistical significance. This result is almost certainly due to the fact that there are only four FMAND cities in the sample.[17]

(c) Competitive bidding does not appear to influence collection prices: there is no significant difference between the coefficients of CCB and COTH,

(d) Making collection service mandatory appears to lower collection prices, although this finding is 'weak'. In specific, there is a difference between the coefficients of FMAND and FOTH only at a 15% level of significance.

(e) Price regulation in general has no effect on collection prices (the coefficient of RR is always insignificantly different from zero). In addition, it makes no difference whether price regulation is done by a regulatory bureau or by contractual agreement (there is no significant difference between the coefficients of RRC and RRB in equation (7)).

(f) The 'other' independent variables, taken either individually or as a group, are not statistically significant. It should be recognized, however, that previous studies, while recognizing the potential importance of these

[14] Alternatively, we could have estimated any one of the first seven equations in Table II and computed the appropriate *t*-statistics for each of the 15 hypotheses. This procedure, however, would have hidden rather than illuminated our classification criteria. See note 16, *infra*.

[15] Since the number of competing sellers may be greater than one in the L and U cities and may therefore differ among these cities, we estimated a separate equation for the L and U cities and included the variable 'number of collectors' in the equation. This variable was not significant. It was also insignificant when entered in equation (5).

[16] Structural arrangements are considered to be in the same group if two criteria are met: the difference in the price level between these structural arrangements is not significant at the 5% level; and each of these arrangements has the same relationship with each of the structural arrangements in another group. For example, CCB and COTH are placed in the same group because their coefficients are not significantly different from one another (*t*-statistic of 0·53 in equation (1)), and because both of them have coefficients which are statistically different from the coefficients of FOTH, L, and U (shown by the appropriate *t*-statistics in equations (1) and (2)). This 'strong' criterion minimizes the chance of incorrectly plasing two arrangements in the same grouping, thereby failing to distinguish between them when we should.

[17] However, when similar structural arrangements are pooled, as in equations (8)–(10) in Table II, FMAND can be distinguished from the FOTH-L-U group at the 5% level of significance.

TABLE II

IMPACT OF ALTERNATIVE STRUCTURAL AND REGULATORY VARIABLES ON COLLECTION PRICES
(t-statistics in parentheses)

		Structural arrangement and regulatory variables									*Other variables (in logarithms)*						
Equation	*Constant*	*CCB*	*COTH*	*FMAND*	*FOTH*	*L*	*U*	*RR*	*RRC*	*RRB*	*Y*	*RF*	*TEMP*	*DEN*	*W*	S^a	R^2/F
(1)	1·155	—	0·056	0·275	0·633	0·885	0·772	0·209	—	—	0·034	0·941	0·228	−0·052	−0·022	0·158	0·55
	(0·68)		(0·53)	(1·52)	(4·45)	(2·63)	(2·54)	(0·68)			(0·98)	(1·12)	(0·59)	(−1·42)	(−1·09)	(1·56)	(12, 62) 6·3
(2)	1·210	−0·056	—	0·219	0·577	0·829	0·716	0·209	—	—	0·034	0·941	0·228	−0·052	−0·022	0·158	0·55
	(0·73)	(−0·53)		(1·29)	(4·84)	(2·49)	(2·40)	(0·68)			(0·98)	(1·12)	(0·59)	(−1·42)	(−1·09)	(1·56)	(12, 62) 6·3
(3)	1·430	−0·275	−0·219	—	0·357	0·609	0·496	0·209	—	—	0·034	0·941	0·228	−0·052	−0·022	0·158	0·55
	(0·84)	(−1·52)	(−1·29)		(1·84)	(1·76)	(1·55)	(0·68)	—	—	(0·98)	(1·12)	(0·59)	(−1·42)	(−1·09)	(1·56)	(12, 62) 6·3
(4)	1·787	−0·632	−0·577	−0·357	—	0·252	0·139	0·209	—	—	0·034	0·941	0·228	−0·052	−0·022	0·158	0·55
	(1·11)	(−4·45)	(−4·84)	(−1·84)		(0·73)	(0·45)	(0·68)			(0·98)	(1·12)	(0·59)	(−1·42)	(−1·09)	(1·56)	(12, 62) 6·3
(5)	2·040	−0·885	−0·829	−0·609	−0·252	—	−0·113	0·209	—	—	0·034	0·941	0·228	−0·052	−0·022	0·158	0·55
	(1·20)	(−2·63)	(−2·49)	(−1·76)	(−0·729)		(−0·86)	(0·68)			(0·98)	(1·12)	(0·59)	(−1·42)	(−1·09)	(1·56)	(12, 62) 6·3
(6)	1·927	−0·772	−0·715	−0·496	−0·139	0·113	—	0·209	—	—	0·034	0·941	0·228	−0·052	−0·022	0·158	0·55
	(1·16)	(−2·54)	(−2·40)	(−1·55)	(−0·45)	(0·86)		(0·68)			(0·98)	(1·12)	(0·59)	(−1·42)	(−1·09)	(1·56)	(12, 62) 6·3
(7)	1·159	—	0·060	0·327	0·661	0·813	0·700	—	0·135	0·065	0·031	0·088	0·269	−0·051	−0·023	0·169	0·55
	(0·68)		(0·57)	(1·53)	(4·23)	(3·71)	(3·74)		(0·80)	(0·37)	(0·87)	(1·03)	(0·67)	(−1·37)	(−1·16)	(1·62)	(13, 61) 5·78

	Constant	CCB+COTH	FMAND	FOTH+L+U	RR	RRC	RRB	*Y*	RF	TEMP	DEN	*W*	*S*	R^2/F
(8)	1·054	—	0·218	0·609	0·047	—	—	0·038	0·087	0·293	−0·050	−0·019	0·155	0·54
	(0·66)		(1·39)	(5·57)	(0·36)			(1·16)	(1·07)	(0·82)	(−1·39)	(−0·97)	(1·56)	(9, 65) 8·54
(9)	1·273	−0·218	—	0·391	0·047	—	—	0·038	0·087	0·293	−0·050	−0·019	0·155	0·54
	(0·79)	(−1·39)		(2·14)	(0·36)			(1·16)	(1·07)	(0·82)	(1·39)	(−0·97)	(1·56)	(9, 65) 8·54
(10)	1·664	−0·609	−0·391	—	0·047	—	—	0·038	0·087	0·293	−0·050	−0·019	0·155	0·54
	(1·08)	(−5·57)	(−2·14)		(0·36)			(1·16)	(1·07)	(0·82)	(1·39)	(−0·97)	(1·56)	(9, 65) 8·54

[a] $S=5$ if $S \geq 5$.

variables, have also obtained poor results for these variables (see Hirsch [1] and McFarland [3]). Possible explanations for our results are the existence of specification errors in the estimating equation and/or measurement errors.[18] An implicit assumption which underlies our results, therefore, is that any possible omitted variables or measurement errors are random with respect to the structural and regulatory variables.

In order to obtain the best estimate of the magnitude of the price difference between the two distinct groups of CCB and COTH versus FOTH, L, and U, we pooled similar arrangements and estimated equations (8)–(10) in Table II. These equations treat FMAND as a distinct variable so that it does not obfuscate the estimate of the price difference between the two distinct groups of cities.[19] The estimates show that collection prices are 75% higher in FOTH, L, and U cities than in contract cities, or 43% lower in contract cities than in FOTH, L, and U cities.[20]

Finally, most of this difference in price level cannot be explained by the fact that contract collectors do not incur billing costs, as do refuse collectors in other cities. Although it is difficult to estimate precisely the additional costs that contract collectors would incur if cities did not assume their billing expenses, a survey of 102 cities in which local government provides collection services indicated that from 3 to 9% of total collection costs are attributable to billing expenses. These figures may understate private billing costs, however, because of government's ability to bill jointly for several services and because of its additional coercive power. Indeed, discussions with collectors in franchise cities suggested that billing costs may be as high as 15% of total collection costs per household (or about 18% of total collection costs per household in contract cities).[21] Such an estimate is also consistent with the results in equation (8) in Table II. In particular, since the essential difference between FMAND and contract cities is that collectors in FMAND incur billing costs while collectors in contract cities do not, the coefficient for FMAND (0·218) should represent the price difference due to billing costs. This estimate indicates that prices in FMAND cities are about 24% higher than in contract cities,[22] which is somewhat higher but still consistent with collectors' estimates of about an 18% cost differential. Taking the upper estimate of 24% and adjusting prices in contract cities upward still leaves a substantial price difference between contract cities and FOTH, L, and U cities: prices in the latter cities remain 41% higher than in contract cities (or than in FMAND cities): or, alterna-

[18] Various tests for multicollinearity do not suggest that this is the cause of these results.

[19] Another procedure is to include FMAND alternately in one group and then the other. This procedure yields similar results.

[20] The percentage difference in price between two structural arrangements is equal to $e^{b_1-b_2}-1$, where b_2 is the coefficient of RR and b_1 is the value of the estimated coefficient of the structural arrangement in question (in this case, +0·609).

[21] $\frac{0\cdot 15x}{0\cdot 85x}=0\cdot 18$, where x = total collection costs per household in franchise cities.

[22] The figure of 24% comes from $e^{0.218}-1$.

tively, prices are 29% lower in contract cities than in FOTH, L, and U cities,

Thus, our major empirical finding is that in contract cities households pay collection prices that are substantially lower than in other cities, even after a generous adjustment is made for billing cost differences.[23]

IV. CONCLUSIONS AND IMPLICATIONS

Of the various private structural arrangements now in use to collect solid waste in US cities, the best scheme seems to be the contract system: where cities contract with private collection firms, make collection service mandatory, grant exclusive service rights to designated sections of the city, and set prices and service standards in the contractual agreement. Prices that households pay for collection service in non-contract cities are at least 41% higher than in contract cities. In addition, we find that the use of competitive bidding to let collection contracts is neither superior nor inferior to simply negotiating contracts with collectors; that price regulation, in any form, does not affect collection prices; and that requiring collectors to obtain a hauling license does not affect collection prices.

Can the findings that prices are 41% higher in 'non-contract' cities be generalized to imply that the adoption of the 'contract' system of refuse collection service will always result in such a large cost savings? Perhaps. Previous discussion in this paper argued that the cost savings that come from government intervention derive from two sources: economies of scale and economies of contiguity. In general, cost savings should be greatest in small cities. Studies of economies of scale in refuse collection indicate that scale economies may exist up to a collector size of about 40,000 people. Thus, in cities with populations of less than 40,000, increasing the number of households served by a given collector should lower average collection cost because of economies of scale as well as because of economies of contiguity. In large cities, however, most of the benefits should come from economies of contiguity. Alternatively, if refuse collection firms in small cities operate in more than one city simultaneously in order to attain an efficient size, government intervention may still be beneficial because it may eliminate or reduce the transaction costs associated with a multiple-city operation. Once again, this cost savings should be greater for small cities.

Whether our estimated 41% price differential can be attributed solely to economies of contiguity, therefore, depends upon how successfully we have controlled for scale economies in the estimating equations. All of these equations included 'size of collection firm *S*' as an independent variable,

[23] In an effort to determine whether this result was in any way due to systematic variations in contractual provisions, we also examined the effect of the following contractual provisions on collection prices: the presence of an escalator clause in the contract to adjust collection prices for changes in cost; the value (total and per household) of the performance bond if required; the number of years since the contract was entered into; and the presence of an option to renew the contract. None of these variables was significant and its inclusion did not change any of the above results.

as well as size of city Y. In no case is the coefficient of S significantly different from zero. Thus, variable S may not adequately control for scale economies. As indicated previously, variable S may not be an accurate measure of firm size with respect to *residential* refuse collection, and may also fail to capture costs associated with multiple-city operations.[24] Consequently, in order to be sure that we are not over-estimating the cost savings due to economies of contiguity, we also employ the procedure of utilizing the findings of previous studies of economies of scale in refuse collection to arrive at a *minimum* estimate for economies of contiguity.

Two types of information are needed to derive this estimate. First, we need an estimate of the extent to which government involvement results in firm size being larger; and, second, we need an estimate of the firm's average cost curve. Previous studies of economies of scale in refuse collection have generally measured firm size as the 'number of people per firm', which is derived by dividing total city population by the number of firms. This can be a poor measure of firm size because it ignores multiple-city operations by collectors. Nevertheless, for our sample, this procedure yields an average firm size of 10,500 people in non-contract (L, U, and FOTH) cities, which will understate firm size if firms in these cities operate in more than one city. Given this estimate, however, and given the fact that the average population size of non-contract cities in our sample is 22,500, collectivizing these cities could be expected to increase average firm size by about 12,000 people for this reason alone. In addition, in the sample used to estimate the above equations, the average size of contract cities (CCB and COTH) is 41,000 people, so that the observed price differential between contract and non-contract cities is further adjusted by calculating what these prices would be *if* average collector size in L, U, and FOTH cities were 41,000 instead of 10,500 people. This procedure attributes as large a portion of the observed price differential to scale economies as possible. Indeed, it probably overestimates the effects of scale.

Previous studies of economies of scale in cities where a single refuse collector services all households (e.g. municipal service and certain contract cities) suggest that average collection prices will fall by about 13% if collector size is increased from 10,000 to 20,000, and by 22% if collector size is increased from 10,000 to 41,000.[25] Thus, after adjusting prices in FOTH, L and U cities downward by 22% to reflect possible scale economy differences between these cities and contract cities, and re-estimating the remaining price difference between these and contract cities, we find that prices in FOTH, L, and U cities are still 10% higher than in contract cities. (See

[24] See note 5, *supra*.

[25] At a 95% confidence interval the range for these price reductions would be: from 1,000 to 20,000, a price decrease of $13 \pm 9\%$; from 20,000 to 30,000, a further decrease of $7 \pm 5\%$; from 30,000 to 40,000, a further decrease of $4 \pm 3\%$. The overall expected decrease is thus $22 \cdot 3\%$. See Stevens [4].

Appendix I.) This, then, is the *minimum* price difference attributable to the economies of contiguity which flow from government acting to collectivize refuse collection services.

In summary, we conclude that:

1. Cities can achieve significant cost savings of from 10 to 41% by adopting what we have called the 'contract' service arrangement.

2. The cost savings due to government intervention can be attributed to two factors: economies of scale and economies of contiguity.

3. As city size (and therefore firm size) increases, the major economic benefit of government involvement derives from economies of contiguity.

4. Realization of economies of contiguity alone should, on average, result in a cost savings of at least 10%, no matter what the size of city is.

5. The regulatory strategies of utilizing competitive bidding or price regulation do not seem important as compared to the decision to adopt the 'contract' service arrangement.

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APPENDIX I

DIFFERENCES IN AVERAGE COLLECTION PRICES, ADJUSTING FOR EFFECTS OF SCALE AND BILLING COSTS

Definitions of groups of cities:

C = CCB + COTH = contract cities
LUF = L + U + FOTH = license, unregulated and non-mandatory franchise cities

	Annual price ($)		*Differences in prices*	
Adjustment to mean price	*C*	*LUF*	*LUF* − *C* ($)	$\frac{LUF-C}{C} \times 100$ (%)
Holding independent variables *Y*, *RR*, *RF*, *TEMP*, *DEN*, and *W* constant	20·42	35·73	15·31	75
Increase prices in contract cities by 24% for billing costs	25·32	35·73	10·41	41
Size of collector adjustment together with the billing cost adjustment	25·32	27·87	2·55	10

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