Appendix B: The policy simulation model

The policy simulation model, set out in the Excel spreadsheet in the CD-ROM accompanying this book, illustrates some issues discussed in the *Toolkit,* suggests outputs that the government's modelers might produce, and illustrates possible approaches to the modeling. In particular, it shows, in a simplified setting, how the analysis of three crucial policy issues can be integrated into standard financial modeling:

- Balancing of tariffs, subsidies, and coverage targets (Chapter 5)
- Choosing the distribution of costs and benefits among stakeholders (Chapter 3)
- Allocating risk (Chapter 6).

The core of the model is a simplified standard financial model of a water utility. Some of the inputs to the model are facts about the utility and the world, such as the number of customers, demand per customer, operating costs, inflation, and the exchange rate. Other inputs are policy choices, such as coverage targets, rules for adjusting tariffs, and whether the operator is responsible for financing investment. Combined, the inputs generate the outputs such as the average tariffs, the number of people connected to the network, and the profitability of the operator. (See the Introduction sheet of the model.)

The model cannot be used to analyze any real-world arrangement. For one thing, it is too simple: it ignores taxes, for example, assumes there is only one type of customer, and lumps operating costs into just two categories (fixed and variable), rather than separately identifying labor, chemicals, electricity, and other inputs. It also ignores many economically important linkages, such as feedback from tariffs to demand and from demand to required investment. Nor does it generate a full set of financial statements for the operator or utility.

The reader should keep in mind that every arrangement needs a model that is built with the particular arrangement in mind and that none of the policy choices (or modeling techniques) are intended as recommendations.

POLICY CHOICES

In the "Policy choices" sheet, the model allows the user to design the illustrative arrangement, choosing coverage targets, subsidies, financing responsibilities, the tariff reset period, and the length of arrangement.

If existing coverage (the proportion of connected to total households) is less than 100 percent, the user sets a target for increased coverage and chooses the year in which this target is to be reached. The model then assumes that coverage will reach the target following an S-shaped curve.

Given the choice of coverage target and other assumptions, the model calculates a tariff that is sufficient to cover the utility's future costs, including the investment costs of increased coverage. The more ambitious the coverage target, the higher the cost and—given certain other assumptions—the higher the tariff that is needed to cover costs.

The model allows the government to lower the required tariff, however, by providing as a subsidy.

Negative subsidies are possible.

The model allows the user to choose the share of investment financing provided by the operator, from zero (for a pure affermage-lease) to 100 percent (for a pure concession or divestiture). The tariff-setting mechanism ensures that the parties financing investment in the model expect to earn a return on the capital they invest.

The model also treats as a policy variable the proportion of financing that comes in the form of debt and whether the debt is denominated in the local or a foreign currency.

The model assumes that tariffs are indexed to consumer prices (just one of the choices discussed in Chapter 6), but allows the user to set the frequency of the reset (for example, every five years).

The tariff reset adjusts tariffs so that, over the reset period, the present value of the operator's future costs equals the expected present value of its revenues.

A tariff reset is also automatically carried out at the beginning of the arrangement to ensure that the prospective revenues are sufficient to cover costs.

Finally, the model allows the user to set the length of the contract, which among other things limits the maximum term of borrowing by the operator.

FACTUAL ASSUMPTIONS

Other assumptions involve the state of the utility and the environment in which it operates.

Most of these factual variables are modeled in a standard way: the initial value of the variable is specified and some assumptions are made that determine its future values. Sensitivity analysis can test how the model's outputs change with different assumptions about the variables, but the outcomes are always deterministic.

Among the deterministic variables are the following:

- The proportion of households that are currently connected to the network
- The existing average tariff
- The cost of making a new connection
- The proportion of nonrevenue water
- Fixed and variable operating costs in real terms (that is, adjusting for inflation)
- The interest rate in real terms.

To illustrate a more complex form of modeling useful for analyzing risk, three variables are not deterministic; as well as having trends, they are allowed to vary unpredictably. These variables are demand per household, the exchange rate, and inflation.

Demand per household has a fixed starting value and a rate at which it is expected to grow. But it is also allowed to vary randomly (see the appendix for the Excel equation that does this). For example, it might be expected to grow at 3 percent a year, but in the modeling actually grow at 4 percent in the first year, 3 percent in the next year, and then fall in the third year. See Figure 6.2 and the model. The exchange rate—defined as the number of local pesos that can be bought with one foreign dollar—also has a fixed starting value and a rate at which it is expected to depreciate (or appreciate). Again, it also is allowed to vary randomly.

Inflation is modeled differently. It has a fixed starting value, but instead of increasing or decreasing indefinitely, it is assumed to have a long-run average level to which it tends to converge. If it is above the long-term average level, it tends to fall. If it is below, it tends to rise. But its path is also subject to random fluctuations that can temporarily take it away from its long-run average level.

Uncertainty about inflation creates uncertainty about the nominal level of operating costs and the interest rate. Uncertainty about the exchange rate creates uncertainty about the local-currency value of debt service and further uncertainty about the nominal level of operating costs. The nominal rate of a variable is given by the Fisher equation:

$$1 + n = (1 + r)(1 + i),$$

where n is the nominal rate (such as the nominal interest rate), r is the real rate (the real interest rate), and i is the inflation rate.

ANALYSIS OF TARIFFS, SUBSIDIES, AND COVERAGE TARGETS

Although the model is too simplistic to be used to model any particular arrangement, it illustrates three types of analysis that a government may want to undertake.

The first is the analysis of the relationship between tariffs, subsidies, and coverage targets. As discussed in Chapter 5, a government may want to test the implications of various targets for coverage (among other things) for the required average tariff. If the required average tariff is too high, it must choose between lowering the target and providing a subsidy. The model provides a simple example of the type of analysis of this issue that governments might undertake (see the graph in the policy simulation model on tariffs and coverage).

ANALYSIS OF STAKEHOLDER EFFECTS

Second, the model illustrates the analysis of the distribution of the costs and benefits of different arrangements. Most basically, for a given set of factual assumptions, the model shows a hypothetical arrangement's expected effect on the average tariff and the present value of the operator. It also illustrates a slightly finer-grained analysis of the effects of different arrangements on stakeholders.

To do this, the model assumes two types of households. Some households are connected to the network; the others obtain water from alternative providers at a different, probably higher, average tariff price and incur additional coping costs, increasing their "effective" average tariff (Table A1).

Table A.1 **Illustrative approach to stakeholder analysis**

Costs	Existing customer	Currently unconnected
Average tariff	Average tariff charged by water utility	Average tariff charged by alternative providers
Coping costs	None	Time spent fetching water, the costs of poorer health, and so on
Effective average tariff	Existing average tariff	Tariff charged by alternative providers + (coping cost / average consumption)

The model illustrates how a coverage target affects the two groups. For example, suppose existing coverage is 30 percent and the government's target for coverage in 5 years is 50 percent. The model calculates the average tariff increase necessary to pay for the required investment and compares this tariff with the average tariff currently paid by existing customers and the effective average tariff paid by unconnected households. The model also illustrates the estimation of changes in consumer welfare associated with the changes in average tariffs and coverage.

For the currently connected, the estimated welfare change is the amount they pay now less the amount they pay after prices change:

$$\text{Welfare change (connected)} = \text{Amount paid for old service} - \text{Amount paid for new service.}$$

(The model ignores any feedback from price to demand, so demand is unaffected by the price change.) If the average tariff has to go up to pay for expansion, the welfare of the currently connected falls according to the model. (In practice, their welfare might increase if there were sufficient improvements in the quality of their service, but such changes in quality are not modeled.)

For the currently unconnected who get connections, the welfare impact depends on their total cost of their existing service, the amount they pay when they have the new service, their willingness to pay (WTP) for their existing service, and their willingness to pay for the new service:

Welfare change (unconnected) = WTP (new service)
– Amount paid for new service
– (WTP (old service)
– Amount paid for old service).

The total change in consumer welfare in a given year is given by:

Total welfare change = Welfare change (connected)
× Number of existing customers
+ Welfare change (unconnected)
× Number of currently unconnected customers that get connections.

The total consumer welfare change over the period of the arrangement is given by the discounted sum of the consumer welfare changes in each year. To simplify, willingness to pay and the effective average tariff paid by unconnected households are assumed to remain constant in real terms.

ANALYSIS OF RISK ALLOCATION

Because the model allows demand, inflation, and the exchange rate to fluctuate randomly, it can illustrate the analysis of risk relating to these variables, including the analysis of different allocations of these risks. For example, the model can estimate the extent to which the operator's cash flows or value varies with fluctuations in these variables and the probability of those fluctuations leading to the operator defaulting on its debt.

In the model, the allocation of risks related to demand, inflation, and the exchange rate is affected by the rules for adjusting tariffs (Chapter 6). Risks relating to default are also influenced by the proportion of investment financed by debt and whether the debt is in local or foreign currency. For example, if foreign currency debt is chosen, the risk of default rises. Given a set of factual assumptions, the model can estimate the probability of default given different choices of tariff reset period and different assumptions about the operator's debt, coverage targets, and so on. Using the same techniques, the model also illustrates the risks of tariff changes faced by customers.

APPENDIX: MODELING THE RISK VARIABLES

In the model, demand D in year t is assumed to evolve according to the following equation:

$$D_t = D_{t-1} \exp\left(\alpha - \frac{\sigma_D^2}{2} + \sigma_D \varepsilon\right)$$

where D_{t-1} is the demand in the previous year, α is the forecast rate of growth of demand, σ_D is an estimate of the volatility of demand growth, and $\varepsilon \sim N(0,1)$ is a standard normal random variable (generated by Excel's NORMSINV(RAND) function).

The use of this equation means that demand is expected to grow exponentially at a rate equal to α, but will fluctuate, the expected size at of the fluctuations at a given time being proportional to demand at that time and the volatility parameter.

The exchange rate, ER_t is assumed to evolve according to the same type of equation:

$$ER_t = ER_{t-1} \exp\left(\mu - \frac{\sigma_{ER}^2}{2} + \sigma_{ER} \varepsilon\right)$$

where μ is the expected rate of depreciation of the local currency against the foreign currency, σ_{ER} is the volatility of the exchange rate, and ε is (another) standard normal random variable.

Inflation is given by the following equation:

$$I_t = I_{t-1} \exp\left[\beta(\bar{I} - I_{t-1}) - \frac{\sigma_I^2}{2} + \sigma_I \varepsilon\right]$$

where $\bar{I}$ is the long-run average level of inflation, β is a parameter that determines the speed with which inflation tends to revert to its long-run average level, and σ_I is the volatility of inflation. The use of this equation means that inflation is more likely to rise when it is below its long-run average level and more likely to fall when it is above its long-run level.

More information **Financial modeling**

On financial modeling generally: Benninga 2000.

On modeling a water utility: PPIAF and World Bank Institute 2002.