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Estimating Marginal Capital Costs of Municipal Service Expansion

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In Idaho, and generally throughout the West, towns are growing rapidly and will continue to do so. The growth of the private sector — business, industry and population — is reflected in the public sector as an increased demand for services. At the same time, this era of budget limitations, high inflation rates and resistance to tax increases demands careful management of public monies. Thus, the impacts on local government costs and revenues (fiscal impacts) must be estimated when municipal service expansions are required to accommodate growth.

Estimation of the fiscal impacts of development involves consideration of many factors. Different types of development — residential, industrial and commercial — will place different demands on public services, each affecting municipal expenditures differently. Municipal revenues from various development types will also differ. To estimate fiscal impacts and make the necessary growth management decisions, local officials need information and methods to analyze it. This publication provides some of this information and a simple estimation technique for determining a key component of fiscal impacts — capital costs.*

The focus is on the capital costs associated with relatively small additions to existing water, sewer and street systems. The term "additions to," also referred to as "**marginal**," is an important concept. The study assumes that services are already being provided, that they will be extended to new users if necessary, and that capacity exists to accommodate additional demand. Growing towns commonly face this situation, as opposed to those where growth is so rapid or large (boom towns) that entire new systems are necessary.

Previous analysis of public service costs in Idaho has been done under the auspices of a regional program entitled "Coping with Growth." A series of cost estimation workbooks was part of that program (8, 9). This additional work is complementary to those efforts, not a replacement.

Capital Costs

Capital costs are defined as those associated with the construction or installation of physical facilities required to deliver or provide a given public service. Included are the costs of material, labor, equipment, accessory components, overhead and profit. The study of fiscal impacts revealed that private developers — rather than the municipalities — usually pay the marginal capital costs associated with development. The issue in such cases is whether full marginal costs are being covered. When municipalities do pay the costs, their estimation is of concern to both local officials and townspeople, because the funds will come from the taxpayers themselves. The information presented here provides a way of making the estimates for both cases.

Bases for Estimating Capital Costs

Three public services — water, sewer, and streets and roads — were selected for analysis on the basis of responses by local officials to questions concerning development. Water and sewer services were generally the most often mentioned in terms of impacts. Streets and roads were included because of

*The information presented in this publication is part of a study which examined fiscal impacts of various types of growth in Idaho cities with less than 10,000 population. (Forthcoming University of Idaho Research Bulletin 123, *Initial and Long-term Fiscal Impacts of Developments on Rural Municipal Governments.*)

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their visibility in development situations and the lack of much previous analysis.

An "engineering-economic" model is often used for estimating the capital costs of public services. Studies in Missouri, Nevada and Oklahoma provide examples of the methodology (3, 6, 7). Engineering (design) criteria and economic (price) data are systematically incorporated with assumptions to determine a general relationship between the service demanded or provided and the cost.

Because of the significance of the assumptions, cost estimates are only as good as the supporting assumptions themselves. Mackey (7), in the Nevada study, suggested two advantages of these types of studies: (a) the flexibility to alter assumptions if they are different in a specific area, and (b) the flexibility to incorporate unique features of each public service.

Design Standards

In addition to engineering and economic criteria, regulatory concerns also affect the provision of public services. Federal, state and local standards may all come into play. It was assumed that local standards were at least as stringent as state guidelines. The minimum standards for water, sewer and streets and roads, which are important for cost-estimating, are presented in the following exhibits.

Exhibit 1. "Standards" for water system design and construction (4).

1. The minimum water main size is **6 inches** in diameter.
2. Valve spacing is **500 to 750 feet.**
3. Hydrants are spaced every **500 feet** and have a minimum **6-inch** connection.
4. Trenching and backfilling are suitable for the local situation.
5. The minimum house connection (service) line is **.75 inches.**

Exhibit 2. "Standards" for sewer system design construction (5).

1. The minimum pipe size of any gravity sewer carrying raw sewage is **8 inches** in diameter.
2. Manholes are installed at ends of lines, changes of pipe sizes, grade or alignment and at distances no greater than **400 feet** apart for sewers **15 inches** or less.
3. Manholes are poured in place or as pre-cast concrete with minimum inside diameter of **48 inches** and **22 inches** access (cover).
4. Trenching and backfilling are suitable for the specific location.
5. The minimum size for house connections is **4 inches.**

Exhibit 3. "Standards" for street design and construction (10).

1. The design depth (base plus surface) of streets and roads is at least **6 inches.**
2. Sidewalks are a minimum of **5 feet** wide.
3. The minimum width of traffic lanes is **12 feet.**

These minimum standards are a "floor" for estimating the costs of system additions. More stringent local ordinances would result in higher costs. Since trenching and backfilling standards say nothing about specific design criteria, the following assumptions were made: water system trenches are 3 feet wide by 4 feet deep, and sewer conveyance system trenches are 4 by 6 feet. Personal contact with engineers provided the 4-foot depth for water systems, while the other values are average estimates (1, 4, 5, 10, 11). Trenching is highly dependent on local soil conditions, pipe sizes, the expected amount of work to be done in the trench itself and other factors. The gravity flow of most sewage systems is another key in trench depth.

A three-step backfill operation was assumed in this study. The bottom zone, directly around the pipe, was assumed to be hand filled and tamped. (This process is costly, but sources indicated a careful bedding of the pipe is optimal.) The middle zone is assumed to be loosely compacted with no special work done and the final zone was filled, tamped and restored to conditions similar to surrounding surfaces. The volume of the backfill was assumed to equal the volume in the trench.

Different assumptions were made about the backfill zones for the two systems under analysis. For water systems, the bottom zone represented one-quarter of the volume, the middle was one-half and the top was one-quarter. Sewer system backfill zones were each one-third of the total volume.

The design standards for streets and roads set out in Exhibit 3 are all exceeded by the assumed criteria used in the model: a width of 40 feet, a base course of 6 inches and paving of 1½ inches of bituminous material. Sidewalks were arbitrarily chosen to be 6 feet wide poured in concrete slabs 6 feet long by 4 inches deep. Curbing is 6 inches high with 8-inch concrete berms.

Engineers contacted indicated that piping is predominantly plastic (polyvinylchloride or PVC) or ductile iron in water systems. Sewer systems are PVC, ductile iron or asbestos cement.

Adjusting Estimates for Price Changes

When using the model to make estimates, current costs of material, equipment and labor often are not available, especially in small towns. The sources of such costs may be several years old, and therefore must be updated to provide accurate estimates. This can be done with a price index, which is a general estimate of cost/price changes over time.

Previous researchers found the Implicit Price Deflator for Gross National Product (IPD-GNP) for state and local governments to be the best index for municipal governments (2). The IPD-GNP is based on 43 commodities purchased by state and local governments (12). Table 1 shows the values of this index since 1975. Use this information as a basis for expectations about future prices. When adjusting costs, use the total cost, not each separate component in the total.

For example, if the index for 1981 were 200, and the latest prices available were from 1979, the prices can be updated to 1981 estimates:

1. 1981 prices are 200/169.8 = 1.178 times the level of 1979 prices.
2. Multiply this factor by the 1979 prices to get 1981 estimates.

As another example, if costs must be estimated for construction planned in 1982, the index can provide an estimate of expected price changes. The average 1975-80 price change was (187.7/128.3 - 1.0) ÷ 5 = 9.3 percent. Thus, if economic conditions are expected to remain the same through 1982, prices or costs can be estimated to increase by 9.3 percent per year from 1980 to 1982.

Applying the Model

This section illustrates the step-by-step process for estimating capital costs in Idaho for three services: water distribution, sewage conveyance and streets and roads. Since water and sewer services share many common physical components, the illustrations for using the models are combined. Differences between the two have been discussed previously. The illustrations use the design standards previously described, but they may also be used with other specifications. The user must insert the length of additions in the parentheses.

The prices/costs used in this section are from the 1979 Means Data Book (1). They were adjusted to 1980 dollars using the index discussed in the previous section.

Prices with an (†) are directly related to design standards. Changes in those standards do not necessarily imply a proportional change in prices because labor costs may not be affected even though the amount of materials is different.

Table 1. Values of the Implicit Price Deflator for Gross National Product for state and local government in recent years (1972 = 100) (12).

1975	128.3
1977	146.0
1978	156.9
1979	169.8
1980	187.7

Water and Sewer Systems

Step 1. Trenching

water: 3 ft × 4 ft × (   ) ft ÷ 27 × $2.88/cu yd = $______

sewer: 4 ft × 6 ft × (   ) ft ÷ 27 × $2.88/cu yd = $______

Step 2. Pipe

water: 6 in PVC @ $5.66†/ft × (   ) ft = $______

sewer: 8 in PVC @ $8.77†/ft × (   ) ft = $______

Step 3. Backfilling

water: 3 ft × 4 ft × (   ) ft ÷ 27 × ¼ × $15.35/cu yd +
3 ft × 4 ft × (   ) ft ÷ 27 × ½ × $.82/cu yd +
3 ft × 4 ft × (   ) ft ÷ 27 × ¼ × $1.58/cu yd = $______

sewer: 4 ft × 6 ft × (   ) ft ÷ 27 × 1/3 × $15.35/cu yd +
4 ft × 6 ft × (   ) ft ÷ 27 × 1/3 × $.82/cu yd +
4 ft × 6 ft × (   ) ft ÷ 27 × 1/3 × $1.58/cu yd =
$______

Step 4. Accessories

water: number of gate valves × $423† each +
number of hydrants × $877† each = $ ______

sewer: number of manholes × $714† each = $ ______

Step 5. Total

water: Trenching, $_____ + Pipe, $_____ +
Backfilling, $_____ + Accessories, $_____ =
$______

sewer: Trenching, $_____ + Pipe, $_____ +
Backfilling, $_____ + Accessories, $_____ =
$______

Streets and Roads

Step 1. Base (base course plus grading)

40 ft × (   ) ft - 9 × $1.06†/sq yd +
40 ft × (   ) ft - 9 × $.47†/sq yd = $ ______

Step 2. Paving

40 ft × (   ) ft ÷ 9 × $1.99 †/sq yd = $______

Step 3. Curbs and Sidewalks

curbing: (   ) ft × 2 sides × $2.43†/ft = $______ +
sidewalks: (   ) ft ÷ 6 × 36 sq ft × 2 sides × $1.47†/sq ft =
$______

Step 4. Total

Base, $_____ + Paving, $_____ +
Curbs and Sidewalks, $_____ = $_____

Summary

Estimating the capital cost of public services is one component of fiscal impact analysis. The "economic-engineering" model has been the basis of many such studies. The models reported here differ from previous work in three significant ways:

1. The role of standards is explicitly stated.
2. A method for examining price changes over time is included.
3. The models are used to estimate marginal (additional) system costs.

Explicitly considering the role of standards provides a basis for determining the minimum capital costs associated with system additions. Price indexing provides a systematic way of adjusting for inflation. Focusing on marginal system additions represents a more realistic analytic approach to the majority of developments.

Although one might think of models only in terms of predicting future impacts, they can also be used to evaluate previous developments. This *ex post* evaluation provides useful information when planning future developments.

The estimates obtained are only approximations. Substituting locally obtained data should result in better estimates. More detailed study will increase precision, but unexpected or unknown factors cannot be completely eliminated. Assumptions and/or "fudge factors" will be a part of even the best estimates.

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