Sensitivity of Construction Contract Prices to Required Rate of Return and Retainage

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The fair and reasonable markup (FaRM) is the smallest markup that satisfies the required rate of return (RRR) of the contractor for the particular project at hand or its general risk class. The microcomputer-based FaRM pricing model provides a systematic and efficient framework for analyzing the forecast cash flow stream of the project and for estimating the minimum acceptable price (MAP). The model utilizes a LOTUS 1-2-3 spreadsheet and can be implemented on most IBM or IBM-compatible microcomputers. The computerized model delivers speedy responses to a variety of what-if questions investigating the sensitivity of FaRM and MAP to the RRR of the contractor and to the retainage policy of the agency. Once the FaRM pricing model has been implemented, contractors should bid lower on projects that are more attractive, and should become more competitive in other ways as well. This strategy should result in lower costs to agencies while satisfying the RRR of the contractors. Conversely, contractors can maintain their RRR on the less attractive projects by submitting higher bid prices.

An earlier article reviewed conventional pricing practices used in construction within the framework of basic price-setting models used in free-market economies (*1*). The contractors' lack of financial and managerial skills coupled with the intense competition inherent in competitive bidding were identified as the factors responsible for improper pricing decisions by contractors.

The fair and reasonable markup (FaRM) pricing model proposed a present-value approach to pricing of construction contracts (*2*). This approach was a cost-oriented pricing technique in the sense that it attempted to ensure an adequate return on the investment of the contractor. The FaRM pricing model demonstrated that the markup was a function of the required rate of return RRR and the cash flow schedule of the project.

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Once the FaRM pricing model has been implemented, contractors should bid lower on projects that are more attractive, and should become more competitive in other ways as well. This strategy should result in lower costs to agencies while satisfying the RRR of contractors. Conversely, contractors can maintain their RRR on the less-attractive projects by submitting higher bid prices.

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FaRM PRICING MODEL

The model considered several factors and eventually adopted the following definition for the markup that was considered fair and reasonable:

> The FaRM would be viewed as the smallest markup which satisfies the required rate of return (RRR) of the contractor for the particular project at hand or its general risk class, where the RRR is the return investors expect the firm to earn on its projects. This is the return required to maintain the present market price of a share of common stock of the firm (*2*, p. 375-376).

The basic FaRM pricing model was demonstrated with a manageably sized, hypothetical example project—the University of Illinois' International Friendship House (UI-IFH). The example project assumed an RRR of 2 percent per period (month) including a premium for uncertainties involved in the project. The UI-IFH example project assumed that there were no federal, state, or local income taxes and that inflationary pressures were negligible (*2*, p. 376).

COMPUTERIZED FaRM PRICING MODEL

The microcomputerized FaRM pricing model is demonstrated by the same UI-IFH example project so that results of the manual and computerized models can be easily compared without unnecessary repetitions.

The model uses LOTUS 1-2-3, Release 2.01 (L123-2), spreadsheet and can be implemented on most IBM or IBM-compatible microcomputers with a minimum of 256K random-access memory (RAM) (*3*). The row and column format of this popular spreadsheet combined with macros, functions, and the formula-writing capabilities of L123-2 provide an efficient framework for programming the FaRM pricing model. The spreadsheet-based model is cost-effective and should serve as a powerful and user-friendly educational software that demonstrates versatility of spreadsheets as well.

Input Data

As soon as the computerized FaRM pricing model is loaded, the software prompts the user to enter total cost of the project, the initial retainage, and the required rate of return. The user may wish to enter the project name, I.D. number, and the user's name as well.

The major input data consist of the project's cumulative-total-cost curve, commonly known as the "S curve" or the progress report, which is readily accessible. Figure 1, the modified cumulative total estimated cost curve, shows the S curve for the hypothetical example project UI-IFH.

The term "modified" signifies that the vertical axis shows cumulative cost as a percentage of the total estimated cost of the project. Other information needed as input to the model includes billing, payment, and retainage policies that are usually specified in the contract (*2*, p. 376-380).

Cash Flow Schedule

A modified version of the cumulative cash flow schedule for the UI-IFH example project is presented in Table 1. The information depicted in Figure 1 is directly entered in this table under Column *a* by the user.

Cash flow analysis is primarily concerned with the amount and timing of the actual funds transferred rather than costs incurred. Thus, Table 1 is based on the assumption that the management requires the company to have available at the end of each time period sufficient funds for the projected total incurred cost of the following period (*2*, p. 380-381).

The cumulative unallowables are also direct entries by the user. These are cost items, such as home office overhead (HOOH) expenses that may not be directly chargeable to the owner under certain contracts such as cost-plus-fee projects (*2*, p. 387). The UI-IFH example project assumes that there are no unallowable costs so that the results can be compared with those of the original manual FaRM pricing model.

Billing-policy factor constitutes the last input data that are directly entered by the user under Column *d*. This factor enables the user to adjust cash flows if some of the incurred costs cannot be included in certain progress billings and other situations such as front-end loading. Examples of such expenses include cost of mobilization, haul roads, installing plants, and materials delivered to the site but not yet used in any completed work (*2*, p. 381).

The model is based on a payment time lag of one period. The contractor submits progress billings at the end of each period. The owners or engineers have one period to process, verify, and arrange the payment. Thus, the contractor usually receives the actual payment at the end of the following period (*2*, p. 382).

Output Data

The microcomputer-based FaRM pricing model then generates the remaining part of the data presented in Table 1. The model automatically computes the FaRM as a function of the RRR and the cash flow schedule of the project for each run as presented in Table 2.

The computer then generates a list such as the following one in which the MAP is determined by adding FaRM and cost of bond to the total chargeable cost of the project.

Total chargeable cost of project	$720,000
FaRM at 4.5 percent	32,400
Contract price before bond premium	$752,400
Cost of bond	5,275
Minimum acceptable price (MAP)	$757,675

Assigning a new value to any one of the variables results in automatic computation of a new set of cash flow schedule, FaRM, and MAP. This feature provides speedy responses to a variety of what-if questions for performing sensitivity analysis.

SENSITIVITY ANALYSIS

The accuracy of the FaRM and MAP estimated by the model is, of course, a function of the accuracy of the input data. But, at the busy time period just prior to bidding on or negotiating a construction contract, only a limited amount of information is available. Thus, most of the input data to the model can best be described as random variables.

The FaRM pricing model assumes that all the values entered, for example, costs, cash flows, RRR, and so forth, are expected values. Instead, RRR should include an allowance, that is, a premium, to compensate for the uncertainties involved in cash flow figures and other input data. Thus, the accuracy of the RRR is a key factor in the success of the model. Estimating the RRR, however, is more an art than a science, at least at the present state of knowledge. Therefore, the impacts of varying RRR on FaRM and MAP should be of utmost interest to major parties involved in the construction process. The computerized FaRM pricing model provides an efficient system for conducting such sensitivity analyses. In fact, all data presented in the following sections are generated by the model.

Sensitivity of FaRM and MAP to RRR

Figure 2 shows the sensitivity of the fair and reasonable markup to the required rate of return for the UI-IFH example project. The data confirm that FaRM is quite sensitive to RRR. The passage of the curve through the origin serves as a spot check for verifying the accuracy of the analysis. Recall that the basic UI-IFH example project analyzed here assumes that there are no unallowable costs. That is, the example is based on the premise that every item of cost to the contractor is included in the pool of the total estimated cost of the project. Thus, if there were no time value of money and no uncertainties involved in the project, both unrealistic but implied by a zero RRR, then FaRM would indeed be zero as well.

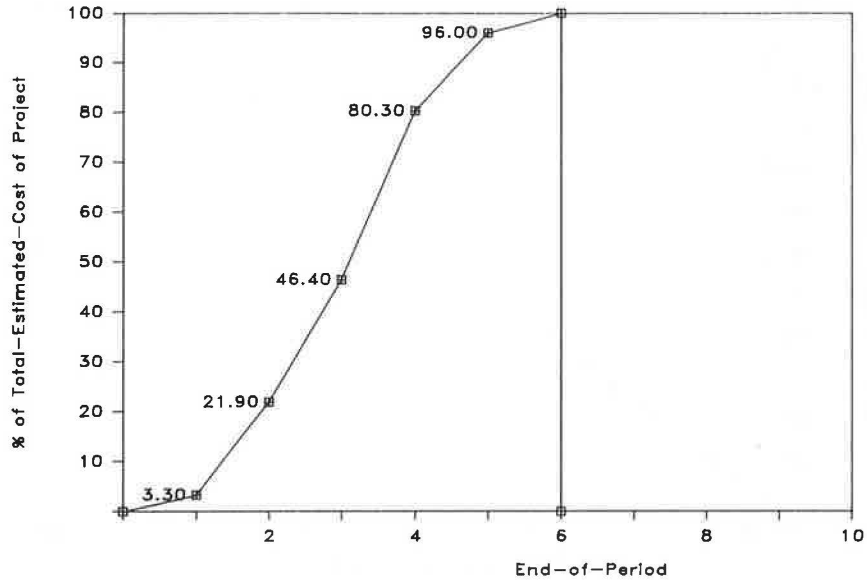

FIGURE 1 Modified cumulative total estimated cost curve.

TABLE 1 MODIFIED CUMULATIVE CASH FLOW SCHEDULE

End of Period j	Cmltv. Total Cost a	Less: Cmltv. Unallo-wables b	Cmltv. Charge-able Costs c	Billing Policy Factor d	Cmltv. Bill-able Cost e=c.d	Less: Retain-age @ 10.0% f	Cmltv. Payments before FaRM: Due g	Recvd. h
0	3.3		3.3	1.00	3.3	-0.33	2.97	--
1	21.9		21.9	1.00	21.9	-2.19	19.71	--
2	46.4		46.4	1.00	46.4	-4.64	41.76	2.97
3	80.3		80.3	1.00	80.3	-8.03	72.27	19.71
4	96.0		96.0	1.00	96.0	-9.60	86.40	41.76
5	100.0		100.0	1.00	100.0	-10.00	90.00	72.27
6								86.40
7								100.00
8								
9								
10								
11								
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15								
16								
17								
18								
% of Total Cost	100.0		100.0	1.00	100.00	-10.00	90.00	100.00
Cost in $1000	720		720	1.00	720.00	-72.00	648.00	720.00

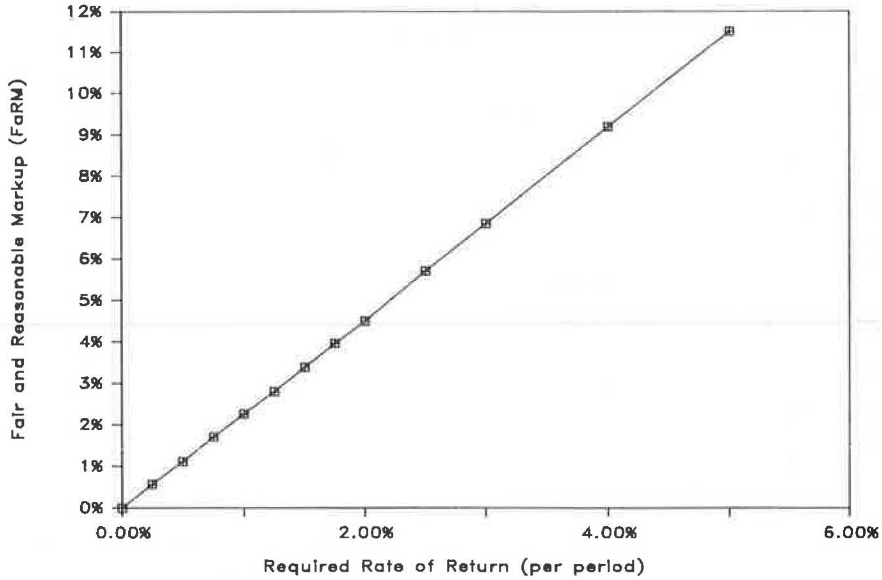

FIGURE 2 Sensitivity of FaRM to RRR.

TABLE 2 FaRM: A FUNCTION OF RRR AND CASH FLOW SCHEDULE

End of Period	Present Value Factor at R = 2.00%	Cash Outflows (Total Cost for the Following period) as % of Total-Cost of Project		Cash Inflows (Payments before FaRM Received) as % of Total Cost of Project	
j	(P/F,R%,j)	c(j) = a(j) - a(j-1)	PV[c(j)]	s(j) = h(j) - h(j-1)	PV[s(j)]
0	1.000	-3.3	-3.30	--	--
1	0.980	-18.6	-18.23	--	--
2	0.961	-24.5	-23.54	2.97	2.85
3	0.942	-33.9	-31.93	16.74	15.77
4	0.924	-15.7	-14.51	22.05	20.37
5	0.906	-4.0	-3.62	30.51	27.64
6	0.888	--	--	14.13	12.55
7	0.871	--	--	13.60	11.85
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
Sum of c(j)		-100.0	-95.14		
Sum of s(j)				100.00	91.03

NPV(R%,N' periods) = [1 + m(f)] Sum PV[s(j)] + Sum PV[c(j)] = 0

$$m(f) = - \frac{\text{Sum PV}[c(j)]}{\text{Sum PV}[s(j)]} - 1 = \frac{95.14}{91.03} - 1 = 0.045$$

FaRM= 4.5%

Computations of FaRM as presented in Table 2 indicate that FaRM is not a linear function of RRR. Figure 2 shows a linear relationship because of a 0 to 5 percent range for RRR and because this small example project will be substantially complete by the end of the sixth period.

Figure 3 shows the sensitivity of FaRM to a wider range of RRR. The plot confirms that the general relationship is convex and not linear. That is, the marginal increase in FaRM becomes larger as RRR increases. However, a linear assumption may be an acceptable approximation as long as the RRR is limited to perhaps 20 percent per period and cash flow duration is shorter than some 12 periods.

Figure 4 shows the sensitivity of the MAP to the RRR. The shape of the relationship is, of course, similar to that of Figure 2. The MAP varies from $725,063 for zero RRR to $808,477 for an RRR of 5.00 percent per period.

Sensitivity of FaRM and MAP to Retainage

Figure 5 shows the sensitivity of FaRM to retainage for the UI-IFH example project. This plot indicates that FaRM is sensitive to retainage but not as sensitive as it was to RRR. FaRM still increases from 4.0 percent at no retainage to 5.0 percent at 20 percent retainage—a 25 percent increase, which is not negligible.

Figure 6 shows the effect of varying retainage on the MAP. As retainage grows from 0 to 20 percent, MAP increases from $754,124 to $761,371.

FaRM and MAP are not, in general, linear functions of retainage. Again, Figures 5 and 6 show linear relationships simply because they are based on a 2.0 percent RRR and a six-period duration. Figure 7 shows the sensitivity of MAP to the same zero to 20 percent range of retainage but with an RRR of 100 percent. This plot also confirms that the general relationship is not linear but convex. In other words, the incremental increase in MAP grows with increasing retainage. Again, a linear assumption might be acceptable as long as the cash flow stream extends no more than, say, 12 periods and RRR is no larger than some 20 percent per period.

SUMMARY AND CONCLUSIONS

The microcomputer-based FaRM pricing model automatically computes FaRM as a function of RRR and the cash flow schedule of the project based on a present-value analysis. The MAP is determined by adding FaRM and cost of bond to the total chargeable cost of the project. Assigning a new value to any one of the variables results in automatic computation of a new set of cash flow schedule, FaRM, and MAP data. This feature provides speedy responses to a variety of what-if questions for performing sensitivity analysis.

The model uses LOTUS 1-2-3, Release 2.01, spreadsheet and can be implemented on most IBM or IBM-compatible microcomputers with a minimum of 256K RAM. The row and column format of this spreadsheet combined with its macros, functions, and formula-writing capabilities provide an efficient framework for programming the FaRM pricing model. The spreadsheet-based model is cost-effective and should serve as powerful and user-friendly educational software.

FaRM and MAP are quite sensitive to RRR but the general relationships are convex and not linear. That is, the marginal increases in FaRM and MAP become larger as RRR increases. FaRM and MAP are not as sensitive to retainage as they are to RRR. FaRM and MAP are not, in general, linear functions of retainage. In fact, the incremental increases in both FaRM and MAP grow with increasing retainage.

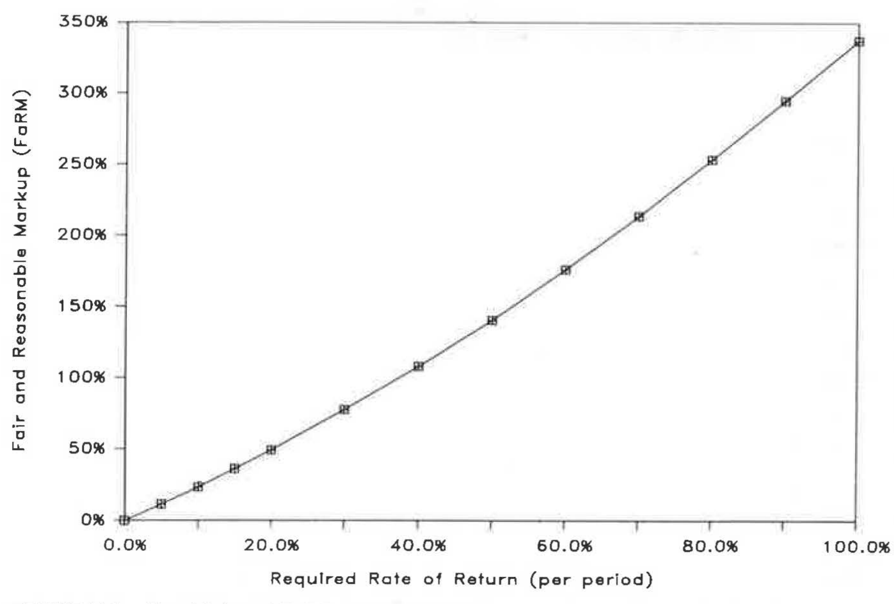

FIGURE 3 Sensitivity of FaRM to large RRR.

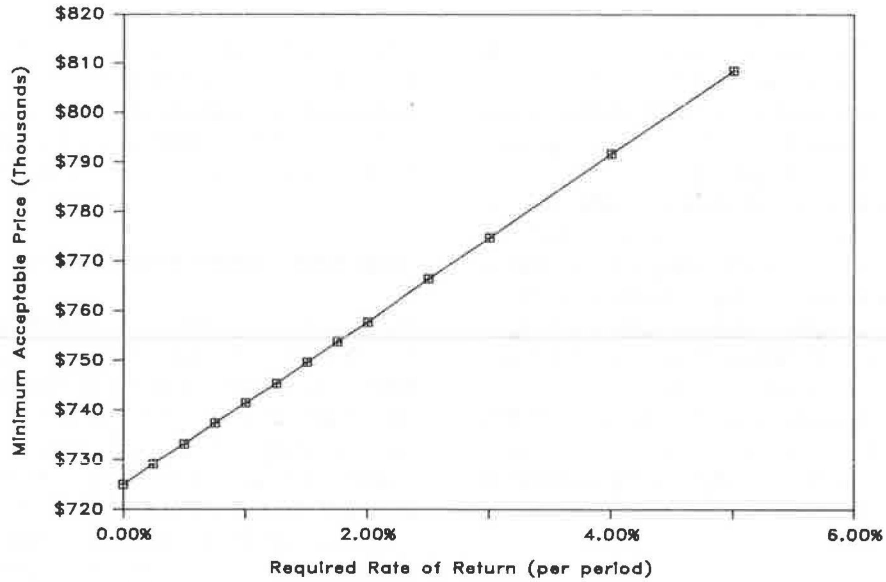

FIGURE 4 **Sensitivity of MAP to RRR.**

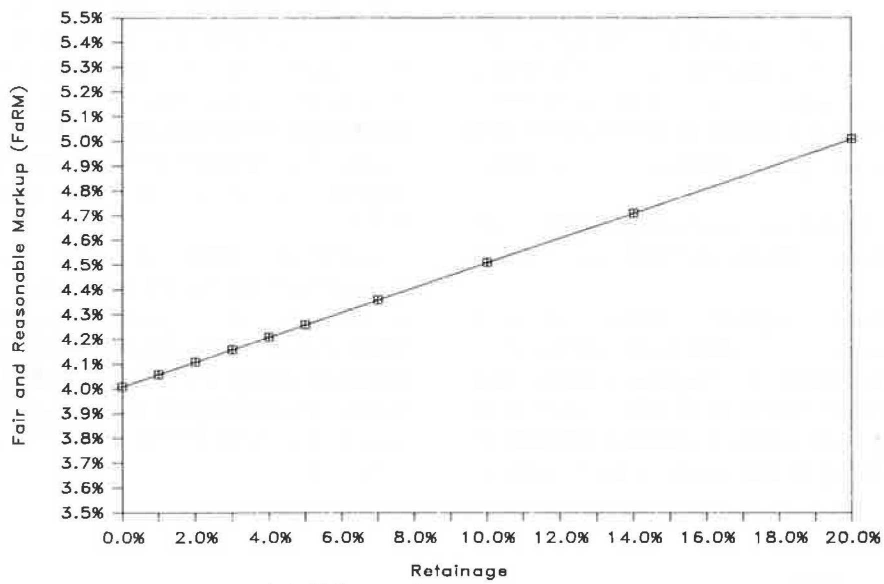

FIGURE 5 **Sensitivity of FaRM to retainage.**

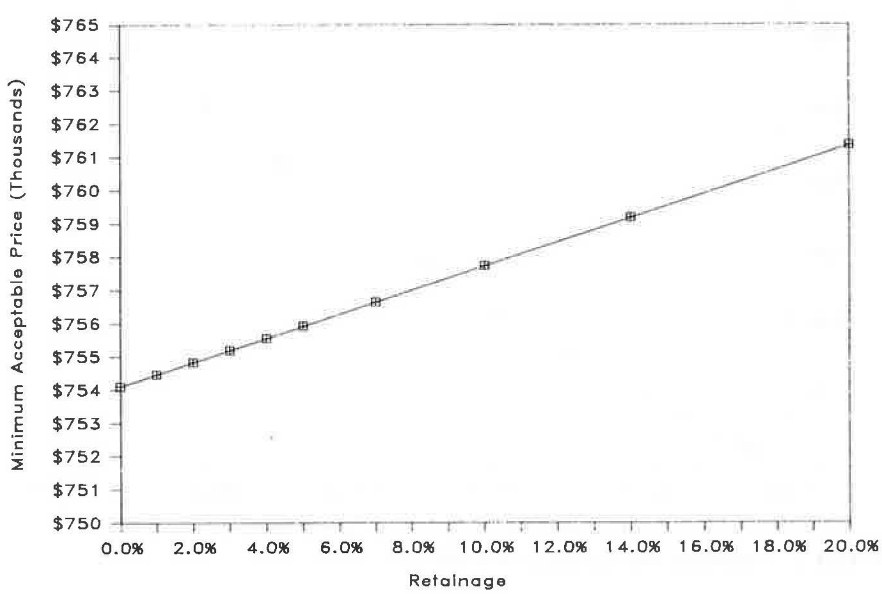

FIGURE 6 **Sensitivity of MAP to retainage.**

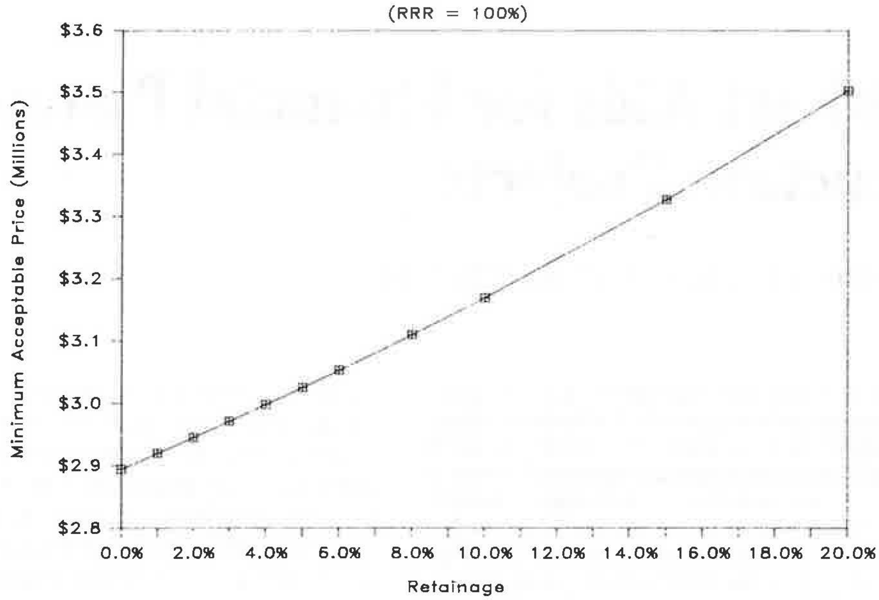

FIGURE 7 Sensitivity of MAP to retainage at RRR = 100 percent.

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