Performance Evaluation Gradient

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Abstract

The Performance Evaluation Gradient (PEG) model quantitatively compares the relative merits of government operation versus outsourcing to provide government needed goods and services. DOD outsourcing is the contracting out of business-related activities to save money. PEG provides a means to minimize procurement, operations and maintenance, and investment costs for a broad range of products and services. Products are categorized by their associated input parameter values. The model evaluates the effect of fourteen key economic parameters on per-unit costs. This section describes the current budgetary environment and the relation of PEG to Functional Economic Analysis (FEA). PEG is applied to a Local Area Network (LAN) services example and summary results are presented.

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Purpose

The Infrastructure Engineering Directorate of the Defense Information Systems Agency (DISA) Center for Information Management is responsible for defining an information utility to provide data processing, storage, and value-added services to DOD users. One of the key questions on how to structure the utility is whether to contract for services or provide them within DOD. The primary goal of PEG is to aid in answering this question. Present procurement regulations and practices lead to long procurement and installation delays when compared to commercial practice. The age of the government installed base is far higher than in industry . These effect the potential cost of government-provided services. Key information utility questions include:

- What are the key parameters that affect the outsourcing decision?
- What products or services are more efficiently outsourced ?
- What products or services are better provided by the government ?
- How do government procurement delays affect costs ?
- How does the age of installed equipment affect costs ?
- What is the most cost effective equipment turnover rate ?

A secondary goal of PEG is to provide the basis for a Functional Economic Analysis of promising products or services. FEA is a methodology for modeling the costs, benefits, and risks associated with alternative investment and management practices, and is the primary decision support methodology for DOD business re-engineering. Since July 1991 functional managers have been tasked with preparing FEAs for all proposed information technology alternatives. A FEA requires projection of workload, system cost, and performance five years into the future. It uses a discounted present value distribution of savings as a measure of effectiveness. Effectively projecting performance into the future in the fast-changing information technology environment requires a system dynamics model. PEG uses dynamic modeling to provide the discounted present value savings distribution.

Model description

The model is implemented in version 2.0 of the i Think graphical simulation language. Each graphical symbol has an underlying supporting equation and documentation. Figures 1 and 2 give the graphical representation of the model for both government and commercial sectors. The continuous simulation model is a linked set of nonlinear integral difference equations. Figure 1 shows the government sector and figure 2 shows the commercial sector. The commercial sector structure adds salvage, depreciation, Return On Equity (ROE) and profit to the government sector. Otherwise, the model structure is the same. Of course, some of the parameter values are different. Note similar variables in the commercial sector have the same abbreviation as the government sector followed by a "C". Both sectors have a fee-for-service cost per unit (CPUopn & CPUopnC) that is calculated over the simulation time.

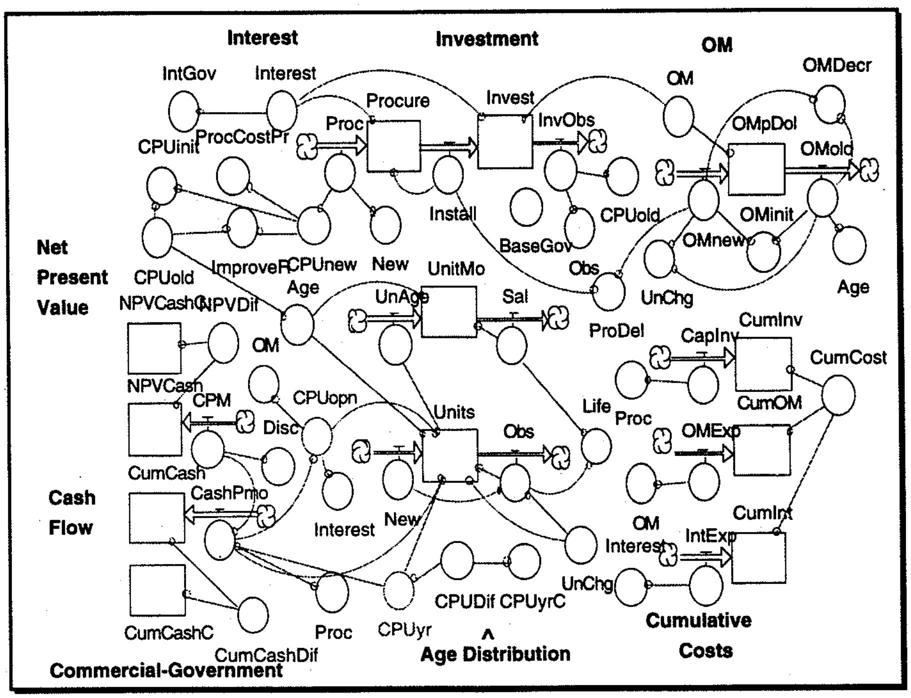

Figure 1. Government Sector Model

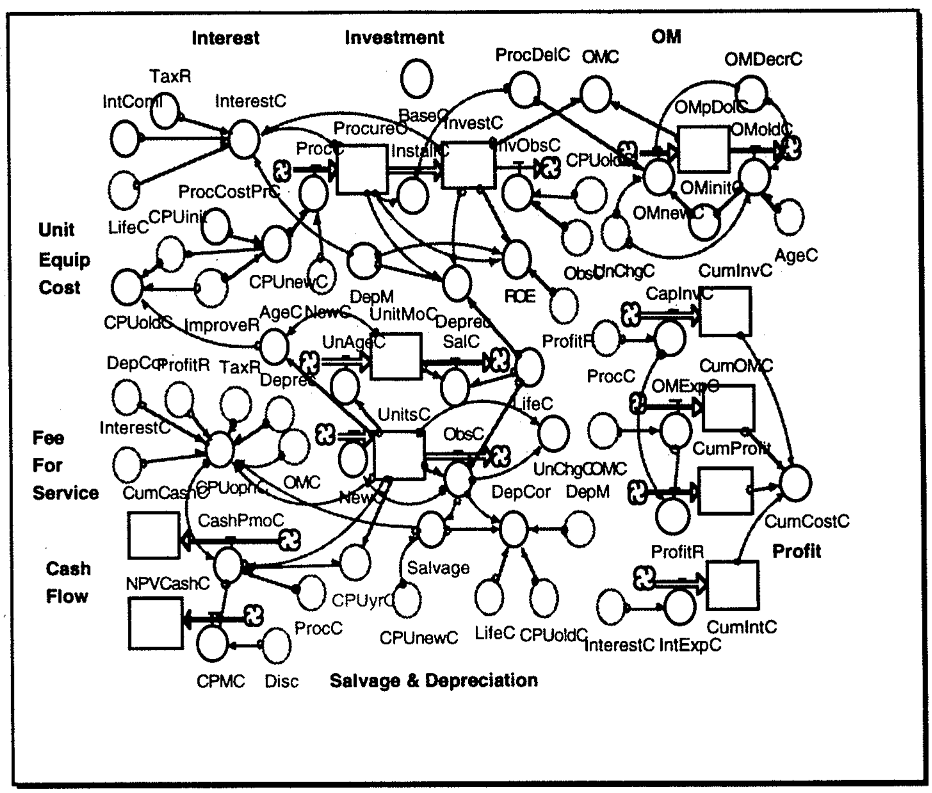

Figure 2. Commercial Sector Model

Measures of effectiveness

The two primary output measures of effectiveness used in the model are cumulative cash flow over the operations period, and discounted cash flow over the operations period. The operations period can be any length. For the fast-changing LAN environment we chose 60 months. Functional economic analysis uses discounted cash flow as its prime measure. The government discount rate of 10 percent was chosen, although other values are easily set.

Key Controlable parameters

The Local Area Network (LAN) services area was chosen as an example case. This area has significant savings potential. LAN equipment and maintenance costs are decreasing in excess of twenty percent per year. LAN services is one of the fastest growing components in the federal ADP budget. Operations and maintenance are a significant proportion of total costs. We estimated the present operating point (baseline parameter values) for both DOD and commercial service provision.

In the PEG model, cumulative cash flow is a nonlinear function of several input parameters. A baseline operating point was chosen and each parameter was individually varied from this operating point. The parameters that have the same values (operating point values in parenthesis) for both government and commercial sectors include:

- Initial LAN port unit equipment cost ($2000)
- Equipment price reduction (20 percent per year)
- Initial operation and maintenance cost per dollar invested (50 cents per year per dollar investment)
- Decrease in operation and maintenance cost (10 percent per year)
- Procurement cost percentage of unit equipment cost (4 percent)
- Equipment lifetime (36 months)
- Proportion of total unit equipment cost paid during the procurement and installation interval (25 percent)
- Discount rate for net present value calculation (10 percent)

Parameters that have different government and commercial values include:

- Average installed base age (30 months government, 15 months commercial)
- Procurement processing delay (12 months government, 3 months commercial)
- Interest rate (9 percent government, 16 percent commercial)

The parameters that only apply to commercial operations include:

- Commercial federal and state tax rate (40 percent)
- Equipment salvage value (25 percent of new equipment price)
- Depreciation life (twice equipment life- straight line depreciation)

The model easily accommodates changes in any of the parameter values.

Model results at operating point

No inflation rate was assumed for the model runs. Figure 3 shows how the yearly per port cost for both commercial and government operation decrease over the course of the simulation. The initial 1992 cost per port per year is $3200. The curves are almost identical since the operating point is close to break even cost. This includes a 60 percent commercial profit on sales. Figure 4 shows the cumulative government cost picture. Operations and maintenance are by far the largest cost category, followed by cumulative investment and interest. Note that installed capital investment (Invest) decreases throughout the simulation. More costly old equipment is replaced by less costly new equipment. The number of installed units is fixed at 30,000 for both government and commercial sectors. Future releases will investigate growth or reduction in installed base.

The overall system boundary for this model is drawn around DOD rather than the entire government. The depreciation tax loss helps the commercial firm at the price of reduced Treasury income. This is equivalent to a Treasury subsidy to DOD outsourcing.

Factor sensitivity analysis

Over a five year operation period, the break-even commercial profit is 60 percent of sales. The break-even profit is where commercial and DOD operation are equally costly. If vendors are willing to accept a profit below the break-even point, then it is more efficient for the government to outsource the modeled services. This result is sensitive to the price reduction role, the installed government base age, and the procurement delay. The examples case assumes a 20 percent annual price reduction rate in equipment cost. For a commodity product or service, with no equipment price reduction, the break-even profit is 27 percent of sales. Greater rates of equipment price reduction result in higher break-even profits. A 30 percent price reduction rate produces a 92 percent break-even profit. If the average DOD installed base age is reduced from 30 months to the commercial value of 15 months, break-even commercial profit is reduced from 60 percent to 37 percent of sales. A reduction of DOD procurement delay from 18 months down to the commercial value of 3 months reduces total LAN procurement, operations, and maintenance costs by ten percent. These results are based on the commercial tax benefits available from depreciation and interest expense write-offs. In effect, the Federal Treasury is subsidizing DOD outsourcing.

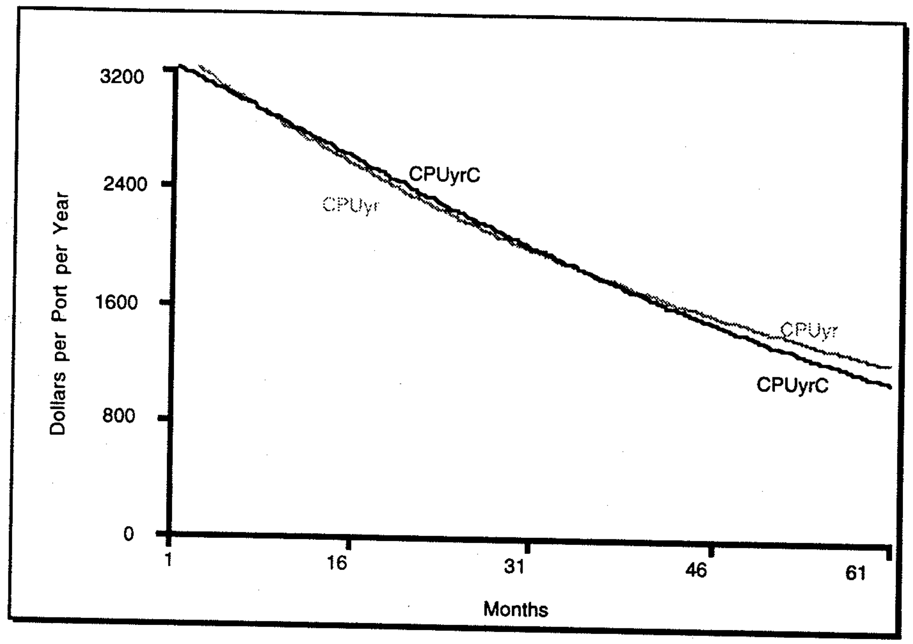

Figure 3. Yearly Port Costs

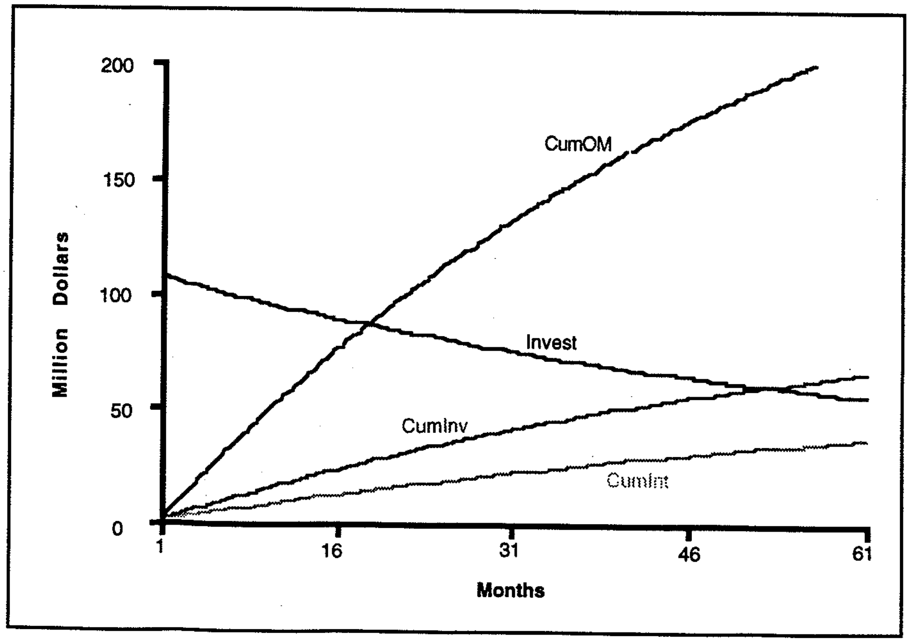

Figure 4. Cumulative Government Costs

Figure 5 shows the cumulative commercial cash flow advantage for various government procurement delays at the operating point. The operating point was chosen near the boundary where DOD and commercial service provision are equally costly. At twelve months or more government procurement delay outsourcing is superior. At nine months or less procurement delay DOD service provision is superior (assumes 60 percent commercial break-even profit on sales).

Figures 6 and 7 show the percent increase in cumulative government and industry cash flow for various equipment lifetimes at the operating point. The optimal equipment lifetime is approximately 36 months for industry and 42 months for government. The commercial salvage value, depreciation and interest expense write-offs lead to a shorter optimal commercial equipment life time. Longer or shorter equipment lives than the optimum result in increased costs. The optimal equipment life is dependent on the operating point. Faster equipment price reduction rates and greater operation and maintenance costs as a proportion of investment lead to shorter optimal equipment life times. Higher procurement cost proportions and interest rates lead to longer optimal equipment life times. The reciprocal of equipment life time in months is the equipment turnover rate per month.

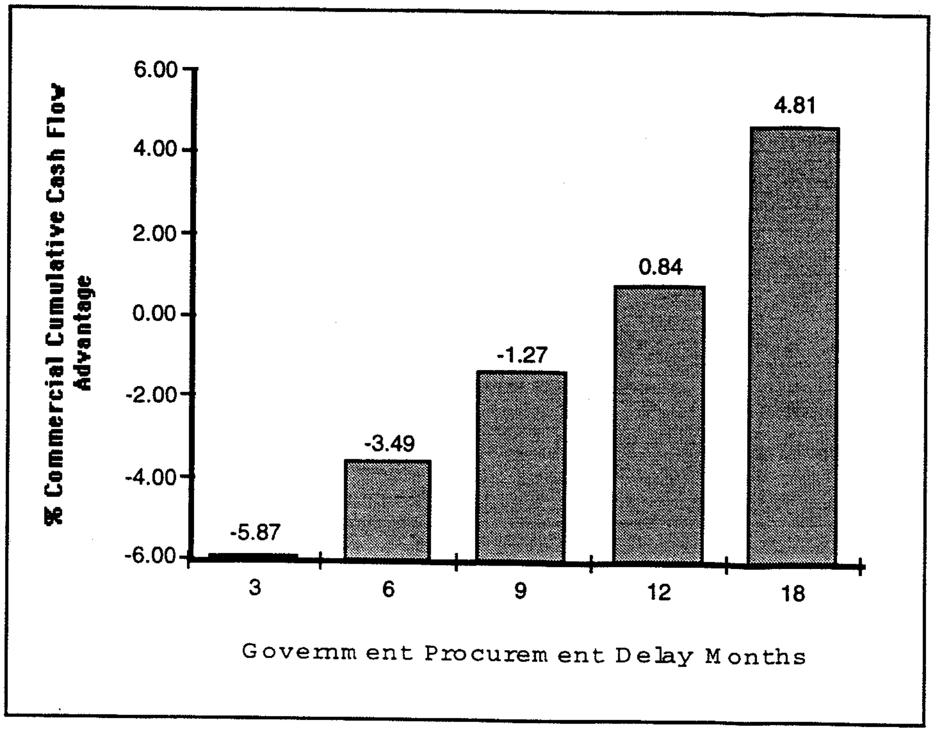

Figure 5. Commercial Cumulative Cash Flow Advantage Versus Government Procurement Delay At LAN Operating Point

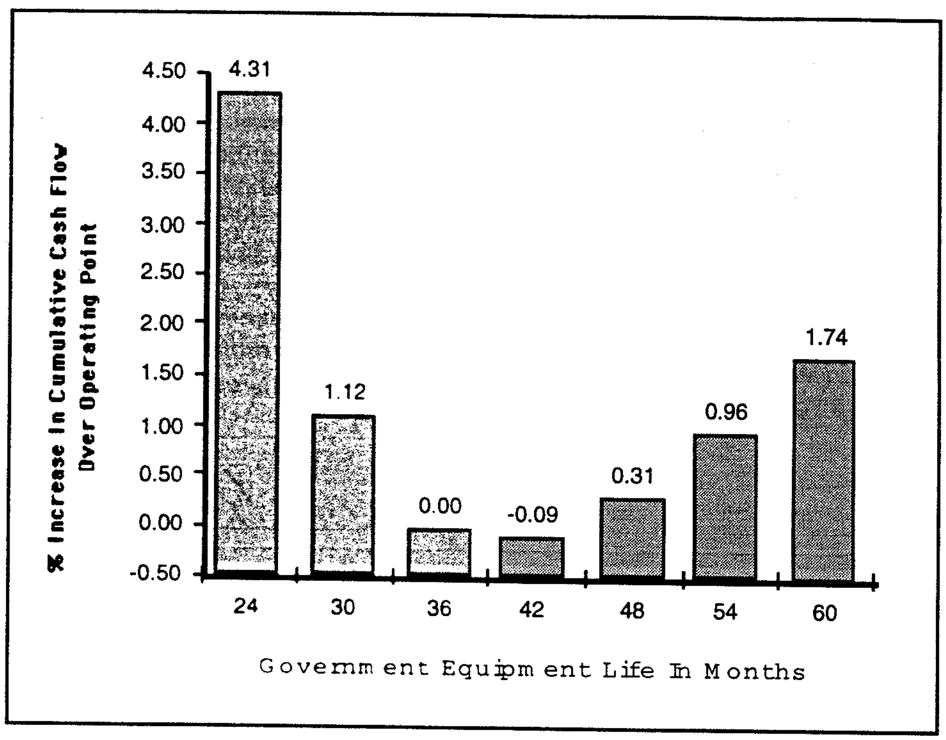

Figure 6. Cumulative Cash Flow Versus Government Equipment Life At LAN Operating Point

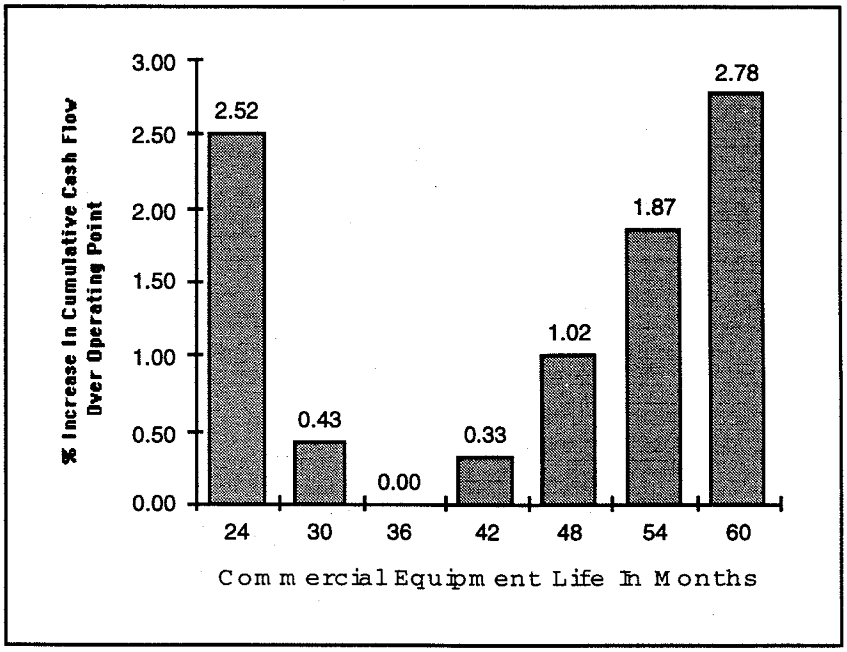

Figure 7. Cumulative Cash Flow Versus Commercial Equipment Life At LAN Operating Point

Gradient

The gradient gives the change in output per unit change in selected parameter value when all other parameters are held fixed. It is the partial derivative of the output measure relative to each controllable model parameter. The model output measures are the cumulative cash flow and the discounted cash flow. The gradient gives the normal to the hyperplane tangent to the iso-cost surface (see figure 8). It is the direction of fastest increase in cost. Figures 9 and 10 show the cumulative cash flow gradients for government and commercial operation. For example, in Figure 9 every 1 percent increase in government procurement cost proportion (ProcCost percent) of equipment price results in 1.64 percent increase in total cumulative cash flow (cost) over the operations period. The factor abbreviations, full names, and factor change for gradient calculation (in parenthesis) are as follows:

- Life6moDec, equipment lifetime decrement (6 months)
- Proc mo, procurement and installation time increase (1 month)
- Interest%, Interest rate increase(1%/year)
- Price %, equipment price increase (1% / year)
- OM/$Init%, initial annual operations and maintenance dollars as a percentage of investment dollars increase (1%)
- OM/$inc%, increase in operations and maintenance costs (1%/year)
- ProcCost%, increase in procurement processing cost as a percentage of equipment price (1%)
- Profit%, increase in profit as a percentage of sales (1%)
- Tax%Dec, decrease in tax rate (1%)
- DepLife%Dec, decrease in depreciation life time (1%)
- Salvage Dec, decrease in salvage percentage (1%)

The dot product of the gradient with a proposed policy vector, which represents a plan to change parameter values, gives the cost impact of that policy. Gradients and policy vectors should be investigated at various operating points in future extensions of the model. Since the actual iso-cost surface is curved, the gradient only holds for a small region around the operating point. Another extension would be to fit a quadric surface to a set of model runs. This would aid in determining minimal cost operating points and apply over a larger operating region. A simple three-parameter example is given in the next paragraph.

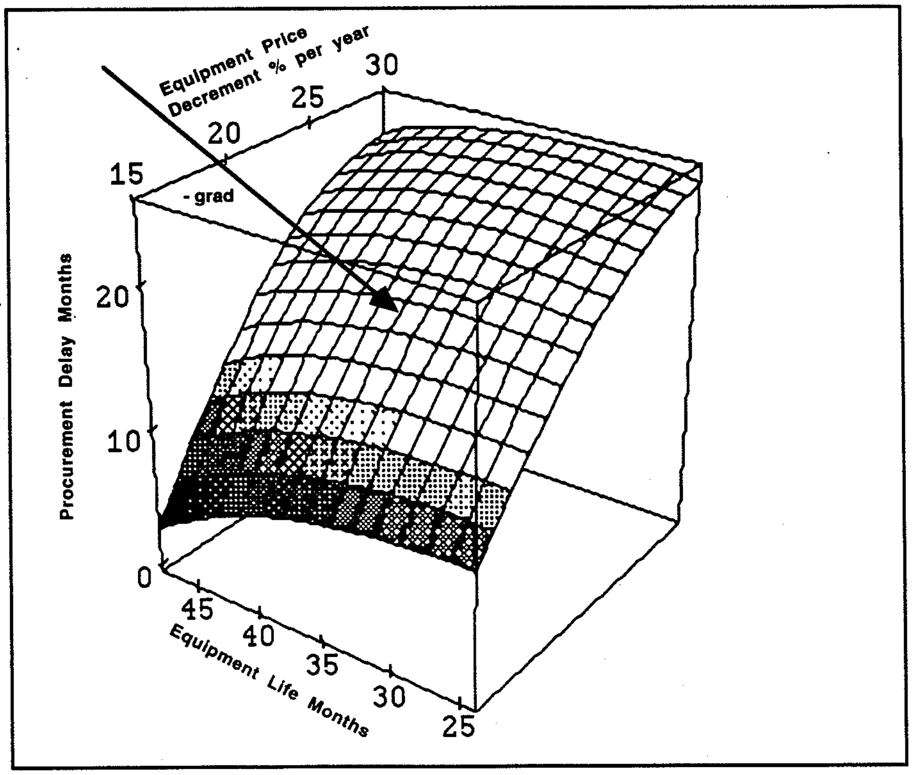

Figure 8. 60 Percent Cost Reduction Surface and Gradient

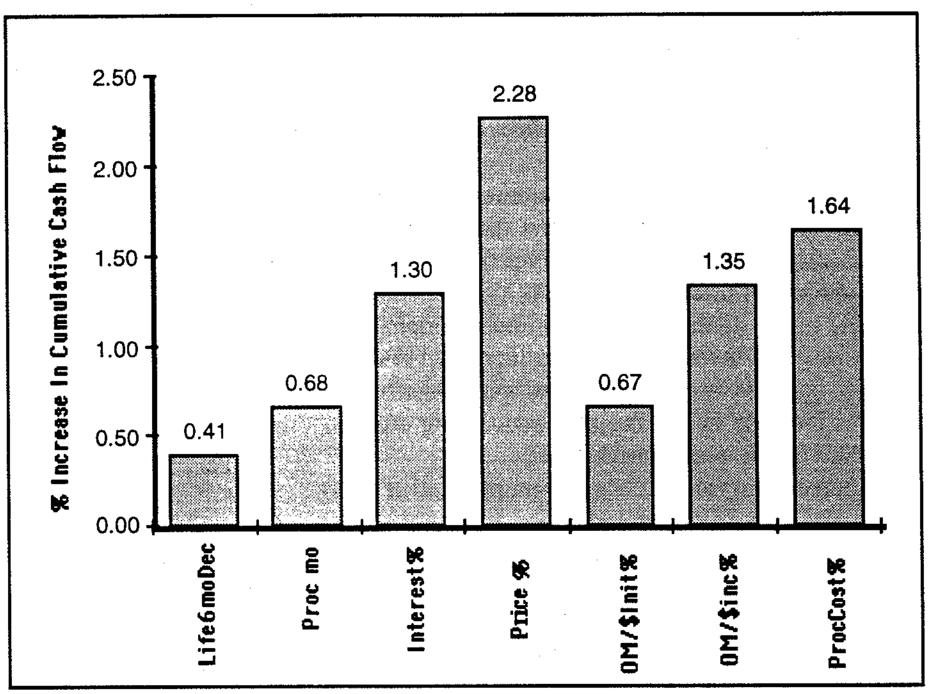

Figure 9. Government Cumulative Cash Flow Gradient

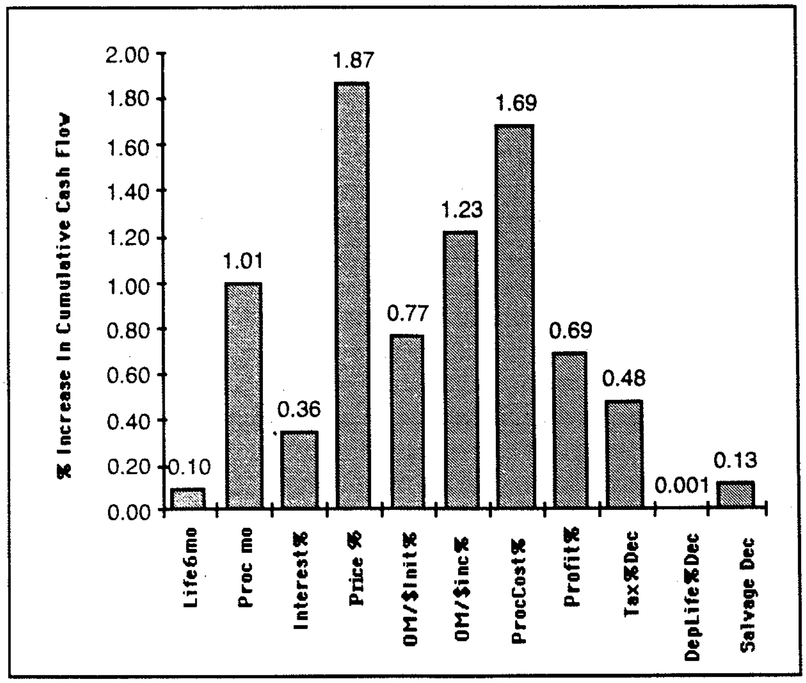

Figure 10. Commercial Cumulative Cash Flow Gradient

Cost hypersurface

A complete factorial design of 27 PEG runs was completed to vary equipment lifetime, procurement delay and decrement in equipment price. The output measure was total cost per unit at the end of the five year run divided by initial cost per unit at the start (C). The following parameter abbreviations and values were used.

- (life) equipment life in months [24,36,48]
- (dec) decrement in equipment price percent per year [10,20,30]
- (delay) procurement processing delay in months [3,12,21]

The following quadric surface was least squares fit to the commercial data.

$$C = .701 - .003\ \text{life} - .032\ \text{dec} + .013\ \text{delay} + .00006646\ \text{life}^2 + .0004526\ \text{dec}^2 + .00007181\ \text{life dec} - .0001424\ \text{life delay}$$

All terms were highly significant (.0008 t probability level for life coefficient , .0001 t probability level for all other factor coefficients). The multiple correlation coefficient squared was 99.7 percent, so only 0.3 percent of the data variability was not explained by the equation. To obtain the 40 percent total cost surface (60 percent reduction), we set C=.4 and solve for procurement delay (delay) in terms of equipment life (life) and decrement in equipment price (dec).

$$\text{delay} = (301 - .003\ \text{life} + .00006646\ \text{life}^2 - .032\ \text{dec} + .0004526\ \text{dec}^2 + .00007181\ \text{life dec}) / (.013 - .0001424\ \text{life})$$

To obtain the gradient (grad) we take the partial derivatives of C relative to life, dec, and delay. The gradient (grad) gives the direction of most rapid cost increase, and is perpendicular to the cost surface at the operating point. We are interested in the negative gradient, i.e. the direction of most rapid cost decrease. Figure 10 shows the cost surface and perpendicular gradient. Though we can only show 3 dimensional surfaces, the mathematical techniques apply equally to higher dimensions.

Conclusions

The PEG model can quantitatively evaluate the economics of outsourcing. The model is general and can separately be applied to a wide variety of product categories. Products are categorized by their similarity in average parameter values. A by-product of the model is a cost per unit output versus simulation time. This should aid in setting fee-for-service algorithms.At the assumed operating point, the break-even commercial profit is 60 percent of sales. Thus outsourcing LAN services seems superior. However this is based on some key assumptions that should be checked:

- Average government installed base age of 30 months versus 15 months for commercial (37 percent break-even profit for both 15 months)
- DOD system boundary that does not account for the depreciation tax losses to the Treasury
- No government outsourcing monitoring costs (not contained in the model)
- There is no DOD salvage value - change in regulations or equipment refurbishment and reuse could change this assumption
- LAN equipment price reductions of 20 percent per year (higher growth rates lead to a higher break even profit)

Significant government cost reduction can be obtained from a reduction in procurement delays (7 percent of total costs by reducing delay from 12 months to 3 months). The optimal government equipment life time is approximately 42 months (for the assumed operating point). Lower capability growth rates and smaller operations and maintenance decrement rates would lead to longer optimal equipment life times.

LAN services are only one category of product. Other categories should be defined for products with different characteristics (different average parameter values operating point) such as:

- Equipment price decrement rate
- Operations and maintenance cost proportion
- Procurement cost proportion and time delay

Products can be ranked by the break even commercial profit on sales. The highest profit products are the prime candidates for outsourcing. A by-product of the model is cost per unit versus time. This should guide setting fee-for-service algorithms. The model provides simplified sensitivity analysis, so the impact of changes in cost of any model parameter can be determined. process itself. Thus the policy vector differs practically from the gradient. The potential policy vector envelope should be explored in future work.

References

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