The Effect of Pricing of Local Services on Urban Spatial Structure

POLLY ROBERTS

One hears a lot about how the improper pricing of roads and other utilities subsidizes urban sprawl. However, people who assert this often seem a little vague on just what goes wrong and what can be done about it.

I have constructed a hypothetical model of a water distribution system in order to work out how water should be priced and how incorrect pricing will distort the system. I base the model on one constructed by M.M. Gaffney.[1] I hope that readers will pardon me for inflicting a numerical example on them. I feel that the curves and crisscrosses in which economists indulge sometimes conceal the trees in an abstract forest.

Imagine that I own a row of plots A, B, C, D, E, F, G, H, I, J, and so on, running gently uphill. I have a tenant on each plot. I plan to build a system for distributing water to the plots. How should I price the water, and how far should I extend the pipe so that I maximize the increased rent (my profit) I can collect from my tenants?

This is a straightforward business investment problem. In fact, it omits tricky questions like size and location of plots, size and location of plant, timing, obsolescence, short-run versus long-run costs, and all such questions that usually complicate business decisions. Given adequate information, I can find a unique correct solution. I simply follow the basic rules of business investment: price all variable inputs at marginal cost, and undertake all incremental fixed investments on which the rate of return exceeds the interest rate.

Here is the information:

a. I have a source of water just below plot A. I pay $4 per gallon for the first twenty gallons of water, $8 per gallon for additional water. That means that if I use twenty or fewer gallons, my marginal cost is $4; if I use twenty or more, my marginal cost jumps to $8, though of course the average cost remains below $8.

b. It costs me 50¢ to lift the water past each plot. For example, the marginal cost of a gallon of water delivered to plot C will be $4 or $8 + (3x50¢) = $5.50 or $9.50—depending on whether the marginal cost at the source is $4 or $8.

c. The plots are equally productive (of crops, housing, widgets, or whatever). The marginal product of the first gallon of water is $40; of the second, $30; of the third, $20; and of the fourth, $10. To make this clear, say that, for example, the tenants raise yaks. Their costs, including everything but water, come to $40 per yak. The yaks sell for $50. The first gallon produces pasture for four yaks, yielding 4x ($50 - $40) = $40. The second gallon produces pasture for another three yaks, yielding $30; the third, another two, yielding $20; and the fourth gallon, one more yak, yielding $10. That makes the marginal product $40, $30, $20, $10, a reasonable pattern of diminishing returns.
d. My tenants rationally buy water up to the point that marginal product equals marginal cost. They will not pay more than $10 for the fourth gallon, $20 for the third, $30 for the second, or $40 for the first. For a water price equal to or under $10, they will buy four gallons and produce a surplus of $40 + $30 + $20 + $10 = $100 minus the cost of four gallons. For a price between $10 and $20, they will buy three gallons, for a surplus of $90 minus the cost of three gallons. For a price between $20 and $30, they will buy two gallons, for a surplus of $70 minus the cost of two gallons. For a price between $30 and $40, they will buy one gallon, for a surplus of $40 minus the cost of one gallon.
e. I will collect the surplus from my tenants as rent. For example, if I sell a tenant four gallons at $9 each, he will produce a surplus of $100 - 4x$9 = $64. I can collect a rent of $64 from him.
f. The pipes cost me $200 times the square root of their capacity. Thus a two-unit capacity pipe costs $200 $\sqrt{2}$ = $282.80. There is a valid geometrical reason for this cost pattern: while the circumference of a pipe, and hence the materials in it, increases in proportion to the radius, the volume increases in proportion to the *square* of the radius. In practice, engineers use the rule of thumb that as capacity doubles, costs increase by a 1.6 factor. In other words, costs increase to the 0.68 power of capacity, instead of 0.5 power for square root. But square roots are less bothersome to use than logarithm tables. Using the square root factor, the pipes cost $200, $282.80, $346.40, $400.00, $447.40, $489.60, $529.00, $565.60, $600.00, and so forth.
g. I decide to amortize the system over fifty years at a rate of 9.9 per cent. This rate conveniently gives me a capital recovery factor (CRF), or instalment to amortize one, of 0.10. [$CRF = i(1+i)^n / ((1+i)^n - 1)$).] Thus the annualized cost of the one-unit pipe is $20, of the two-unit pipe, $28.28, of the three-unit pipe, $34.64, and so forth. While 9.9 per cent should equal the current going interest rate, of course, in practice, slightly different interest rates go for different parties and different

circumstances. My choice of 9.9 per cent means I will accept all rates of return on my capital that equal or exceed 9.9 per cent.

This is all I need. I already know what to charge the tenants for water: the marginal cost to me ($4 or $8) plus the lifting cost of 50¢ per plot. I must now figure out how far to extend the pipe. I should extend it just as far as the rent I can collect from the last plot covers the annualized incremental cost of extending the system to that plot—but no further.

First, I calculate the rent I can collect from each tenant, assuming I charge him the marginal cost of delivering water to this plot. The marginal cost jumps from $4 to $8 once I deliver more than twenty gallons of water. That will happen when I get to plot F, assuming I deliver four gallons each to A, B, C, D, E. So the rent depends on how many plots receive water. Table 1 shows the rent for both less than and equal to twenty gallons (column 7) and for greater than twenty gallons (column 8).

To see how far to extend the pipe, I perform the following experiment on paper. I extend the one-unit capacity pipe to plot A. I check to see if the rent I can collect ($82) exceeds the cost of the pipe ($20), which it does. I then extend the pipe to plot B. The incremental cost of extending the pipe to plot B is the cost of adding a two-unit capacity pipe going to plot A ($28.28) and shoving the one-unit pipe up to plot B. I check to see if the rent ($80) exceeds the incremental cost ($28.28), which it does. I then proceed to plot C. I shove the one-unit and two-unit capacity pipes one plot uphill and add a three-unit pipe ($34.64) going to plot A. My incremental cost of serving C is thus $34.64, and my rent is $78. I continue as shown in Table 2, column 5, all the way up to plot G. Note that at plot F the rent drops sharply as I shift to water whose marginal cost to me is $8. For each of plots A to G, the rent exceeds the incremental cost. If I try to go to plot H, however, I find that the incremental cost ($56.56 for an eight-unit capacity pipe) exceeds the $54 I can collect in rent. So I stop at plot G.

That completes the problem. To maximize my profits, I charge the tenants the marginal cost of delivering the water to them, $8 + 50¢ per plot lifting costs. I extend the pipe system to plot G. I collect $66 rent from A; $64 from B; $62 from C; $60 from D; $58.50 from E; $57 from F; and $55.50 from G. I also collect a surplus on my supply system of 20 x ($8-$4) = $80.

What is my return on this investment? My cost is the sum of seven pipe segments of capacity one through seven: $269.52. My return is the sum of the rents, $423 + $80 on the supply, a total of $503. That gives a surplus of $503-$269.52 = $233.48. As a return on the initial capital investment of $2695.20, $503 a year for fifty years gives 18.7 per cent.

But notice that if I did not collect rent from my tenants, I would lose

TABLE 1

COST OF WATER AND RENT FOR EACH PLOT

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	MC H_2O ≤ 20 gal	MC H_2O > 20 gal	Gallons used	Total value added	Total cost $H_2O \leq 20$ (1) x (3)	Total cost $H_2O > 20$ (2) x (3)	Rent ≤ 20 gal (4)–(5)	Rent > 20 gal (4)–(6)
A	$4.50	$ 8.50	4	$100.00	$18.00	$34.00	$82.00	$66.00
B	5.00	9.00	4	100.00	20.00	36.00	80.00	64.00
C	5.50	9.50	4	100.00	22.00	38.00	78.00	62.00
D	6.00	10.00	4	100.00	24.00	40.00	76.00	60.00
E	6.50	10.50	4 or 3	100 or 90	26.00	31.50	74.00	58.50
F		11.00	3	90.00		33.00		57.00
G		11.50	3	90.00		34.50		55.50
H		12.00	3	90.00		36.00		54.00
I		12.50	3	90.00		37.50		52.50
J		13.00	3	90.00		39.00		51.00

The marginal cost of water at the source jumps from $4 for less than or equal to 20 gallons to $8 for more than 20. Hence the delivered cost of water makes the same jump. The rent collected from each plot consequently drops.

TABLE 2

HOW FAR SHOULD PIPE GO AT
9.9 PER CENT (CRF = 0.10), AND 8 PER CENT (CRF = 0.0817)?

	(1) Cost of pipe	(2) At 9.9% for 50 years (x0.10)	(3) At 8% for 50 years (x0.0817)	(4) Rent	(5) Difference at 9.9% (4)–(2)	(6) Difference at 8% (4)–(3)
A	$200.00	$20.00	$16.34	$82.00	$62.00	$65.66
B	282.80	28.28	23.10	80.00	51.72	56.90
C	346.40	34.64	28.30	78.00	43.36	49.70
D	400.00	40.00	32.68	76.00	36.00	43.32
E	447.40	44.74	36.55	74.00	29.26	37.45
F	489.60	48.96	40.00	57.00	8.04	17.00
G	529.00	52.90	43.22	55.50	2.60	12.28
H	565.60	56.56	46.19	54.00	Stop!	7.81
I	600.00	60.00	49.02	52.50		3.48
J	632.40	63.24	51.67	51.00		Stop!

The rent in (4) comes from Table 1, (7) A – E, (8) F – J.
The pipe should be extended only so far as the rent from the furthermost plot exceeds the annualized incremental cost of extending the pipe to that plot. At 9.9 per cent, the last plot is G; at 8 per cent, it is I.

money badly on this venture. I would earn $80 from supplying the water. I would lose the annual cost of the distribution system, $269.52, for a net annual loss of $189.52.

Now that I have figured out how to price the water correctly and how far to extend the pipe, I can find out what will happen if I do things wrong.

First, what if I use the wrong discount rate? Public agencies notoriously use too low discount rates. Say that instead of 9.9 per cent, I use 8 per cent which gives me a CRF of 0.0817. I show the result in Table 2, column 6. At a discount rate of 8 per cent, I will extend the system to plot I, two plots beyond the correct limit at plot G. If I use a rate of 5 per cent, giving a CRF of .0548, I will go all the way to plot O, eight plots beyond the correct limit.

Next, suppose that I am a municipal water company. I virtuously amortize my capital at the proper rate of 9.9 per cent. But I do not collect any rent because the occupants of the plots are not my tenants. I price water uniformly and try to operate on a break-even basis. What will I charge for water, and how far will I extend the system?

The figures indicate I should charge each plot $29.22 a gallon and extend the system all the way up to plot J, the tenth plot. Each plot buys two gallons. I earn a revenue of 10 x 2 x $29.22 = $584.40. My costs come to $80 for twenty gallons at $4 a gallon, plus $55 lifting costs, plus $449.32 for ten pipe segments equals $584.32. Each plot owner retains a surplus of $40 + $30 - 2x $29.22 = $11.65. For ten plots, the total surplus comes to $115.60—quite a bit less than the $233.48 when the system was correctly priced.

Now suppose I am a regulated private utility company supplying water. Regulations limit me to a 9.9 per cent return on my capital and require me to charge all owners of plots the same price for water. What will I do? Exactly the same thing as the municipal water company.

Since I am restricted to 9.9 per cent on my capital, and I consider that an acceptable return (though barely), I will try to get 9.9 per cent on as much capital as possible. I will therefore extend the pipe all the way out to plot J. That gives me 9.9 per cent on ten pipe segments. If I went any further, the system would operate at a loss, lowering the return below 9.9 per cent. This overextension is the familiar "Averch-Johnson effect": if you restrict a company's rate of return on its capital, it will invest too much capital.[2]

As one can easily work out with this example, rate limitations have an interesting effect. If the limit on the rate of return is too high to restrict the obtainable rate, my company acts like a monopolist. It charges $30 a gallon for water. I extend the system only to E, two plots below the correct limit at G. If I go past E to F, my incremental cost, $48.96 for a size six pipe and $14 for two gallons of water, will exceed the $60 I collect. For plots A through E, my average rate of return is 14.6 per cent. If my rate of return is restricted below this, I will extend the pipe to further plots: the higher price the regulators let me charge compensates for the lower return on outlying plots. At 9.9 per cent, I get to plot J. Of course I do not build the system at all if the regulators try to keep me below 9.9 per cent.

Suppose now that instead of uniform rate pricing, I engage in perfect monopolistic discrimination. I charge each plot owner $40 for the first gallon, $30 for the second, $20 for the third, and $10 for the fourth. This way I collect rents indirectly through water prices instead of directly through rents. If my rate of return is not limited, I will correctly go to plot G and no further. If I tried to go beyond G, my rate of return on the incremental investment would drop below 9.9 per cent. Of course, in reality, monopolistic price discrimination might not work so well. My customers may sit on their plots and do nothing; they have nothing to lose by sitting and nothing to gain by knocking themselves out to raise yaks.

This difficulty aside, now suppose I am a discriminating monopolist whose rate of return is limited to 9.9 per cent. How far will I go? Some fairly obvious calculations show I will run the pipes all the way out to plot O. In so doing, I dissipate all the surplus in the system by a vast overextension. By coincidence, as I showed above, an incorrect 5 per cent discount rate will also lead me to plot O. That shows how much waste an overly low discount rate can cause.

All those mistakes I have mentioned—too low a discount rate, uniform rate average cost pricing, uniform rate pricing, and monopolistic price discrimination with a limit on the rate of return—will cause overextension of the system. Uniform rate average cost pricing will also cause waste by discouraging water use. So will monopolistic price discrimination, in practice if not in theory, by allowing plot owners only minimal incentive to use water.

These mistakes have their parallels in real life practices of utilities, public and private. Clearly, they help explain urban sprawl.

In addition, my model omits some other factors that encourage overextension. I assumed all the plots to be equally productive. In practice, centrally located plots will be much more productive than peripheral ones. Hence, there will be more surplus to collect from central plots to subsidize service extension to fringe plots.

I also assumed totally elastic demand for the output. Yet demand for an output like housing is presumably fairly inelastic. To the extent that average cost pricing discourages the proper housing density in the centre, it might make extension in the fringe areas look even more attractive.

Finally, for public utilities, there are the bureaucratic empire builders. Given half a chance, they will divert tax money from other sources into overextending the system. Private utilities overextend for a related reason: to preempt the franchise on serving an area before someone else gets it.

On the other hand, real life utilities, public and private, clearly tap only a fraction of the surplus they create. Witness the leap in land values with the coming of mass services. Utilities may also divert part of what they collect to purposes other than extending the system.

My model also shows something interesting about the nature of the subsidy to fringe plots. Whether I am an average cost pricer or a monopolist, I charge more than the marginal cost of water *at every outlet*. I do not subsidize submarginal plots H, I, J, and so on by selling them water extra cheap, but by building them a water delivery system whose costs outweight the benefits.

It seems logical that for real life utility systems, the price also exceeds marginal cost, except possibly for the most remote outlets. How much would, of course, vary with the outlet; the ratio of fixed to variable costs; and, for public utilities, the amount of money the utility collected from taxes, on the one hand, or added to the rates as a kind of sales tax, on the other.

Hirshleifer, De Haven, and Milliman argue that public water companies charge rates *below* marginal cost.[3] They support this conclusion with the two facts that (a) water companies, notably in southern California, typically operate at a deficit and (b) water is supplied under increasing cost conditions.

In response to the first fact, the deficit or surplus of a utility proves little about the price. Hirshleifer *et al.* abundantly demonstrate that California water agencies are overextended and mismanaged, which helps account for their losses. The Penn Central did not go bankrupt because its rates were too low. In many cases, the ICC set them too high to prevent railroads from undercutting trucking.

As for the second fact, water is indeed supplied under increasing cost conditions, for the obvious reason that as a water supply expands, one must go to increasingly distant and costly sources. But that does not mean that the marginal cost of the distributed water exceeds the average cost.

In my model, I pay $4 a gallon for the first twenty gallons, and $8 thereafter. I collect a surplus of 20x($8-$4) = $80 on my supply. If I distribute water at marginal cost ($8 + 50¢ a plot), and collect no rents from my tenants, I will run an annual deficit on the distribution system of the entire fixed cost: $269.52. I will run a deficit on the combined supply and distribution of $189.52. If I mistakenly practise uniform rate average cost pricing, my price *must* exceed marginal cost.

When would uniform rate average cost pricing result in water priced below marginal cost? Obviously, only where the surplus on the supply equals or exceeds the annualized fixed costs of distribution.

How likely is that? In a utility, where fixed costs greatly exceed variable costs, not very. Typical horribly-overextended distribution systems further reduce the likelihood of prices below marginal cost. Utilities can approach marginal cost pricing only by making up the deficit from other sources, preferably a tax on the surplus that accrues to their customers.

Individual Assessment of Outlets

Some of the confusion over the relationship of marginal cost, average cost, and price possibly arises from a failure to distinguish each outlet of the distribution system. Each outlet should count as a separate market, with its own supply cost and demand schedule. That means there must be some way to assign fixed costs to each outlet.

I cannot divide the average cost of the system among the outlets, any more than, as Hirshleifer *et al.* point out, I can divide the cost of a sheep into the cost of mutton and the cost of wool. I can, however, figure out the incremental cost of serving one outlet, given that I serve the others, just as I can figure the cost of providing wool, given that I provide mutton, and vice versa.

I have already calculated the incremental cost of extending the system to plot G: $52.90, the price of a size seven pipe at the base of the system. How do I find the other incremental costs?

To start, what is the cost of providing service at plot A, assuming that B, C, D, E, F, and G get service? Clearly, it is the difference between the size six pipe that would cross A if A did not get water, and the size seven pipe: $3.94. What about B? The cost of serving B, given that A, C, D, E, F, and G get service, is the difference between the sizes six and five pipes that would cross A and B if B did not get water, and the size six and seven pipes, which equals the difference between the size seven and the size five pipe: $8.16. The incremental cost of serving C is likewise the difference between the size seven and the size four pipe: $12.90. To continue this progression, see Table 3 column 2.

Notice that the incremental costs for A through G add up to considerably less than the fixed costs for the whole system: $158.68, as opposed to $269.52. Similarly, one would expect the cost of providing wool, given that I provide mutton, and the cost of providing mutton, given that I provide wool, to add up to less than the cost of a sheep.

Now that I have the incremental costs for each point, I can construct diagrams of supply and demand. Figure 2 shows supply and demand at the source. Average cost is rising but remains well below marginal cost. Figure 3 shows plot A: average cost is above marginal cost and declining; consumer surplus greatly exceeds total costs. Figure 4 shows plot G, the furthermost plot. Again, average cost is declining and above marginal cost, but there the consumer surplus approximately equals total cost. These diagrams show a little more clearly that while average costs may rise with increasing volume at the supply, they may decline with increasing volume at a given outlet.

Just for fun, I have constructed Figure 5, an attempt to show supply and demand for the whole system at once. Since there is no correct way to assign average costs, I made the arbitrary assumption that I provide four units of water to plot A, then four to plot B, and so forth, as I extend the pipe. The results look a bit weird.

How feasible is it in practice for utilities to use marginal cost pricing and to avoid overextending? I would argue that legal institutions, rather than intrinsic difficulties, discourage proper pricing and service limits.

Overextension is less excusable than failure to use marginal cost pricing. Even though they work with much rougher data than those I concocted, ordinary businesses can and do make the proper calculations all the time. They would not last very long if they did not. For example, an entrepreneur putting up a high-rise apartment building adds floors until the incremental cost of one more floor equals the present value of his expected rents from that floor. That is what I did in my model. A utility should not have much trouble doing the same, even if it does not in fact collect the rent.

What about marginal cost pricing? Utilities, public and private, set rates according to venerable rules of thumb, often written into law. But laws can

FIGURE 1
HYPOTHETICAL WATER DISTRIBUTION SYSTEM

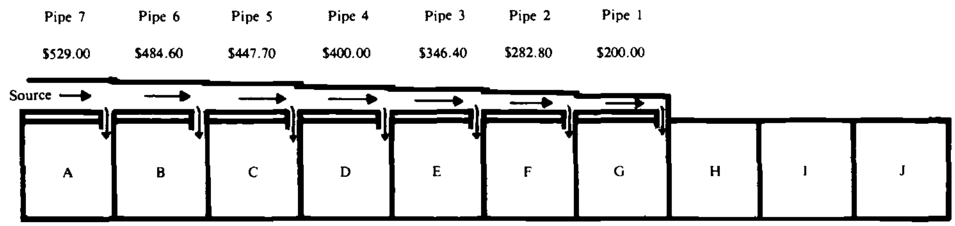


FIGURE 2
SUPPLY AND DEMAND AT THE SOURCE

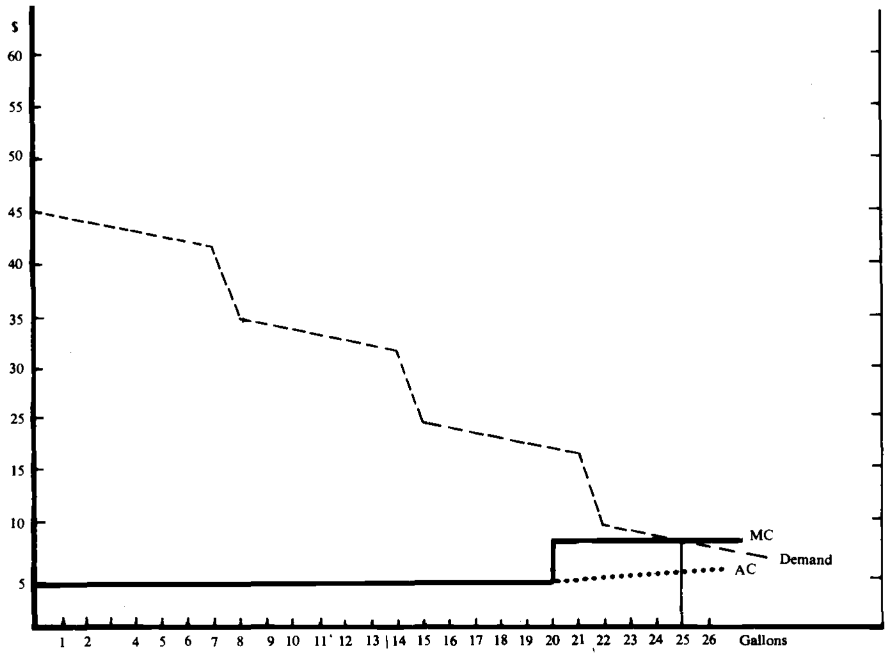


FIGURE 3

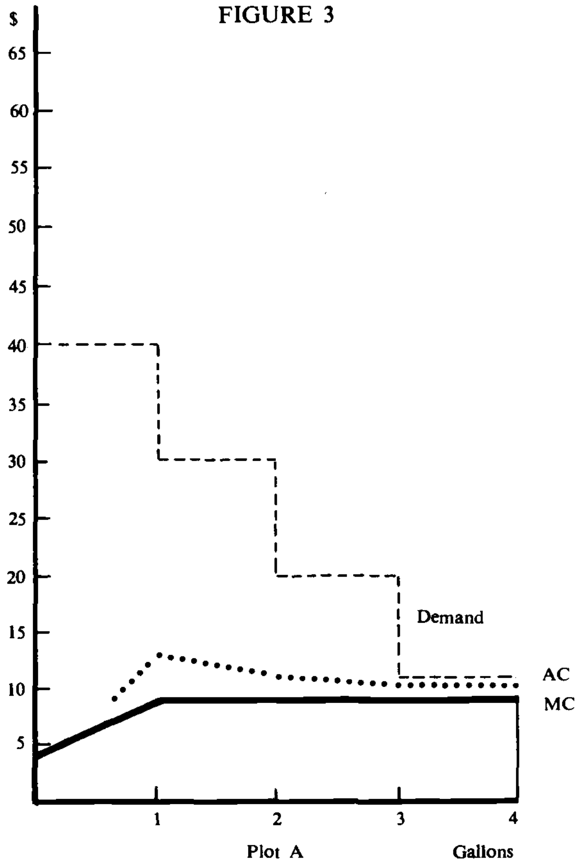


FIGURE 4

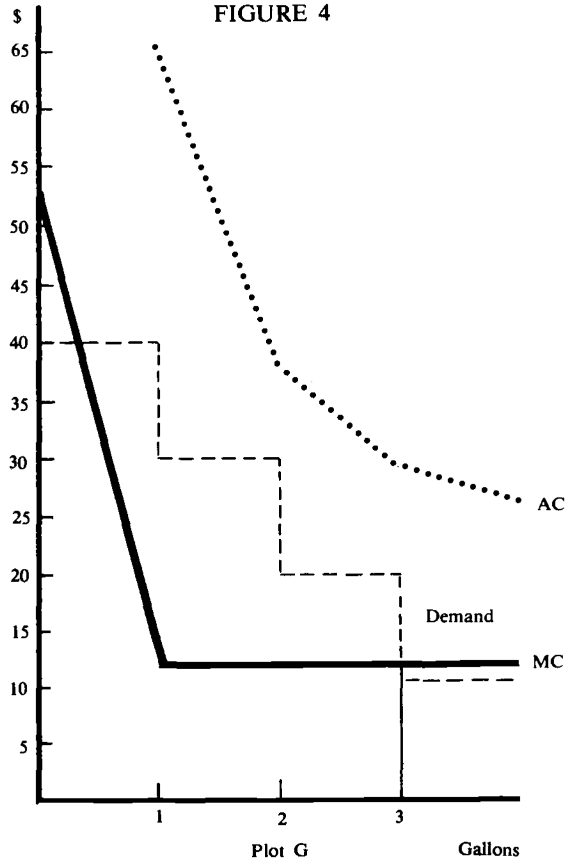
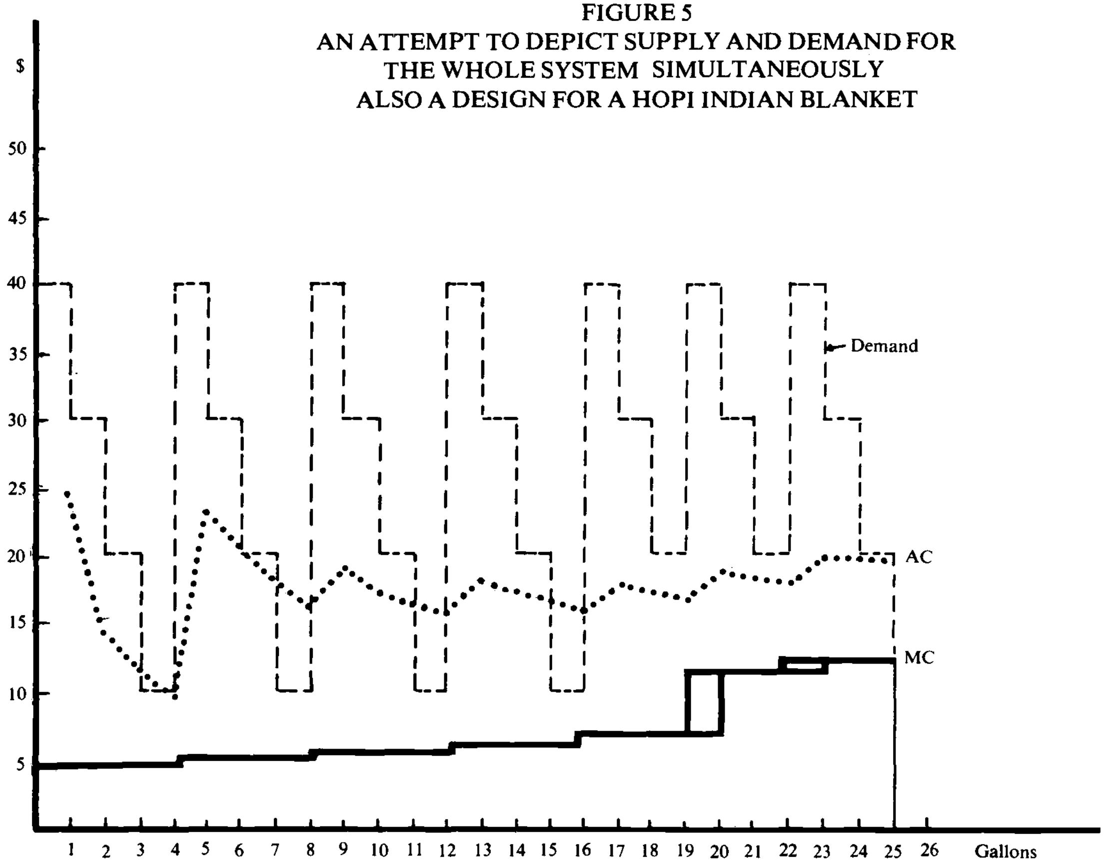


FIGURE 5
AN ATTEMPT TO DEPICT SUPPLY AND DEMAND FOR
THE WHOLE SYSTEM SIMULTANEOUSLY
ALSO A DESIGN FOR A HOPI INDIAN BLANKET



be changed, given a clear rationale for doing so. Most people consider the greatest obstacle to marginal cost pricing the familiar allegation that utilities would have to be subsidized to make up the difference between average and marginal costs.

To begin with, I consider this a misuse of the term "subsidy." A subsidy should mean a bonus that allows a price to be set below marginal cost. The apartment owner does not subsidize his tenants by selling them water and electricity at marginal cost, that is, what the utilities charge *him*. He does not add a surcharge for the pipes and wires in the building.

More important, a utility practising marginal cost pricing would operate at a deficit because the law prohibits it from collecting some of the surplus it creates, not because that surplus is not there. An apartment owner would operate at a deficit if the law prohibited him from collecting the rent. In fact, he would abandon the building, as have some owners of rent controlled apartments in New York.

Public utilities that rely partially on property taxes do collect some of the surplus, which should permit them to set rates closer to marginal cost. But the *ad valorem* property tax, on land and improvements alike, reaches that surplus imperfectly. It penalizes the very improvements that make it possible for customers to use the service. It is as if the apartment owner based his rents partially on the value of his tenants' furniture!

Hirshleifer, De Haven, and Milliman suggest that utilities should collect some of the surplus by monopolistic price discrimination. Utilities already do this to some extent with declining block rate schedules. But monopolistic price discrimination does not permit more central locations to offer cheaper water, as they should. It is regressive, since smaller users, like apartment dwellers, tend to have lower incomes. Finally, to administer monopolistic price discriminination at all accurately, utilities would have to compile detailed dossiers on their customers. Aside from the expense and inequity, it wouldn't work anyway. Imagine if the apartment building owner tried to collect his rents via the water and electricity bills. He might end up with a building full of hippies living by candlelight!

In short, I see no practical way to collect the surplus generated by a utility other than to collect it directly. Since the surplus will be capitalized into land values within the service perimeter, a stiff tax on land values offers the best way to collect it. In the meanwhile ordinary taxation of property will do better than nothing.

Hookup fees may also help. Return to my model for a moment. I actually provide my tenants with *two* services: water and a water distribution system. (The distinction is clearer for road transportation; the city provides the roads, and private individuals provide most of the traffic.) I have already calculated in Table 3, column 2, the incremental cost of providing

TABLE 3

INCREMENTAL FIXED COST ASSIGNED TO EACH OUTLET, AND OPPORTUNITY COSTS

	(1) Rent ($)	(2) Inc cost at 9.9 per cent (x 0.10)	(3) Opportunity cost (1)-(2)
A	66.00	$ 3.94	$62.06
B	64.00	8.16	55.84
C	62.00	12.90	49.10
D	60.00	18.26	41.74
E	58.50	29.62	28.88
F	57.00	32.90	24.10
G	55.50	52.90	2.60

In this case, the rent (1) derives entirely from Table 1 (8), the rent when more than twenty gallons are used.

The incremental fixed cost assigned to each outlet is the additional cost of providing service at a given outlet, assuming all the others receive service. This is the cost of pipe 7 - pipe 6 ($529.00 - $480.60) for plot A; pipe 7 + pipe 6 - (pipe 6 + pipe 5) = pipe 7 - pipe 5 ($529.00 - $447.40) for plot B; pipe 7 - pipe 4 ($529.00 - $400.00) for plot C; and so forth – all times the CRF of 0.10.

The opportunity cost is the net loss if a plot is held totally idle, instead of being used for raising yaks.

the distribution system to each outlet, assuming I provide it to all the others. I can charge each outlet this amount, as a one-shot lump sum, or an annualized payment.

In Table 3, column 1, I have listed the surplus generated at each plot for comparison with the incremental cost in column 2. Notice that the incremental cost increases going uphill until it approximately equals the surplus. Were plot owners charged the incremental cost as a hookup fee, they would have no incentive to demand that the system be overextended. The owners of plot H and more remote plots would not pay more than water service benefited them.

In my particular example, the sum of the incremental costs, or hookup fees, $158.68, plus the $80 surplus on the supply, comes to $238.68—not as much as the $269.52 fixed costs. For a system with lower fixed costs in proportion to variable costs, however, hookup charges might enable utilities to avoid a deficit while still charging marginal cost.

Hookup fees have a further advantage. As lump sums not dependent on actual water use, they would not discourage use as do water prices exceeding marginal cost. On more remote but still supramarginal plots they would strongly encourage plot owners to put their plots to highest and best use to pay the fees.

This brings me to a question that Professor William Vickrey has raised. Should not the owners of plots A through F be charged something simply for being there, for occupying space past which water must be carried to serve plot G? I would answer Professor Vickrey's question with a qualified "no." The plot owners should not pay just for being there. For example, suppose plot A to be a barren rock, useless for anything. Clearly, one would not charge A a penny because the pipe to plots B through G must cross plot A.

Yet if plot A is perfectly good for yak raising, then Professor Vickrey's argument is correct. But how much should they pay? At the very least, the incremental cost of service, the hookup fee. But better, they should pay the opportunity cost too. The opportunity cost is simply the surplus that the plot earns when put to highest and best use, minus the incremental cost of service. The opportunity cost represents the real net loss to society from failure to use the plot. At the extreme, it is the difference between the value of the kingdom and that of the horseshoe nail. I show the opportunity cost in Table 3, column 3. Notice that the opportunity cost is highest for plot A and declines to almost nothing at plot G.

But why bother to figure out how much, if anything, should be charged as hookup fee and how much as opportunity cost? It makes better sense just to collect the surplus.

Notes

1 Mason Gaffney, "Land and Rent in Welfare Economics," in *Land Economics Research*, ed. M. Clawson, Harris and Ackerman (Baltimore: Johns Hopkins University Press, 1962), p. 162.

2 Harvey Averch and Leland L. Johnson, "Behavior of the Firm under Regulatory Constraint," *American Economic Review* 52 (1962): 1052-69.

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