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Public Versus Private Production Efficiency in Switzerland: A Theoretical and Empirical Comparison

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□ IN THIS ESSAY *public* (municipal) production of an urban service is compared to production of the same service by *private firms.* Such a comparison must be based upon a theoretical analysis in order to derive meaningful conclusions from empirical evidence.

The purpose of this essay is to:

- make a contribution to a research area in which economics and public policy analysis have had *little application.*[1]
- test propositions about the *relative efficiency* of governmental versus private production, thus stressing the comparative analysis of institutions.
- make some suggestions about *desirable organizational arrangements* for a specific municipal service—namely, residential refuse collection.

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The emphasis lies in a comparative approach to both theoretical analysis and empirical research; no institutional arrangement is perfect in the sense of achieving completely efficient (cost-minimizing) production. If this basic view is accepted, it follows that it will be necessary to analyze and contrast institutions which are *imperfect*. "Market failure" and "governmental failure" coexist.

In this paper, we first consider the arguments for and against private and public production. There are valid theoretical arguments for and against each kind of production arrangement. Empirical evidence is necessary to test the relative efficiency of the two arrangements. In the second part, a model of refuse collection for Swiss cities is developed and empirically tested.

On the basis of this analysis, it is concluded that, in the cities studied, private is more efficient than governmental production. On the other hand, as argued in the final part of this paper, the governmental task does not end if the service is privately produced. Governmental activity instead takes a new form: that is to develop safeguards to assure that private production will be more efficient. In particular, it needs to find ways to maintain competitive pressures. This involves problems of information, uncertainty, and control.

THE RELATIVE EFFICIENCY OF PUBLIC AND PRIVATE REFUSE COLLECTION: THEORETICAL CONSIDERATIONS

THE NATURE OF REFUSE COLLECTION

Refuse collection has (practically) no properties of a collective good, compared to, for example, public transport or schools. There are, however, negative externalities connected with *consumption*, namely the bad smell and public health hazards resulting from untreated wastes (Gueron, 1972). There has, therefore, been public intervention in the production of this service for a very long time, It is *collectively* decided that wastes must be disposed of in regular sequence and treated at specified locations.

There are few significant externalities associated with the *production* of refuse collection (if the noise involved in picking up garbage is disregarded). Although final disposal of wastes may be subject to strong negative external effects, this paper is concerned only with refuse *collection*. It is sufficient to indicate that final waste treatment in Switzerland usually rests in the hands of the cantons

(states) or the central government. The lack of significant *externalities of production* connected with refuse collection means that a central reason for governmental production does not apply. There is no theoretical reason why there should not be private production under competitive conditions.[2]

PITFALLS IN PUBLIC PRODUCTION

There are two main arguments against public production:

(a) The fact that there are public property rights in the production unit means that there is more discretion by the managers, enabling them to run the firm less efficiently.

(b) A publicly run production unit is subject to more restrictions than a private firm because it is part of a general system of public administration. These additional restrictions are very likely to impair production efficiency.

These two arguments are discussed in more detail below: the first section relates to the property rights aspect (see, e.g., Alchian, 1967, and Furubotn and Pejovich, 1972) and the second to bureaucratic organization.

Inefficiency Due to Public Ownership

Managers of a *private* enterprise are, under perfectly competitive conditions, forced to follow the interests of the shareholders, i.e., to maximize profits and the value of the firm in terms of share prices. If an inefficient policy is undertaken, the present owners will interfere, or the resulting reduction in the value of shares will enable outsiders to gain the majority. In both cases, the inefficient management will in theory be dismissed. Therefore it is in the managers' own interest to choose an optimal output (i.e., to take into account consumers' preferences) and to produce services at the lowest cost possible. Under conditions of perfect competition, the quality and price of the product are continually controlled by the market.

Control of managerial behavior is much weaker in *public* enterprises. The taxpayer, as the "owner" of the firm, and the consumer, as the user of the product, have little incentive to exert effective control. To evaluate how efficiently a public "firm" is run, individuals must be willing to bear the costs associated with

obtaining information about the output and costs of that firm. The costs of obtaining this information may be very high—particularly where the goods themselves are not amenable to measurement and evaluation. Given the uncertainty of achieving increased efficiency, and the small benefit likely to accrue to an individual as a result of such improvements, most individuals would find it irrational to devote much time and/or effort to such activity.

With public production, the consumer rarely has the choice to react as he might in the market, namely to "exit" (see Hirschman, 1970:21 ff.), i.e., to switch to a competitive supplier if the product is unsatisfactory. Often, the only possibilities may be to boycott the service altogether or to move to another community. Both of these alternatives may involve sizable costs.

"Voice" or protest is another means of influencing the quality and efficiency of public service delivery. It is, however, likely to be effective discontinuously, only. Furthermore, in the special case of refuse collection, it is unlikely to be a focal point around which professional voice-makers (the opposition party) can organize a successful election campaign. This may happen only if obvious and large mistakes are being made. In theory, management will avoid undertaking actions which might lead to such mistakes. However, there is still much room for production inefficiencies.

Inefficiency Due to Bureaucratic Organization

Inefficiencies in municipal production of public services may also result from the manner in which the public bureaucracy is organized. Bureaucratic inefficiencies result from a variety of factors.

Often the goods and services offered by a public firm are financed through the general budget or by various kinds of taxes not directly related to the quantity consumed. This arrangement may provide a *positive* incentive to managerial inefficiency, particularly if salary and prestige are linked to budget size, i.e., to the costs of operation. Bureaucratic *rules* and *regulations* may have an even stronger impact—affecting both the input and output side of a public enterprise. With respect to *inputs*, it is reasonable to assume that trade union influence is stronger and likely to affect productivity more negatively in public than in private enterprises. Politicians often depend on the trade union vote for survival and may be inclined to grant wage demands and other favors, because the costs of such actions are distributed broadly over a large section of the population.

Another reason why politicians may be reluctant to oppose trade union demands is that strikes may strongly reduce their reelection chances.

Public managers usually have little say in their sector's wage determination. They may not be able to adjust relative wages to reflect the marginal productivity of various occupations and workers. They have little opportunity to set wages to give positive incentives for better work. Generally there are rigid constraints on wage differentiation. Wage increases must be set following bureaucratic rules—in particular, regarding age and seniority. The restrictions imposed with respect to wages are marked in the case of refuse collection where 60% to 80% of costs consist of wages.[3] Managers of municipal enterprises are also subject to strong restrictions with respect to hiring and firing. Often workers must be kept on the payroll who, in the private sector, would have been dismissed.

Input restrictions of the kind mentioned are not absent in private firms, especially in large enterprises. However, what matters is that such constraints are much *greater* in the public sector and that managers of private firms have more scope for differentiation and discrimination (see Becker, 1971:31 ff.; Arrow, 1973:10).

There are also bureaucratic restrictions on the *output* side. The production level and—more important from the point of view of costs—the distribution among the various kinds of output are often governed by rules and regulations. The management has few opportunities to vary the composition of supply in response to changes in costs and (perceived) demand conditions.

There are thus a number of a priori theoretical reasons why public production may be "inefficient." It may appear to be advisable to switch from public to private production. This conclusion is, however, warranted only if private production is organized so as to guarantee the efficiency properties pertaining to the model of competitive supply. The point of reference must be the functioning of an institution in the real world, and not a model in which "perfect efficiency" is guaranteed by the appropriate choice of *assumptions.*[4] The following section is concerned with the possible inefficiencies of private production.

INEFFICIENCY IN THE PRIVATE SECTOR

In the private market economy, inefficiencies may arise from several kinds of *lack of competition.*

In the case of residential refuse collection, competition does not occur among a large number of firms.[5] Private collectors receive a license allowing them to operate in the market, usually under a contract for a fixed period of time. Even if there are several firms in the market, there are certainly not the large number of price takers required to meet the assumptions of the model of perfect competition. Competition is, at best, oligopolistic, making possible a wide variety of results with respect to efficiency.

Market entrance is not free. Although start up costs in residential refuse collection are not high, a production license must be obtained and there are many rules and regulations which must be observed.[6] Licenses may be acquired by buying out an existing firm (an option which rarely occurs) or as a result of a decision by authorities that additional suppliers are needed to increase the level and/or quality of performance.

Firms already in the market may, however, oppose such an extension. It may be worthwhile for them to form an *interest group* which seeks to restrict entry, to divide the collection area among existing firms, and to set the rates to be requested from the various local authorities. These prices may be set at a level where the most inefficient firms can survive, providing all other firms with a *differential rent.*

These rates often have the character of a cost-plus arrangement. Such cost-plus arrangements may encourage firms to tolerate cost increases because they will be compensated anyway. Under these circumstances—as in the public sector—private firms cannot be expected to resist excessive wage demands.

Such regional monopolies or oligopolies are likely to develop as a result of the structure of incentives facing firms already in the field. The problem cannot be solved merely by suggesting that such a development "should not be allowed to happen." The formation of imperfect markets is the result of a socio-political process within which there are actors operating in their own self-interest. This process cannot be changed simply by invoking the overall superiority of perfect competition. It may well be that those involved in refuse collection, including both private firms and public bureaucracies, find such solutions more advantageous than increased competition. Private contractors and the public bureaus which are supposed to fix the licenses and contracts so as to achieve maximum efficiency often form a tacit coalition based on their mutual dependence and long acquaintance (Stigler, 1971).

INTERIM CONCLUSIONS

The case for the superior efficiency of private production is no longer so obvious as when public sector inefficiencies are discussed in isolation. There are certainly many convincing reasons why public production is likely to be inefficient. It has, however, been shown that when the assumption of perfect competition is abandoned, inefficiencies must also be expected in the private sector.

Theoretical reasoning alone cannot settle the dispute of whether private or public production is *more efficient.* It is necessary to resort to *empirical tests.*

THE RELATIVE EFFICIENCY OF PUBLIC AND PRIVATE REFUSE COLLECTION: EMPIRICAL ANALYSIS

PREVIOUS STUDIES

The simplest method of determining efficiency differences between private and public production is to calculate the *per-unit* costs of refuse collection, the unit being the household, or the quantity or weight of waste. A comparison using this measure alone is, however, most unsatisfactory because differences in the *quality* of service (e.g., where the waste is picked up) and in *technical conditions of production* (e.g., whether the topography is hilly) are not allowed for.

A model which takes these differences into account has been devised (Hirsch, 1965). It is assumed that the cost of refuse collection depends on the amount of service (U), the quality of service (Q), the technical conditions of production (T), the factor prices (FP), and the level of technological knowledge (TK). The average unit cost per ton (AC) thus is:

$$AC = f(U, Q, T, FP, TK, D_1, D_2). \qquad (1)$$

The function also includes two dummy variables (D_1 and D_2) which represent the institutional condition of production (private versus public) and the type of financing (charges to private households versus financing through the general budget).

In the estimation equation of household refuse collection in 24 suburbs of the St. Louis City-County area the following specific variables were included (Hirsch, 1965:90 ff.):

X_1 = 1960 average annual residential refuse collection and disposal cost per pickup in dollars.

X_2 = number of pickup units.

X_3 = weekly collection frequency.

X_4 = pickup location, where curb pickup is 0 and rear of house pickup is 1.

X_5 = pickup density, i.e., number of residential pickups per square mile.

D_1 = nature of contractual arrangements, where municipal collection is 0 and private collection is 1.

D_2 = type of financing, where general revenue financing is 0 and user charge financing is 1.

The estimation yields:

$$X_1 = 6.16 + \underset{(0.000\,195)}{0.000\,089\,X_2} - \underset{(0.000\,000\,000\,832)}{0.000\,000\,000\,436\,X_2^2} + \underset{(1.14)}{3.61^*\,X_3} + \underset{(1.50)}{3.97^*\,X_4}$$

$$- \underset{(0.000\,442)}{0.000\,611\,X_5} \underset{(2.40)}{-1.87\,D_1} + \underset{(1.10)}{3.43^*\,D_2} \qquad (2)$$

$\bar{R}^2 = 0.76$; N = 24.

The standard deviations are given in parentheses below the respective parameter estimates, which have an asterisk if they are statistically significant at the 95% confidence level.

It should be noted that the model tests the costs of waste collection *and* disposal and that the costs refer to the *costs per pickup* (and not per household or per ton). The dummy variable D_1 for the type of production institution had no statistically significant influence upon costs; it seems that there is no clear difference of efficiency between private and public production. The type of financing exerts a significant influence on costs. It is, however, rather surprising that the coefficient is positive. It would be expected a priori that charges (which are assumed to be similar to prices) would lead to a higher cost-consciousness on the part of consumers and producers, leading to a pressure to hold costs down.

The relative efficiency of different institutional forms of production of refuse collection was also tested recently for 27 public and private enterprises in Montana (Pier, Vernon, and Wicks, 1974). A production function with fixed proportions was found to fit the data best. The cost functions derived led to the conclusion that

public production was less efficient than private production at a low output level and more efficient at a high output level when *capital costs* are considered. With respect to *labor costs* public production was found to be more efficient than private across all size ranges. For localities larger than about 1,750 inhabitants, average costs for municipal refuse collection were lower than for private firms.

The Montana study is interesting, particularly because it attempts to estimate a production function. It must, however, be criticized on various grounds.[7] Output is not measured by quantities or the number of households served, but rather by pickup places. Differences in the quality and technical conditions of refuse collection are not sufficiently allowed for. Moreover, the methodological approach used is inappropriate for examining the relative efficiency of institutions. *Separate* production and cost functions were estimated for private and public production. A comparison of the result with respect to efficiency is admissible only if the two sectors produce under the same general conditions. In general this cannot be expected. To test the relative efficiency of the two institutional arrangements *one single* estimation equation is required for private and public production. The relative effect on average costs then can be isolated by introducing dummy variables for the two types of service institutions.

A MODEL OF REFUSE COLLECTION FOR SWISS CITIES

A cost function of residential refuse collection in 103 Swiss cities was estimated with the intention of avoiding the shortcomings of the previous studies. About half of these cities are served by private collectors (mostly on a contract basis), and the other half by public enterprises.

Average costs of refuse collection per residential household (AC) are assumed to be influenced by quantitative and qualitative factors, by the technical conditions of production, by factor prices and the state of technology. The *quantity* of refuse collected is measured by the average annual number of tons of refuse carried away from each household (U_1). In Switzerland it is also important to consider the additional refuse created by the inflow of foreign workers in the summer and/or winter (U_2) and, in a smaller degree, the number of tourists lodging in private apartments and homes (U_3). Another important factor is the refuse that may be generated by individuals commuting between place of residence and place of work. Thus U_1 is

amended by three additional variables: U_2 is the annual average number of foreign workers, relative to the residential population; U_3 is approximated by the average annual number of lodgings for night, relative to the residential population; and U_4 measures the decrease in household refuse collection demand due to outgoing commuters, relative to the residential population.[8] It is expected a priori that U_1 to U_3 (U_4) tend to increase (decrease) average cost.

The *quality* indicators consist of pickup location (Q_1), number of collections per week (Q_2), and the distinction between joint ($Q_3 = 1$) or separated ($Q_3 = 0$) collection of ordinary household garbage and bulky wastes (Q_3). Average costs are expected to rise the farther from the street the refuse is picked-up and the more often it is collected (because the quantity per collection is reduced). The effects of collecting bulky wastes along with other household refuse cannot be determined a priori. Although the collectors are already at the pickup point, the handling is more difficult and there is less possibility for automation. Other factors affecting quality are the noise produced (Q_4) and the mess left on the street (Q_5), which are, however, difficult to determine empirically.[9]

Among the *technical conditions* of refuse collection are the economies connected with increasing density of collection area, which is split up into the number of pickup points per kilometer of city streets (T_1) and the number of households per pickup point (T_2). Another important feature in Switzerland is the topography, measured by the differences in height within a city (T_3) and the intensity of snowfall, approximated by the number of days with snowfall (T_4). The larger these differences and the more intensive the snowfall, the higher are time and fuel costs. Finally, the distance to the waste deposit site (T_5) may be expected to positively affect average costs.

The *factor prices* (FP) have an influence on the input mix; the higher the relative cost of labor, the more capital will be substituted for labor.

The *state of technological knowledge* and its precise influence on average costs is difficult to evaluate independent of factor prices. It may well be that the crew size (TK_1) and type of equipment (TK_2) are determined by relative factor prices and do not have a direct influence on average costs. If, however, there are institutional constraints making it impossible for a refuse collection firm to take advantage of new technology, costs may be directly affected (see Downing, 1975:9 ff.). The same argument applies, of course, to the firm's capacity to adapt to changes in relative factor prices.

Inclusion of these variables allows one to control all relevant factors and thus to compare average costs for *public* ($D_1 = 0$) and *private* ($D_1 = 1$) production. The *type of financing* is controlled through another dummy variable D_2 ($D_2 = 0$ if general budget financing, $D_2 = 1$ if the households are charged).

The estimation equation thus is:

$$\underbrace{AC = h\,(U_1, U_2, U_3, U_4;}_{\text{quantity}}\ \underbrace{Q_1, Q_2, Q_3, Q_4, Q_5;}_{\text{quality}}\ \underbrace{T_1, T_2, T_3, T_4, T_5;}_{\text{technical conditions}}$$

$$\underbrace{FP;}_{\substack{\text{factor}\\ \text{prices}}}\ \underbrace{TK_1, TK_2;}_{\substack{\text{technological}\\ \text{knowledge}}}\ \underbrace{D_1, D_2).}_{\substack{\text{institutional arrangement}\\ \text{and type of financing}}} \qquad (3)$$

The theoretically expected signs of the partial derivatives are:

$$\frac{\partial h}{\partial U_1}, \frac{\partial h}{\partial U_2}, \frac{\partial h}{\partial U_3}, \quad \text{all} > 0;$$

$$\frac{\partial h}{\partial U_4}, \quad < 0;$$

$$\frac{\partial h}{\partial Q_1}, \frac{\partial h}{\partial Q_2}, \quad \text{both} > 0;$$

$$\frac{\partial h}{\partial Q_4}, \frac{\partial h}{\partial Q_5}, \quad \text{both} < 0;$$

$$\frac{\partial h}{\partial T_1}, \frac{\partial h}{\partial T_2}, \quad \text{both} < 0;$$

$$\frac{\partial h}{\partial T_3}, \frac{\partial h}{\partial T_4}, \frac{\partial h}{\partial T_5}, \quad \text{all} > 0;$$

$$\frac{\partial h}{\partial D_2} < 0;$$

The other signs cannot be determined through a priori reasoning.

APPLICATION OF THE MODEL

An empirical application of this model was undertaken using data collected by the authors on refuse collection in the 112 largest Swiss cities. The smallest city included in the survey was Stans, with 5,100 inhabitants, and the largest was Zürich, with 422,600 inhabitants. More than half of the Swiss population lives in these 112 cities.

The data on costs, which include operation costs, depreciation and interest on the capital invested, and other data relevant to equation (3), were collected by questionnaire. Additional data were taken from the Statistics of Swiss Cities and from the results of the population census of 1970.[10] All the data refer to 1970.

Cities in which industrial and household refuse are collected jointly were excluded. Not all of the necessary data were available for a number of other cities. For the estimation of the average cost curve, there remained 103 cities, of which 55 have a municipal and 48 a private refuse collection service. For some of the variables no satisfactory data could be obtained, in particular for factor prices (FP) and for the state of technological knowledge (TK_2).

The estimation results using the remaining variables are given in Table 1. Standard step-wise least squares multiple regression was used, leaving only those variables in the equation which were statistically significant at the 95% confidence level, or nearly so. A look at the correlation matrix indicates that there are no serious problems of multicolinearity.[11] The variables for outgoing commuters (U_4) and pickup location (Q_1) and for the joint or separate collection of household garbage and bulky wastes (Q_3) have been excluded due to their insignificant effect on average costs. This result is quite plausible: in Switzerland, refuse is almost always placed near the street so that there are too few observations for the alternative case. The opposing effects on average costs connected with Q_3 just seem to balance.

Equations (4) and (5) in Table 1 differ in that they are designed to answer different questions. In equation (4) the problem of the *budgetary implications* for the households and taxpayers is studied. Accordingly, a ceteris paribus comparison between average *costs* of municipal production (assuming near-zero profits) and *prices* of private suppliers is undertaken.[12] This does not constitute a comparison of production efficiency.[13]

In equation (5) the question of *relative production* efficiency is studied. A comparison is made between average real production costs

of public and private enterprises. Thus, in the case of private firms, the average gross profits before tax are deducted. It is assumed that the average gross profit rate of private suppliers amounts to a markup of 7% upon production costs.[14]

All variables (with the exception of D_2) have the theoretically expected sign. The most important result is that the statistically significant dummy variable D_1, indicating the institutional form of production, has a negative sign: *public production* of refuse collection seems to be subject to *higher average costs* than private production.[15] This result does not change when the five largest Swiss cities (Zürich, Basle, Geneva, Berne, and Lausanne), which all have a municipal refuse collection, are excluded.

The sign of the dummy variable standing for the type of financing, D_2, is positive (although at a somewhat lower degree of significance), which is contrary to a priori theoretical expectations, but it corresponds to Hirsch's and Kitchen's estimates. This sign is plausible if household user charges are in no direct relation to production costs and to the extent of use by each household and/or if the additional costs due to fixing and implementing of the charges are large.

In order to test whether there are economies of scale in production, the *cost per ton of refuse collected* (instead of per household of the residential population as in Table 1) is taken as the dependent variable. Estimates with a log-linear specification proved superior, and they are presented in Table 2. Equation (6) gives the result when costs are compared to prices; equation (7) when real costs are considered only.

With the exception of U_2 and Q_2, all coefficients are statistically significant, and all—with the exception of U_1—have the same sign as in Table 1. The negative sign and the size of the coefficient of U_1 indicate that there are substantial *economies of scale in production:* average costs per ton of refuse collected decrease the more refuse that is collected.

This result contradicts those results reached in comparable studies for some districts in the United States.[16] It is, however, compatible with the results of the more comprehensive study by Savas (1976) covering the whole United States. He concludes that with increasing size of the American cities there are significant economies of scale in production, that the economies are strongly decreasing with an approximate city size of 30,000 inhabitants, and that from 50,000 inhabitants on there are neither positive nor negative economies of scale. This seems to be similar for Switzerland: if cities over 100,000

TABLE 1

ESTIMATES FOR REFUSE COLLECTION COSTS PER HOUSEHOLD (in sFr), 103 SWISS CITIES, 1970 (Linear Specification)

Eq.	Constant	Quantity			Quality	Technical Conditions					Insti-tution	Financing	Test Statistics	
		U_1	U_2	U_3	Q_2	T_1	T_2	T_3	T_4	T_5	D_1	D_2	$\bar{R}^2$	F
(4)	21.19 (1.92)	7.47** (2.50)	4.73* (1.73)	2.30** (6.61)	9.34* (2.01)	-0.34* (-2.15)	-5.04* (-1.97)	0.17* (2.31)	0.23* (2.25)	1.23** (3.12)	-6.57* (-1.92)	5.96 (1.60)	0.65	18.25
(5)	19.06 (1.79)	7.16** (2.49)	4.67* (1.78)	2.20** (6.55)	9.11* (2.03)	-0.32* (-2.09)	-4.82* (-1.95)	0.17* (2.29)	0.21* (2.17)	1.16** (3.07)	-9.03** (-2.75)	5.57 (1.53)	0.65	18.16

U_1 = household refuse (including bulky wastes) per residential household (in tons)
U_2 = inflow of seasonal workers (in percent of residential population)
U_3 = inflow of privately lodged tourists (average daily number of lodgings for the night in relation to the residential population)
Q_2 = frequency of refuse collection per week: twice $Q_2 = 0$, more than twice $Q_2 = 1$
T_1 = number of pickup points per kilometer city street
T_2 = number of households per pickup point
T_3 = differences of height within the city region (in meters)
T_4 = average number of days with snowfall
T_5 = distance between the center of the locality and final refuse disposal site (in kilometers)
D_1 = institutional production conditions: public production $D_1 = 0$, private production $D_1 = 1$
D_2 = type of financing: if largely financed by the general budget $D_2 = 0$, if largely financed by charges to the households $D_2 = 1$

The figures in parentheses below the parameter estimates indicate the t-values. An asterisk indicates statistical significance at the 95% level, two asterisks at the 99% level of security.

TABLE 2

ESTIMATES FOR REFUSE COLLECTION COSTS PER TON (in sFr), 103 SWISS CITIES, 1970 (Log-linear Specification)

Eq.	Constant	Quantity			Quality	Technical Conditions					Insti-tution	Financing	Test Statistics	
		U_1	U_2	U_3	Q_2	T_1	T_2	T_3	T_4	T_5	D_1	D_2	$\bar{R}^2$	F
(6)	1.17**	-0.75**	0.09	0.10**	0.06	-0.73**	-0.69**	0.79**	0.22**	0.18**	-0.09**	0.08**	0.62	4.82
	(6.60)	(-9.57)	(0.80)	(3.85)	(1.51)	(-3.41)	(-3.08)	(3.77)	(2.87)	(3.80)	(-2.79)	(2.47)		
(7)	1.14**	-0.75**	0.09	0.10**	0.06	-0.74**	-0.70**	0.79**	0.21**	0.18**	-0.13**	0.08**	0.64	5.32
	(6.38)	(-9.47)	(0.83)	(3.76)	(1.53)	(-3.43)	(-3.08)	(3.79)	(2.82)	(3.77)	(-4.16)	(2.45)		

For notes see table 1

TABLE 3

ESTIMATES FOR REFUSE COLLECTION COSTS PER TON (in sFr), 103 SWISS CITIES, 1970 (Log-linear Specification)

Eq.	Constant	Quantity				Quality	Technical Conditions					Insti-tution	Finan-cing	Test Statistics	
		U_5	U_5^2	U_2	U_3	Q_2	T_1	T_2	T_3	T_4	T_5	D_1	D_2	$\bar{R}^2$	F
(8)	1.05**	-0.87**	0.33**	-0.09	0.06*	0.10*	-0.45	-0.17	0.62*	0.14	0.30**	-0.14**	0.06	0.43	7.56
	(4.38)	(-4.37)	(3.30)	(-0.60)	(1.82)	(1.72)	(-1.58)	(-0.50)	(2.18)	(1.32)	(4.68)	(-3.22)	(1.23)		
(9)	1.03**	-0.82**	0.31**	-0.07	0.05	0.10*	-0.36	-0.03	0.49*	0.12	0.30**	-0.19**	0.05	0.45	8.05
	(4.42)	(-4.26)	(3.21)	(-0.49)	(1.58)	(1.84)	(-1.29)	(-0.10)	(1.78)	(1.24)	(4.83)	(-4.47)	(1.01)		

U_5 = absolute weight of household refuse (in 1000 tons)

U_5^2 = square of M_5 (in 10^6 tons)

For other notes see table 1

inhabitants are excluded, the coefficient for U_1 is even more highly statistically significant.

It may be argued that inhabitants (Kitchen, 1976; Savas, 1976; Quigley and Kemper, 1976), the number of pickup units (Hirsch, 1965), or the average volume of refuse per household (Downing, 1975; see also our estimates in Table 2) are inadequate measures of output. To study the problem one should use the *absolute* weight or volume of refuse. This is done in Table 3, where the absolute weight of waste for each city (U_5) and its square (U_5^2) are included, the latter in order to take into account possible nonlinear relationships. Equation (8) compares costs and prices, equation (9) only costs.

The highly significant sign for the coefficient of U_5 and the positive sign for U_5^2 indicate that the conclusions so far reached are correct: the increase in total household waste is, over a wide range, accompanied by decreasing average costs which rise only at a very high tonnage. The positive *economies of density* reflected by the negative coefficients of T_1 and T_2 in Tables 1 and 2 are no longer visible in the new estimates.

It should be noted that, in all equations (4) to (9), the dummy variable for institutional arrangement of production is statistically significant and of the same sign.

CONCLUSIONS

From the results of this empirical analysis it appears that private production of refuse collection may be preferable to public production. Separation of demand articulation and production has been suggested as one means of overcoming some of the bureaucratic inefficiencies discussed earlier.[17]

As argued above, however, private production will not necessarily be more efficient than public production if imperfect market conditions exist. Some goods and services are publicly *produced* because of a concern that private firms will form coalitions and will be successful in restricting competition. The existence of sizable economies of scale in production, suggested by the empirical analysis, is another factor encouraging the establishment of monopolistic markets (Bish and Warren, 1972).

The possible existence of economies of density points in the same direction. In an area with low density (as measured by the number of pickup points per kilometer city street and the number of house-

holds per pickup point) there are unfavorable technical conditions for each producer, if several of them are producing. From the point of view of the producer it may be desirable to split the area, so that in each area there is only one supplier. This means, however, that there is no competition—at least for the time period in which a license is granted by the authorities.

Obviously, *the governmental task does not end* if it is decided that refuse collection should be undertaken by private enterprises. On the contrary, it is important that governments set *conditions* which make private producers function efficiently over the long run. They have to find ways and means to issue licenses and contracts stimulating competition and cost reductions. If governments provide the wrong incentives for private firms, nothing is gained by leading production to the "market."

The contracts offered may, for example, take the following form (see also Young, 1974):

(1) They should not cover too long a period (4-6 years) in order to stimulate competition for the production potential.

(2) The beginning and end of contract periods should be different from one city to another in order to give firms continuous possibilities to enter the competition for contracts.

(3) To minimize the risk of bad contracting, "performance bonds" should be required, so that the financing institution is responsible (up to the amount of the bond) for undertaking collection where bonded contractors fail to abide by the terms of the contract.[18]

In *low density areas* it is possible to produce pressure to keep costs down by establishing *competitions for the contracts.* In *high density areas* there is more scope for open competition in overlapping and even in identical markets. One may also think of establishing nonprofit enterprises designed to compete with private suppliers. For the reasons discussed above, one should not expect too much from such an arrangement: it may be that managers of such nonprofit institutions are also inclined to highly value a quiet life and to enter into tacit agreements with private suppliers and government bureaucracy. There is no easy way to guarantee competition in markets in which there are factors making collusion worthwhile.

SUMMARY

The relative efficiency of private versus public production of residential refuse collection is studied using the theory of property rights and the economic theory of bureaucracy. The empirical analysis of refuse collection in 103 Swiss cities suggests that private (contract) production may be more efficient. If refuse collection is turned over to private enterprise on the basis of some such evidence, the governmental task, however, does not end. Rather, its role becomes one of establishing the conditions necessary to ensure that private producers function efficiently in the long run. In particular, government must ensure that competitive pressures persist, if the potential savings from private production are to be realized.

NOTES

1. Exceptions which are concerned with production and cost functions of public services and which take account of the specific problems of output measurement in this connection are, e.g., E. Ostrom (1973) and Emerson (1975) on police, Ahlbrandt (1973) on fire protection, and several studies on schooling, surveyed by Hirsch (1973, chap. 11).

2. If there are (sizable) production externalities the aggregate production possibility set may become nonconvex, with the result that the competitive price system can no longer be trusted to bring about the (Pareto) optimal output level. If, however, the optimal production level is known through some other decision-making mechanism, it may still be advantageous to *set* the relative prices so that competitive firms attain it efficiently. For the whole problem see Baumol and Oates (1975, chap. 8).

3. This figure applies to Switzerland. In the United States and Canada it is of similar magnitude; see U.S. Department of Health, Education and Welfare (1970) and Kitchen (1976).

4. This criticism must be raised against many analyses in the tradition of the theory of property rights where all too often a perfectly functioning competitive private firm is contrasted with the inefficiencies of public organization. The opposite mistake is committed even more often. It is often said that if there is market failure, the government must take over the corresponding activity (but see McKean and Browning, 1975).

5. The following exposition is more general, but also applicable to Switzerland. Here, the main difference from other countries–such as, for example, Germany–lies in the conditions of licensing and contracting. The situation is somewhat different for industrial refuse collection.

6. Especially in Germany, the legislation is so difficult to understand that small firms which cannot afford a lawyer may be unable to enter a market. This tendency has increased since the introduction of environmental legislation.

7. For the general problems connected with estimation of production and cost functions for American cities see Emerson (1975).

8. The refuse created by inflowing commuters is not included because it figures under the heading of industrial waste.

9. A concise study proposing a way to measure noise, esthetics, health, safety, and general public satisfaction connected with waste collection is Blair, Hatry, and Don Vito (1970); an application is given in Blair and Schwartz (1972: chap. 3 especially).

10. See Schweizerischer Staedteverband, *Statistik der Schweizer Staedte* (various years) and Eidgenoessisches Statistisches Amt (1972).

11. *Correlation matrix:*

	U_1	U_2	U_3	Q_2	T_1	T_2	T_3	T_4	T_5	D_1	D_2
U_1	1.00	0.10	0.47	−0.01	−0.14	−0.10	−0.17	0.28	−0.17	0.08	0.10
U_2		1.00	0.29	−0.46	−0.14	0.52	0.37	−0.05	0.17	−0.07	−0.15
U_3			1.00	0.03	−0.02	0.05	−0.05	0.49	0.12	−0.04	0.13
Q_2				1.00	0.20	−0.44	−0.29	0.13	−0.03	0.16	0.32
T_1					1.00	−0.04	0.51	0.05	0.03	0.07	0.25
T_2						1.00	0.46	−0.02	0.06	−0.18	−0.19
T_3							1.00	−0.10	0.08	−0.06	−0.04
T_4								1.00	0.02	−0.05	0.14
T_5									1.00	0.01	−0.10
D_1										1.00	−0.38
D_2											1.00

12. The ceteris paribus condition is particularly important here because private enterprises usually have a positive profit and accordingly pay profit taxes. In the case in which public production seems advantageous to the taxpayers it should be noted that profit tax receipts fall when public production takes place. This may in the extreme lead to the effect that public production is more costly.

13. However, almost all "efficiency" studies exclusively compare costs with prices. As far as we are aware Savas (1976) is the only study differentiating between those two questions and concepts, but the implications are not fully worked out.

14. This markup is only approximate because insufficient information was available to calculate a representative average.

15. Similar results have been reached for American and Canadian cities (see Savas, 1976, and Kitchen, 1976).

16. No positive economies of scale in production could be found for the St. Louis City-County area (Hirsch, 1965:91) or for the localities of the Hartford and New Haven districts (Quigley and Kemper, 1976, chaps. 2 and 3). The only exception is Downing (1975:15), who found positive economies of scale for the 64 collection routes of the city of Riverside.

17. For a long time, economists and political scientists have disregarded the advantages of such a separation; but see V. Ostrom, Tiebout, and Warren (1961) for an exception.

18. As Young (1974:57) stresses: "While the execution of a performance bond (in the event of a contractor problem) can be a cumbersome matter, the bond is a valuable device, since financial institutions will presumably be unwilling to underwrite irresponsible firms."

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