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OIL AND GAS WELL INVESTMENT ANALYSIS USING THE LOTUS 1-2-3 DECISION SUPPORT SYSTEM

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ABSTRACT

This paper describes a decision support system using Lotus 1-2-3 designed to introduce the student to widely used measures of investment worth. The software has been applied successfully in the classroom and also on a professional level in evaluating the value of oil and gas investment proposals. The basic procedure involves forecasting revenues and expenses and the resulting cash flows. These cash flows are then evaluated using several different techniques. The student can use sensitivity analysis to gain an appreciation for the critical variables by changing the values of the input variables and observing the corresponding changes in the output variables.

INTRODUCTION

Presentation of capital budgeting and investment analysis techniques is a critical part of any business oriented curriculum. While the described simulation system is rather specialized, it is an excellent vehicle for presenting these concepts and provides hands on interaction with the individual student.

The objectives of capital budgeting are to identify and to rank projects that will maximize the present value of a firm or an individual. A common method of ranking project proposals currently being used throughout the petroleum industry is the discounted cash flow technique (see Thompson and Wright [3]). The annual cash flows associated with an oil or gas property are seldom constant and cannot be treated like an annuity. Non-constant cash flows over time result in a need to evaluate the investment on a year by year basis and can involve huge amounts of "number crunching" for proposals with expected lives of over 20 years. An effective computerized decision support system can greatly reduce the user time required to evaluate a proposal by handling the quantitative aspects of the investment analysis (see McLeod and Mazursky [2]). This will allow the user more time to concentrate on the qualitative aspects of the analysis that require judgment or expert knowledge.

The purpose of this paper is to describe a decision support system (DSS) designed to assist the user in evaluating oil and gas investment opportunities. The input and output variables are described in chronological order in the body of the report with reference to actual output found in Figures A and B. The general description of the system is followed by a critique of its flexibility and limitations. Basic instructions required to operate the system are provided in Appendix I. Appendix II outlines the procedure for calculating the production of oil and gas over a given period.

General Overview

The sequential nature of Lotus 1-2-3 operations resulted in a "dual" spreadsheet (see Bolocan [1]). The input format is demonstrated in Figure A. Most output variables shown in

Figure B were calculated in cells outside of the printed range. This approach was required due to the fact that the value of certain cells in the matrix were dependent on values in cells that came sequentially later. In order to avoid having to calculate the entire spreadsheet twice, the required calculations were located outside of the printed range and sequentially higher on a row basis. Calculation is done on a row by row basis and this allowed the correct values to be available for placement in the printed range. A more detailed description of this technique will be provided in the output variable section of this paper.

System operation is fairly straightforward and the output consists of several generally accepted measures of investment worth. This information can be used to aid in capital allocation decisions.

Input Variables

The input variables will be discussed in chronological order as they appear in Figure A.

1. General Information: The data located at the top of page one identifies the name of the well being evaluated, the name of the owner, and the date the evaluation was run. A space is provided that can be used to distinguish between multiple runs on the same well. The example provided shows that this is the "worst" case analysis of Gusher No. 1.

2. Initial Potential: The initial potential is the expected starting flow rate for both oil and gas in barrels of oil per day and thousand cubic feet of gas per day units respectively. This information is normally provided by an engineering professional who bases his estimate on offset wellbores (if available).

3. Annual Decline Rate: Predicting the annual exponential decline rate requires subjective engineering judgment and can be based on analogous wellbores or local trends. The meaning of the annual decline will be described in detail in the output section of the paper. It is important to note that all input variables displayed on a percentage basis must be input as fractions; e.g., 1.0.

4. Working Interest: This variable describes the percentage of all costs that the evaluated interest must pay. The "evaluated interest" is simply a reference to the individual or group for whom the evaluation is being run.

5. Net Interest: This variable is the percentage of all revenues to which the evaluated interest is entitled. Individual working and net interests will be clearly defined in a document known as the Joint Operating Agreement.

6. Product Prices: Current market prices for oil and gas on a per barrel (BBL) and per thousand cubic feet (MCF) basis are used.

7. Escalate: The escalate variable allows prices to change over time depending on perceived future economic

factors and conditions. A negative value here will cause product prices to fall over time.

8. Maximum Price: This variable allows the user to set a ceiling product price following a systematic escalation described above.

9. Severance Tax Rate: This variable is a tax on gross production revenue that varies from state to state. Oklahoma's current rate is 7.085% for both oil and gas.

10. Annual Expenses: The annual expenses amount is the summation of annual fixed and variable expenses associated with the operation of the new well proposal. This variable is also generally referred to as operating and maintenance expenses.

11. Escalate: The escalation option for annual expenses is independent of the escalate variable for prices (#7).

12. Discount Rate: The desired discount rate is applied to annual cash flows that will be displayed in the output. There are several criteria used to select the discount rate such as the evaluated interest's average investment opportunity rate, the cost of capital, or perhaps some management established minimum acceptable rate of return.

13. Project Life: The maximum life of the project to be considered is independent of the overall economics. Historical data sometimes shows that the physical life of the wellbore in question may be less than the economic life. The system is set up to end the evaluation based on the input project life or the economic limit, whichever comes first.

FIGURE A
DATA FOR OIL & GAS WELL INVESTMENT APPRAISAL

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ID#                              Oil           Gas

1 Well Name:  Gusher #1
  Case:  Worse
  Owner:  Big Dollar Oil Co.
  Date:  4/16/86

2 Initial Potential       40   BOPD      80   MCF
3 +Annual Decline Rate  15.00% per yr  15.00% per yr
4 +Working Interest     80.00%         80.00%
5 +Net Interest         75.00%         75.00%
6 #Product Prices       $12.00  per bbl $1.50  per mcf
7 +Escalate              0.00% per yr   0.00% per yr
8 ?Maximum Price        $25.00  per bbl $3.00  per mcf
9 +Severance Tax Rate    7.085%         7.085%

10 Annual Expenses       $8,500
11 +Escalate              5.00% per yr
12 +Discount Rate        12.00%
13 *Project Life            20  years
14 Starting Year          1986
15 $Investment Required 500000

16 !Discounting Method       1


+ All percent values must be entered as fractions

# Current oil and gas market prices

? Ceiling price for oil and gas

* Maximum life of product

$ Time zero investment

! Discount method:  1-mid period, 2-end period
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The economic limit is defined as that point in time where the annual cash flow becomes negative.

14. Starting Year: This variable provides a starting reference point for the evaluation.

15. Investment Required: The estimated time zero investment variable is the dollar amount required to generate the forecasted cash flows. It is the cost of the proposed well.

16. Discounting Method: Two types of fiscal year discounting methods are available in the analysis. Inputting 1 assumes that all annual cash flows following the initial investment occur at mid-year--June 30th. Inputting 2 assumes that cash flows occur at the end of the year.

17. General Information: Brief input instructions and descriptions for some of the input variables are provided at the bottom of Figure A.

Output Variables

Output variables will be described in chronological order as they appear in Figure B.

1. Gross Production: One of the most common and generally accepted methods of forecasting future oil and gas production is the exponential (constant percentage) decline technique. The basic relationships and process are as follows:

$$q = q_o e^{-dt}$$

q_o = Starting flow rate
q = Ending flow rate
e = 2.718
d = Annual decline rate
t = Time from q_o to q

The starting flow rate and annual decline variables provided as input data can be used to calculate the rate at any time t in the future. To calculate the total oil or gas produced during a period (year) both the starting and ending rate must be known. The starting and ending rates for oil and gas are calculated outside the printed range and above where this data is required to generate printed output.

Integration of the rate equation above will result in a relationship that can be used to calculate fluid produced during any given time period.

N_p = Production from time = 0 to time = t

$$N_p = \int_0^t q \, dt$$

substituting for q:

$$N_p = \int_0^t q_o e^{-dt} \, dt$$

Integrating:

$$N_p = \frac{q_o}{-d} e^{-dt} \Big|_0^t$$

Applying Limits

$$N_p = \frac{q_o}{-d} [e^{-dt} - e^0]$$

Recalling that $q = q_o e^{-dt}$

$$Np = \frac{q_o - q}{d}$$

This is the basic relationship used to calculate the gross annual production for oil and gas. An example calculation is provided in Appendix III.

2.   Net Production: Net production is simply the product of gross production and net revenue interest.

3.   Revenue: Net revenue is the sum of net oil production times oil price and net gas production times gas price.

4. Production + WP Taxes: The production tax as mentioned earlier is simply a severance tax placed on gross revenue from oil and gas production. WP stands for windfall profit tax. This charge has currently fallen out of project analysis due to the fact that depressed product prices are at the present time below the base price used to determine windfall profit and the corresponding taxes.

5.   Future Investment: The future investment column was provided to allow the user to account for future expenses not included in normal operating expenses. For example, the $40,000 incurred in year four in Figure B is for a

replacement gear box and motor for a pumping unit. This forecasted expense would not be included in the annual expense column. If future one time investments of this nature are forecasted, the user must place these values in the appropriate cells prior to calculation.

6. Operating Income: Operating Income equals Revenues minus (Production and WP Taxes), minus Operating Expenses and minus Future Investments.

Operating income also has to be calculated outside of the printed range and above the printed output cell so that the economic limit can be identified and the evaluation terminated at that point. Including negative cash flows in the evaluation would not be realistic.

7. Discount Factor: The discount factor is used in the compound interest formula to calculate the present value of future cash flows discounted at a given rate.

$$PV = FV * \frac{1}{(1+i)^n}$$

PV = Present Value

FV = Future Value

i = Discount Rate

FIGURE B
PRODUCTION SCHEDULE & ECONOMICS

Well Name: Gusher No. 1   Owner: Big Dollar Oil Co.   Date: 4/16/86
    Case: Worst

| | (1) GROSS PROD | | (2) NET PROD | | PRICES | | (3) | (4) | (5) | (6) | (7) | | (8) |
YEAR	OIL (MBBL)	GAS (MMCF)	OIL (MBBL)	GAS (MMCF)	OIL ($/BBL)	GAS ($/MCF)	REVENUE	PROD + WP TAXES	OPERATING EXPENSES	FUTURE INVEST	OPERATING INCOME	DISCOUNT FACTOR	P.V. @ 12.00%
1986	13.558	27.116	10.168	20.337	12.00	1.50	152525	10806	8500	0	133218	0.945	125880
1987	11.669	59.265	8.752	44.449	12.00	1.50	171697	9301	8925	0	113053	0.844	95380
1988	10.044	51.010	7.533	38.258	12.00	1.50	147781	8006	9371	20000	75616	0.753	56960
1989	8.645	43.905	6.484	32.929	12.00	1.50	127196	6890	9840	40000	40524	0.673	27255
1990	7.441	37.789	5.580	28.342	12.00	1.50	109479	5931	10332	0	67445	0.601	40501
1991	6.404	32.526	4.803	24.394	12.00	1.50	94229	5105	10848	20000	36095	0.536	19353
1992	5.512	27.995	4.134	20.996	12.00	1.50	81104	4394	11391	0	46228	0.479	22130
1993	4.744	24.096	3.558	18.072	12.00	1.50	69807	3782	11960	0	37632	0.427	16085
1994	4.084	20.739	3.063	15.554	12.00	1.50	60083	3255	12558	20000	10126	0.382	3865
1995	3.515	17.850	2.636	13.388	12.00	1.50	51714	2801	13186	0	23553	0.341	8025
1996	3.025	15.364	2.269	11.523	12.00	1.50	44511	2411	13846	0	17776	0.304	5408
1997	2.604	13.224	1.953	9.918	12.00	1.50	38311	2075	14538	0	12679	0.272	3444
1998	2.241	11.382	1.681	8.536	12.00	1.50	32974	1786	15265	0	8161	0.243	1979
1999	1.929	9.797	1.447	7.347	12.00	1.50	28381	1537	16028	0	4135	0.217	895
2000	1.660	8.432	1.245	6.324	12.00	1.50	24428	1323	16829	0	525	0.193	101
2001	0.000	0.000	0.000	0.000	0.00	0.00	0	0	0	0	0	0.000	0
2002	0.000	0.000	0.000	0.000	0.00	0.00	0	0	0	0	0	0.000	0
2003	0.000	0.000	0.000	0.000	0.00	0.00	0	0	0	0	0	0.000	0
2004	0.000	0.000	0.000	0.000	0.00	0.00	0	0	0	0	0	0.000	0
2005	0.000	0.000	0.000	0.000	0.00	0.00	0	0	0	0	0	0.000	0
TOTALS	87.074	400.490	65.306	300.367			1234221	69404	183418	100000	626766		427262

CUM GROSS OIL	87074 BBL	(9)
CUM GROSS GAS	400490 MCF	
CUM NET OIL	65306 BBL	(10)
CUM NET GAS	300367 MCF	

CUM NONDISCOUNTED OPERATING INCOME	626766 (11)
CUM DISCOUNTED OPERATING INCOME	427262 (12)

INTERNAL RATE OF RETURN	5.60% (13)
NONDISCOUNTED X'S INVESTMENT EARNED	1.25 (14)
DISCOUNTED X'S INVESTMENT EARNED	0.85 (15)

(16) PRESENT VALUE PROFILE

DISC RATE	NET P V	DISC RATE	NET P V
5.00%	11289	55.00%	-325511
10.00%	-70216	60.00%	-336219
15.00%	-130101	65.00%	-345670
20.00	-175628	70.00%	-354076
25.00%	-211251	75.00%	-361603
30.00%	-239815	80.00%	-368383
35.00%	-263197	85.00%	-374523
40.00%	-282678	90.00%	-380111
45.00%	-299156	95.00%	-385219
50.00%	-313276	100.00%	-389907

n = DM/2 + years from tune zero to cash flow where DM is the discount method provided as input data.

8. P.V. @ 12%: The present value of future operating income discounted at the given rate as outlined above.

9. Cum Gross Prod: Cumulative gross oil and gas production.

10. Cum Net Prod: Cumulative net oil and gas production.

11. Cum Nondisc Op Income: Cumulative non-discounted operating income.

12. Cum Disc Op Income: Cumulative discounted Operating income.

13. Internal Rate of Return: This variable is the discount rate that equates the future cash flows to the initial investment, or results in a net present value of 0. This is a built-in function that generates a solution through an iterative process.

14. Nondiscounted x's Investment Earned: Nondiscounted cumulative operating income/initial investment.

15. Discounted x's Investment Earned: Discounted cumulative operating income/initial investment.

16. Present Value Profile: The present value of future operating income discounted at the indicated rate minus the initial investment. This is a built-in function that assumes end of period cash flows.

Flexibility and Limitations

The primary advantage of this system is that several different scenarios can be run with a minimum time investment. Students have run a sensitivity analysis on the hypothetical well--Gusher No. 1. In this case it is assumed that some of the input variables, such as the annual decline rate and project life, were known while others like the initial potential, product prices, expenses, and the initial investment were subject to variability. The best, base and worst cases give the decision maker a range of possible values for measures for investment worth and an indirect indication of the risk associated with the investment.

This DSS, while obviously not as sophisticated as some mainframe software packages, does give a fairly good indication of oil and gas investment worth. When the DSS results were compared to various mainframe programs, they were very similar. The DSS is limited to the evaluation of oil and gas properties with production declining at an exponential rate. There are several other decline models arid the exponential decline method does not always provide the best curve fit. Other declining production relationships must be specially calculated and inserted into the DSS.

The sequential computation associated with the spreadsheet causes additional considerations, but most special needs can be handled by customizing the basic spreadsheet for specific applications. This aspect of the system does require, however, that the individual user be familiar with spreadsheet operations. While spreadsheet based decision support systems have certain built-in unavoidable limitations, creative thinking and a thorough understanding of operational procedures can go a long way in reducing inherent disadvantages.

Conclusion

The described software can be used by educators to develop the fundamental techniques of investment analysis. Scenarios developed by the instructor and executed by the student can be an effective demonstration of the importance of certain input variables such as the discount rate and the timing of cash flows. The software has proven to be a very effective learning tool in presenting time value of money concepts and the basics of investment analysis.

REFERENCES

[1] Bolocan, David, Lotus 1-2-3 Simplified, 2nd Edition (Tab Books, Inc., 1986).

[2] McLeod, Raymond, Jr. and Alan D. Mazursky, Decision Support Software for the IBM Personal Computer (Science Research Associates, Inc., 1986).

[3] Thompson, Robert S. and John D. Wright, Oil Property Evaluation (Thompson-Wright Associates, 1985).

APPENDIX I
INSTRUCTIONS FOR USER

A basic understanding of PC operations will be assumed. All references are to Figures A and B. Additional information concerning input and output variables can be found in the body of the report.

A. Place the Lotus system disk in drive A and the data disk in drive B. Turn the machine on.

B. Work through the menus to the Lotus spreadsheet.

C. Use the FILE command to call up the ECON spreadsheet.

D. Move the cursor to the appropriate cells and input the well name, owner, date and case description.

E. Move the cursor to column F and input the required information for oil production. All percent values must be input as fractions. Move the cursor to column H and input the gas information.

F. Move the cursor back to column F and input the rest of the required information.

G. Move to column L and input any forecasted future investments as in the output variable section.

H. Press F9 (Function Key #9) to calculate the new spreadsheet.

I. Save the new spreadsheet to a file name of your choice

J. Obtain a printout of the results if required.

K. Develop a new case or quit.

APPENDIX II
EXAMPLE PRODUCTION CALCULATION

Find: Oil production for year 1 given the information in Figure A.

q_o = 40 BOPD (Barrels of Oil Per Day)

d = 15% per year

Ending Rate: $q = q_o e^{-dt}$

q = (40 BOPD)$^{-.15}$ per year x 1 year

q = 34.428

Yearly
Production: $Np = \dfrac{q - q_o}{d}$

$Np = \dfrac{40.0 \text{ BOPD} - 34.428 \text{ BOPD}}{.15 \text{ per year}}$ = 37.144 BOPD x year

(37.144 BOPD x year) x 365 $\dfrac{days}{year}$ = 13,558 barrels oil

This value corresponds to value printed in Figure B.