The Economics Of Refuse Collection

In Kuwait

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INTRODUCTION * *

Kuwait has been witnessing an unprecedented economic growth since it began exporting oil three decades ago, and, in particular, since 1973. This growth was accompanied by a large increase in population primarily through an influx of immigrants to meet labour needs. As a consequence, Kuwait has experienced a rate of urbanization which is believed to be one of the highest in the world, e.g, about 90 per cent. This has meant an increase in the demand for public services, including the demand for refuse collection. And the existing municipal apparatus has been "caught off-guard". The piling of litter and garbage everywhere has been evident and the problem of refuse collection has been receiving increasing attention and publicity.

The municipality, thus far, has been trying to cope with providing this service with little concern for the economic efficiency of performance. In fact, one cannot find any economic studies of refuse collection and disposal in Kuwait except, perhaps, studies undertaken by foreign consulting firms whose primary objective was aimed at reorganizing the administrative activity of this service.

The present paper is an empirical analysis of the economic structure of refuse collection in Kuwait. A Cobb-Douglas production function is fitted to cross-sectional data for the year 1977. The main objective is to measure the scale of operation of this service. The paper is composed of two parts. Part I describes how the service is performed including its magnitude. Part II presents theoretical as well as empirical estimates of the production function.

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PART I

Refuse Collection and Disposal

Refuse in defined as those solid materials which the society wishes to get rid of.Solid waste includes household garbage and trash, as well as commercial, industrial, and agricultural waste. There are two parties responsible for solid waste collection and disposal, namely: (1) the municipality and, (2) five private contracting companies which are limited to the collection of solid waste from large commercial, industrial and apartment complexes only. Since the municipality shoulders most of the collection and disposal of refuse, this paper will concentrate on municipal activity only.

The municipality collects refuse from all residential areas, government buildings, small shops and establishments and public places including streets throughout the state. The state has been divided into eight geographical districts and each district may have several sanitation centers to make a total of thirty-four centers. The municipality disposes of this refuse in three main landfills, and operates a plant for transforming garbage into fertilizer which has a processing capacity of 100 tons of garbage per day or with an annual production of 4500 tons of fertilizer at a cost of K. D.29 per ton. There are plans to construct a larger plant in the future.

Method of Collection and Disposal

Collection trucks gather at three main distribution centers: (1) Shuwaikh, (2) Fahaheel and (3) Jahra, and from there they are dispatched to the various centers. Each truck is assigned between two to five workers depending on the size of the truck. Distribution of trucks and workers to the various centers is based on past experience. Generally, population density, number of establishments and geographical size will be taken into consideration in deciding how many trucks and workers should be assigned to a given area.

Trucks begin their pick-up rounds each morning, and once they are loaded the larger trucks go directly to the landfill; the smaller trucks unload into large trailers which are located in collection centers. The data collected by each center concerning the number of rounds do not differentiate between small and large trucks; in addition, none of the loads are weighed. Consequently, it is impossible to know exactly how many tons of refuse are collected every day. The range of distance travelled varies from 11 to 45 kilometers. This means that trucks spend approximately 25 per cent of the time collecting, and the remainder travelling to and from the disposal site. (1)

Streets are hand swept. Mechanical sweepers have been tried but with little success. Much of what is swept is sand and most of this material is shovelled onto the unpaved sidewalks from where rain or wind return it to the roadway.

Output and Costs of Solid Waste Collection

Estimates of the amounts of solid waste generated annually are confusing, inconsistent, and contradictory. Only rough approximations are available, and these are only offered to provide a sense of order in the magnitude of solid waste management.

According to a study by the municipality in November 1978, (2) the amount of solid waste collected during that year from residential areas and buildings alone, was estimated to be 643,236 tons (3). There was no mention of the amounts of solid waste collected from commercial and industrial concerns. Since statistics collected show the number of rounds completed every day without any indication of the type of trucks used, four estimates of average daily tonnage were added together and divided by four which gave the average daily production of 11672 tons per day. Table 1 gives estimated output of solid waste for the period 1967-1977.

Total annual collection and disposal costs for 1978 were K D.6,421,184.143 and the cost per ton was K. D.9.982. Table 2 compares solid waste production and costs in Kuwait with that in the U.S.

Trends in the amount of refuse generated indicate rapid growth. Between 1967 and 1976 the population doubled and the same is true of the refuse generated. The author's calculations show that per capita daily of solid waste increased by 13% during this period. There is little doubt that the resources devoted to solid waste collection have increased dramatically. As an indication, there were approximately 3400 workers employed in this service in 1967; while in 1978 the number had grown to approximately 5400, a growth of almost 60 percent during an eleven-year period.

Accompanying the growth in the quantity of solid waste generated and in the resources devoted to its removal, has been a change in the composition of refuse. Due to continuing urbanization, changes in household incomes and tastes, and to technological changes consumption of all types of goods has increased which in turn has led to an increase in the amount of paper and cardboard packing. In Kuwait, wet garbage constitututes a high percentage of household solid waste compared with that of England or the U.S. (4). This is due primarily to the lack of garbage disposals in the homes and also due to consumption of fresh fruits and vegetables in preference to frozen foods.

In short, the size of this service, its continued growth, and the increased concern for public cleanliness, health, and the environment make refuse collection an important policy problem.

PART II

The Production Function — Theory and Empirical Estimates

The production function for an urban public service represents the relationship between inputs of production factors and outputs per unit of time, subject to some constraints. An understanding of this function helps deal with

efficiency problems, including the substitution of one factor of production for another, and the presence of scale economies

A production fuction may be written as follows(5)

$$Q = f(I, S, T) \qquad (1)$$

where I = Input factors
S = Service conditions
T = State of technology

Input factors may be divided into Labour (L), Capital (K), and Material (R). Service conditions refer to a variety of physical, human, financial, legal and political factors that can make it easier, or more difficult, for governments to provide services of a specified quantity and/or quality. Finally, whenever technology changes, we end up with new production functions. (6)

Not all the variables mentioned above are needed in certain empirical production functions. There are many short-run situations where technology and service conditions affecting input requirements remain unchanged: therefore the T and S variables can be dropped. In the case of refuse collection, materials (R) used are of minor importance in production decisions, and may be considered fixed or lumped with capital inputs. While service conditions definitely affect production and input requirements, they change very little and, therefore, may be considered as given. As for technological changes, it is seldom that they lead to sudden changes in the production functions of urban public services including refuse collection; therefore T will be considered fixed(7).

Therefore, equation (1) reduces to

$$Q = f(L,K) \qquad (2)$$

It should be noted that there are numerous problems in measuring Labor (L) and Capital (K). Labor is not homogeneous and needs to be standardized whether we use cross-section or time-series data. This is not easy to do especially if the data are lacking. Similarly, measuring capital is another serious problem. The capital stock of most governments is a conglomeration of equipment and buildings at different stages in their life cycle, and there seems to be no way to disentangle this bundle. Fortunately, capital plays a relatively small role in many urban public services, and errors from inappropriate handling of capital are therefore smaller than they would be in private industry. (8)

There are two major ways to provide estimates of urban service production functions. (9) The first relies on technological information supplied by engineers. The second uses ex post statistical information-either cross-section or time-series data. Engineering data have been used only in a few cases to derive public service production functions as they are inappropriate for the study of scale economies of government units. Ex post data, however, can be subjected to statistical methods to estimate production functions. Most empirical production functions including those pertaining to urban public services, have been derived by using single equation least squares methods. By far the most popular form is the Cobb-Douglas production function :(10)

$$Q = AL^{\alpha} K^{B} Ei, \quad A \geq 0, \quad Q \geq O, K \geq O \qquad (3)$$

where A is a shift parameter and Ei is a disturbances term. The function is a linear one in the logarithms of the inputs and output. Thus we have.

$$\text{Log } Q = \text{Log } A + \alpha \text{Log } L + B\text{Log } K + \text{Log } Ei \qquad (4)$$

If therefore, we measure the logarithms of output and inputs we expect to find a linear relationship with a slope of α in the labor direction and a slope of B on the capital axis. The constant α measures the elasticity of response of output to labor input. For example, a one per cent increase in labor, with the amount of capital held constant, will add α per cent to output. Similarly a one per cent increase in the amount of capital, with no changes in the labor employed, will add B per cent to the level of output. If both labor and capital are increased by one per cent, then output will expand by $(\alpha + B)$ per cent.

The coefficients α and B, and their sum $\alpha + B$, have an immediate interpretation in terms of the concepts of economies of scale. (11) The sum of the coefficients indicates the extent of economies or diseconomies of scale. If $\alpha + B > 1$, then a doubling of both inputs will give rise to a more than twofold increase of output. If $\alpha + B < 1$, then a doubling of both inputs will cause output to expand less than twofold. When $\alpha + B = 1$, then a doubling of both inputs will cause output to double.

If there were economics of scale, i.e., $\alpha + B > 1$, in production over the whole range of output and if the entrepreneur could purchase labor and capital on the market at fixed prices and sell his output without changing the price, then it would be profitable always to expand output. On the other hand, if there were diseconomies of scale, i.e $\alpha + B < 1$, over the whole range of outputs, it will always increase the profits of a firm to split itself into smaller parts, until each firm is of an infinitely small size. Costs per unit of output decrease as the size of the firm is reduced. (12).

Empirical Test of the Production Function of Refuse Collection in Kuwait.

Refuse collection activity is viewed as a production process whereby the municipality, as a firm, combines various inputs to produce this service per unit of time. The output is measured by the number of trip-loads per day as a proxy for tons of garbage. The inputs are labor and capital employed to produce trip-loads per day in 1977 in 34 centers of garbage collection. Data used to fit equation (4) are given in Table 3. The Cobb-Douglas production function produced results of the estimated production which are shown in Table 4 below:

Table 1

Solid Waste Tonnage **
1967 - 1977

Year	No. Of Rounds	Amount of Waste * (in Tons)
1967	115433	265,518.9
1968	121132	278,603.6
1969	131573	302,617.9
1970	143335	329,670.5
1971	160327	368,752.1
1972	172730	397,279
1973	212473	488,687.9
1974	214731	493,881.3
1975	217564	500,397.2
1976	248607	571,796.1
1977	254252	584,779.6

* Amount of waste was arrived at by multiplying the number of rounds times 2.3 tons per round.
** Municipality annual reports

Table 2

Source	Residential Per Capita Per day	Municipal	Cost Per Ton
Savas (a) (1977); U.S.	2.4 lbs	3.36—4.92 lbs	(1971) $32.08 (1977) $37.97
Hines (b); U.S.	5.5 lbs		with litter $88.00 without litter $22.00
Memco/Kuwait(c)	2.64 lbs		$25.2
Kuwait Municipality	3.3 lbs		$36.00

(a) —E.S. Savas, "Solid Waste Collection in Metropolitan Areas" in Elinor, Ostiom, Editor, **The Delivery of Urban Services,** Vol. 10, **Urban Affairs Annual Reviews,** (Bev. Hills: Sage Publications, 1967), pp. 201 — 229.

(b) —Lawrence G. Hines, **Evironmental Issues** (N(New York: W.W. Norton & Co., 1973) p.290 and p.295

(c) —Middle East Management Consultants Office, "National Cleaning Company — A report on Waste Disposal", Dec. 24, 1977, Kuwait, (Memiograph).

(d) —Kuwait Municipality, Statistical Study, 1978.

Table 3

Numbers of labourers, vehicles and trip loads in 1977, Average daily figures from the cleaning department

Cleaning Centers No. Name	Population 1975 P	Skilled labourers P	Unskilled labourers P	Vehicles per day * Nos.	Trip loads/ day Nos.	Population/ labour ratio
1 North Hawalli	130,565	22	144	12	35	526
2 South Hawalli		22	156	13	39	
3 Farwaniyah	74,037	40	256	7	35	350
4 Kheitan & Airport	63,185	27	223	12	31	320
5 Qeblah & Salhiya	14,643	13	118	5	15	150
6 Sharq	45,561	14	184	8	19	299
7 Um Sedda	17,912	15	132	8	20	164
8 Sulaibikath	41,201	13	135	4	15	369
9 Eastern Salmiya	113,943	20	185	15	36	530
10 Western Salmiya		10	75	13	22	
11 Maiden Hawalli	22,414	9	126	13	26	215
12 Rumaithiya & Salwa	30,273	25	195	5	21	188
13 Surrah	7,885	10	59	4	7	162
14 Jahra & Satellites	37,091	15	193	12	12	232
15 Sayhad Al Awazem & Shadadiyah	40,616	17	84	5	117	585
16 Faheel & Satellites, Fintas & Reqah	141,256	92	698	42	109	248
17 Shuwaikh 'B'	3,116	11	104	6	20	36
18 Shamiyah	7,359	11	59	3	9	151
19 Nuzha & Abdullah-Al Salem	11,191	9	108	2	11	125
20 Faiha	10,381	13	49	3	11	256
21 Deihay & Dasmah &-Beidlqar	26,260	15	130	2	19	244
22 Kifan	13,575	9	58	4	12	283
23 Khaldiyah & Yarmouk	9,522	12	85	5	11	135
24 Cortoba & Adailiyah	8,997	10	48	4	11	227
25 Rawda	12,330	10	56	3	9	266
26 Kadisiyah &-Mansouriyah	15,550	14	93	5	15	203
27 Shaab	7,114	7	37	4	15	232
28 Omariya	10,642	11	56	3	20	230
29 Rabiya	8,564	10	43	4	8	241
30 Failaka	3,967	6	49	3	9	98
31 Industrial Shuwaikh	4,905	18	120	7	21	
32 Soukh in the city	—	29	225	4	30	—
33 Sheep Market	—	29	225	4	30	
33 Sheep Market	3,453	13	37	2	9	—
34 Shuwaikh Vegetable-Market	—	4	127	—	7	—

Source: Municipal Records compiled by a Swedish Coonsulting Firm, 1979.
* Vehicles were used as proxy for K on the assumption that other types of Capital Stock, e.g buildings are uniform across centers and make up only small proportion of the total stock of capital.

Table 4

Estimated Coefficients of the Refuse Collection Production Function, Kuwait 1977

	A	α	B	R^2
Coefficient	.096	0.46	0.33	
t-Value		5.2	3.96	.67
Sample Size	34 observations			

With 31 degrees of freedom, these estimates are statistically significant at 5% level of significance. Estimated coefficients indicate that while output is elastic with respect to both inputs, it is more so with respect to capital. This suggests that a10 percent increase in labor would produce a 4.6 percent increase in output and a 10 percent increase in capital would produce a 3.3 percent increase in output. The above results, however, must be regarded with caution, because of data deficiencies.

The important question that we need to address ourselves to is whether refuse collection is better carried out on a decentralized or centralized basis. For policy making this is equivalent to asking whether each cluster of housing and economic activities ought to provide its own refuse collection service or not. Statistically, this question is equivalent to the following tests:

$$\text{Ho} = (\alpha + B) \geqslant 1$$
$$\text{Ha} = (\alpha + B) < 1$$
$$t = \frac{(\alpha + B) - 1}{\text{Var } \alpha + \text{Var } B + 2 \text{ Cov } (\alpha + B)} = -2.0 >$$

$>$ t 5% With (31 degrees of freedom) which lead us to reject the null hypothesis in favour of the alternative hypothesis.
This indicates the existence of diseconomies of scale in refuse collection activity in Kuwait.

It might be interesting to note that, on the whole, horizontally integrated urban public services, in the U.S., such as police, primary and secondary education, refuse collection, high school education, hospitals and fire revealed either the absence of economies of scale or uncertainty of their presence.(13)

In summary, the empirical tests in this paper showed that the sum of the coefficients $\alpha + B$ i.e., 0.46 + 0.33 is less than one, an indication of decreasing returns to scale. This implies that it is better to carry out this service by smaller units and that more competition can be created if private firms were allowed to participate in this activity. In other words decentralized services are justified.

FOOTNOTES

(1) —This estimate is obtained from a preliminary report by a foreign consulting firm for the municipality, 1977.
(2) —" A Statistical Study of Annual Costs of Collection and Disposal of Solid Waste." Prepared by the office of the Director of the Municipality, November 1978 (Arabic).
(3) —This figure was arrived at by multiplying the average load of each type of truck used on October 16, 1978 by the number of rounds each truck completed that day and again multiplied by 365 days.
(4) —R.F. Mallard, Preliminary Report Concerning Refuse Collection and Disposal Submitted to the Kuwait Municipality on December 1977 p.2 (Arabic).
(5) —Werner Z. Hisch, "The Supply of Urban Public Services," in **Issues in Urban Economics,** Harvy S. Perloff and Lowdon Wingo, Jr., eds. (Washington, D.C.: Resources For The Future, 1968). p. 485.
(6) —Hirsch, Ibid., p.486
(7) —Hirsch, Ibid., p.486
(8) —Hirsch, Ibid., p.490
(9) —Hirsch, Ibid., p. 487
(10) —A. A. Walters, **An Introduction to Econometrics,** second edition, (London: MacMillan and C0., Ltd., 1970). p. 275.
(11) —Walters, Ibid., p. 276
(12) —Walters, Ibid., p. 277
(13) —Werner Z. Hirsch, **Urban Economic Analysis,** (New York: McGraw-Hill Co., 1973) pp. 331-332

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(1) —E.S. Savas. "Solid Waste Collection in Metropolitan Areas" in Elinor Ostrom, Editor, **The Delivery of Urban Services,** Vol. 10, Urban Affairs Annual Reviews, (Bev. Hills:Sage Pyblications, 1976), pp. 201-229.
(2) —Lawrence G. Hines, **Environmental Issues,** (New York:W.W. Norton & Co., 1973) pp. 290-295
(3) —Werner Z. Hirsch, "Cost Functions of an Urban Government Service: Refuse Collection," **Review of Economics and Statistics, V** Vol. 47, February 1965, pp. 87-92.
(4) —A. A. Walters, "Production and Cost Functions: An Econometric Survey," **Econometrica,** Vol. 31 (January-April 1963) pp. 17-19.

اقتصاديات تجميع القمامة في الكويت

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تحظى مشكلة النظافة في دولة الكويت باهتمام متزايد من قبل المسؤولين فيها على مختلف المستويات ، ومبعث هذا الاهتمام يعود في الغالب ، الى ما لهذه المشكلة من ابعاد صحية وبيئية ذات تأثير مباشر وملموس على صحة المواطنين ونظافة البيئة التي يعيشون فيها ، خاصة مع الزيادات المضطردة في عدد السكان والتوسع العمراني ـ افقيا وعموديا ـ وانتشار ظاهرة التمدين بمعدلات عالية . فبعد سنوات ما بعد اكتشاف وتصدير النفط ، شهدت الكويت تطورات هائلة في مختلف المجالات كان من نتائجها أن زاد الطلب كثيرا على الخدمات العامة خاصة فيما يتعلق باعمال النظافة وجمع القمامة والتخلص منها ، مما استدعى اهتمام الدولة وحرصها على تقديم هذه الخدمة العامة بصورة مناسبة .

اما الجوانب الاقتصادية لمشكلة النظافة العامة في الكويت ، وخاصة ما يتعلق منها بكفاءة الاداء وانتاجية العاملين فيها وتكاليف القيام بهذه الخدمة العامة ، فلم تحظ بنفس الدرجة من الاهتمام الامر الذي يدعو الى القيام بدراسات علمية في هذا المجال . ولذلك فان الهدف الرئيسي من هذه الدراسة هو التعرف على مختلف الجوانب الاقتصادية لاعمال النظافة العامة في الكويت مع التركيز على قياس حجم هذا النشاط وابراز العوامل المؤثرة فيه . في هذه الدراسة ، ينظر الى اعمال النظافة العامة على انها خدمة يجري انتاجها من قبل البلدية عن طريق استخدام كميات محددة من مختلف عوامل الانتاج من عمل ورأس مال في عملية انتاجية منظمة تتحمل بموجبها البلدية كامل تكاليف الانتاج .

وينطوي هذا البحث على دراسة ميدانية للتركيب الاقتصادي لاعمال النظافة حيث تستخدم دالة الانتاج من نوع كوب ـ دوغلاس وتطبيقها على احصاءات مقطع عرضي لسنة ١٩٧٧ . وخلصت نتيجة هذه الدراسة الى أن نشاط اعمال النظافة يعاني من تناقص عائد الحجم ويعني هذا انه من الافضل ان تقوم بهذا النشاط وحدات انتاجية اصغر حجما خصوصا عن طريق مؤسسات خاصة ليتاح لها المنافسة بين بعضها البعض ولكي تقوم بأداء هذه الخدمة على وجه أفضل من الكفاءة .