# Optimal *f*: A Capital Management Tool for Multi-Well Drilling Commitment Decisions

**James A. MacKay and Gary P. Citron**

Rose and Associates, LLP, 7660 Woodway Dr., Ste. 590, Houston, Texas 77063

GCAGS Explore & Discover Article #00203*
http://www.gcags.org/exploreanddiscover/2017/00203_mackay_and_citron.pdf
Posted October 30, 2017.

*Article based on a full paper published in the *GCAGS Transactions* (see footnote reference below), which is available as part of the entire 2017 *GCAGS Transactions* volume via the GCAGS Bookstore at the Bureau of Economic Geology (www.beg.utexas.edu) or as an individual document via AAPG Datapages, Inc. (www.datapages.com), and delivered as an oral presentation at the 67th Annual GCAGS Convention and 64th Annual GCSSEPM Meeting in San Antonio, Texas, November 1–3, 2017.

## ABSTRACT

**Capital management tools are designed to maximize the return and mitigate the risk of a substantial financial loss. When applied to oil and gas investments, they use information about prospect size, chance, value and capital available to assist with working interest decisions for individual wells (MacKay, 2015). These decisions can be combined to assess an appropriate mixture of projects at recommended working interest levels for a more diversified portfolio (MacKay and Citron, 2016). Both previous publications used the Kelly Criterion to estimate HOW MUCH of a particular project should be capitalized. Optimal *f* addresses not how much but to HOW MANY projects should be capitalized. It is designed to address a group of similar projects where all could be flowing discoveries, but of highly variable initial productive rates and/or present values. Thus, Optimal *f* could be a helpful tool for sizing the number of wells in unconventional pilot projects.**

**We will focus on a group of nine similar wells that are sequentially drilled using the well present values and the capital available and calculate the number of additional well commitments that should be made in the same project or play. The results for each of the nine wells will be accumulated sequentially and the proposed future commitment will be calculated after the completion of each well as the well count builds from two to nine wells.**

Originally published as: MacKay, J. A., and G. P. Citron, 2017, Optimal *f*: A capital management tool for multi-well drilling commitment decisions: Gulf Coast Association of Geological Societies Transactions, v. 67, p. 217–225.

Rose & Associates

# Optimal *f* : A Capital Management Tool for Multi-Well Drilling Commitment Decisions

James A. MacKay
Gary P. Citron

2017 presentation of the Optimal f in a paper session at the GCAGS convention in San Antonio.

Rose & Associates

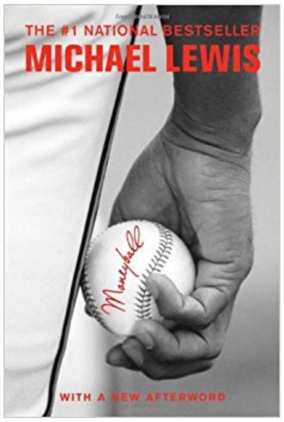
# Optimal $f$ : A Capital Management Tool for Multi-Well Drilling Commitment Decisions

James A. MacKay
Gary P. Citron

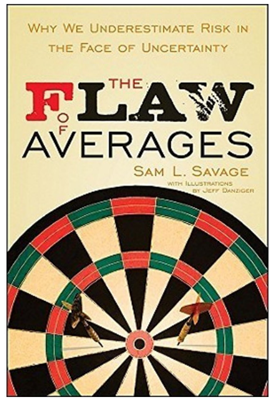
Part 3 in a series of GCAGS Papers

This is a continuation of the discussion of the Kelly Criterion published in the prior two years of the GCAGS transactions.

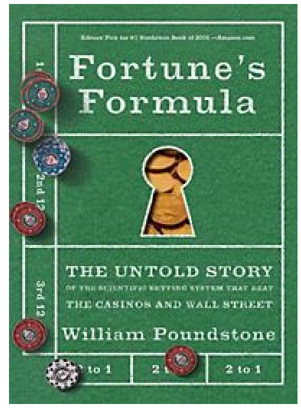
# Capital Management Decisions:




Utilizing Objective Data




Expected Value Limitations




The Kelly Criterion

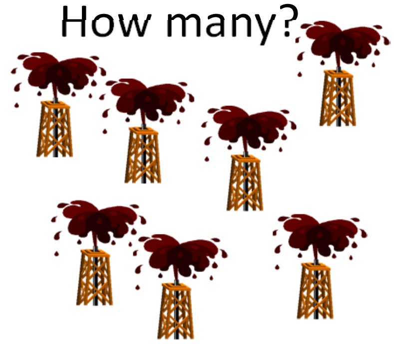
This presentation is a merger of three topics.

1. Utilizing objective data
2. Recognizing when the expected value is unrealistic
3. Developing investment strategy that both adds value and preserves wealth

# The Kelly Criterion & Optimal *f*

1. Optimal *f* is an extension of the Kelly Criterion
2. The question changes from

How much? to How many?



10% to 100%? 1 to 7 wells?

The Optimal f is designed to address the question “How many wells?” rather than the question “What percent of the well should I take?”.

## The Kelly Criterion: A Review

1. The Kelly Criterion is used by the financial industry to allocate capital.
2. The Kelly Criterion balances preserving wealth and adding value.
3. MacKay (2015, 2016) modified the formulas for the oil industry and published the results in last 2 year's GCAGS proceedings.

GCAGS 2016

Both the Kelly criterion and Optimal f are designed to allocate wealth to a project as well as protect wealth from erosion.

# Calculating The Kelly Criterion

The Kelly Criterion (K) is a simple, easy to create ratio of Expected Value (EV) to Present Value (PV)

$$K = EV / PV$$

GCAGS 2016

I have modified and simplified the Kelly criterion to be the ratio of expected value over present value.

## Calculating The Kelly Criterion

Kelly Criterion for an upcoming Project B:

Gain (G) = \$30; Cost (C) = \$10; Chance (Ps) = 50%

PV = G – C = 30 – 10 = \$20

EV = (Ps x G) – C = (0.5 x 30) – 10 = \$5

**K = \$5/\$20 = 25%**

**Note that the input data are all subjective opinions**

GCAGS 2016

The Kelly criterion as presented previously is based on subjective estimates of future, size, chance, value and cost. It is most applicable to conventional exploration projects for which there are not identical analogs.

## Calculating The Kelly Criterion

Kelly Criterion for a classroom game:

Gain (G) = \$30; Cost (C) = \$10; Chance (Ps) = 50%

PV = G – C = 30 – 10 = \$20

EV = (Ps x G) – C = (0.5 x 30) – 10 = \$5

The first question is usually

“How many tries do I get?”

It is designed to avoid “gambler’s ruin” or not having enough capital to sustain a series of bad outcomes.

## Calculating The Kelly Criterion

Kelly Criterion for a classroom game:

Gain (G) = \$30; Cost (C) = \$10; Chance (Ps) = 50%

PV = G – C = 30 – 10 = \$20

EV = (Ps x G) – C = (0.5 x 30) – 10 = \$5

A better question to yourself is

“This is a good game; can I afford to play it if I have \$15?”

Knowing how much you have to expose is required to do complete the calculation.

## Calculating The Kelly Criterion

Kelly Criterion for an upcoming Project B:

Gain (G) = $30; Cost (C) = $10; Chance (Ps) = 50%

PV = G – C = 30 – 10 = $20

EV = (Ps x G) – C = (0.5 x 30) – 10 = $5

**K = $5/$20 = 25%**

This represents the percentage of capital that should be allocated to the game.

The result is the percent of capital to should be allocated to this project to both preserve and maximize wealth. It is risk neutral because no adjustment has been made to address individual or corporate concerns for the potential loss of capital.

## Utilizing The Kelly Criterion

Therefore 25% of whatever capital (CA) is available should be applied to the game (up to a maximum of 100% of the cost), resulting in the Kelly Working Interest (KWI).
So, if Capital (CA) = \$15; and Cost (C) = \$10

**KWI = (K x CA) / C**

**KWI = (25% x 15)/10 = 38%**

GCAGS 2016

That percentage of wealth needs to be converted to a percentage of the project.

## Risk Tolerance

The capital available can be adjusted up or down. If so it is now a risk tolerance value.

Initial or neutral risk:

**KWI = (25% x 15)/10 = 38% interest**

Lower= risk averse:

**KWI = (25% x 10)/10 = 25% interest**

Higher = risk seeking:

**KWI = (25% x 20)/10 = 50% interest**

The result may be further modified to emphasize either capital growth (risk seeking) or capital preservation (risk averse).

## Calculating Optimal *f*

The Optimal *f* is used by the financial industry to calculate the appropriate number if similar investments.

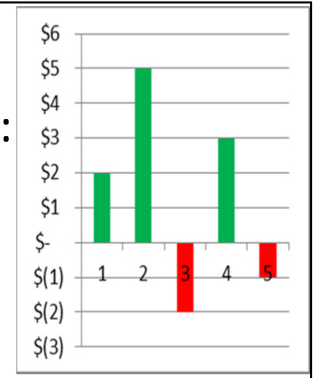
The Optimal *f* (F) can use the results of prior wells to calculate the average PV of all the prior wells (EV) and the average of all the successful wells that have a positive PV (AS)

**F = EV/AS**

Optimal f, like the Kelly criterion is the ratio of two averages: the expected result over the preferred result also known as edge over odds.

# Calculating Optimal *f*

The results in PV of 5 prior wells:




| | |
|---|---|
| \$2 | \$2 |
| \$5 | \$5 |
| -\$2 | |
| \$3 | \$3 |
| -\$1 | |
| EV=Avg PV=\$7/5 | AS=Avg positve PV=\$10/3 |
| **EV=\$1.4** | **AS=\$3.3** |

**F = EV/AS =1.4/3.3 = .42**

**Note that the input data are all objective results**

NOTE: All \$ in millions

The calculation is based on prior results in the same situation rather than forecasted results in a new situation.

## Utilizing Optimal *f*

The OPTIMUM WELL COMMITMENT (W) is the capital available (CA) of \$15 times F (.42) divided by the worst loss (WL) of \$2 :

$$W = CA \times F / WL$$

$$= (15 \times .42) / 2 = 3$$

**Note that the well cost is not part of the calculation**

The numerator is the same as in the KWI using the Kelly criterion but the denominator has changed from cost to worst loss.

# Sensitivity: A 3 times higher PV

The results in PV of 5 prior wells:

| | |
|---|---|
| \$2 | \$2 |
| \$5 changes to \$15 | \$15 |
| -\$2 | |
| \$3 | \$3 |
| -\$1 | |
| EV=Avg PV=\$17/5 | AS=Avg positve PV=\$20/3 |
| **EV=\$3.4** | **AS=\$6.7** |

**F = EV/AS =3.4/6.7 = .51**

**W = CAxF/WL=(15x.51)/2=4**

A higher individual PV does not have much impact on the optimum well commitment because it is diluted by averaging and it changes both the numerator and the denominator.

# Sensitivity: A 3 times lower PV

The results in PV of 5 prior wells:

| | |
|---|---|
| \$2 | \$2 |
| \$5 | \$5 |
| -\$2 changes to -\$6 | |
| \$3 | \$3 |
| -\$1 | |
| EV=Avg PV=\$3/5 | AS=Avg positve PV=\$10/3 |
| **EV=\$0.6** | **AS=\$3.3** |

**F = EV/AS =0.6/6.7 = .18**

**W = CAxF/WL=(15x.18)/6=0**

The optimum will commitment is very sensitive to a much lower individual PV in the list. The result is less than one half or rounded to zero here. This is reasonalble because the EV is only \$0.6 and the potential loss -\$6.0.

# Sensitivity: A 3 times higher CA

The results in PV of 5 prior wells:

| | |
|---|---|
| \$2 | \$2 |
| \$5 | \$5 |
| -\$2 | |
| \$3 | \$3 |
| -\$1 | |
| EV=Avg PV=\$7/5 | AS=Avg positve PV=\$10/3 |
| **EV=\$1.4** | **AS=\$3.3** |

**F = EV/AS =1.4/3.3 = .42**

**W = CAxF/WL=(45x.42)/2=9**

An increase the capital available has a linear impact on the optimum well commitment.

## Summary and Conclusions:

1. The Optimal *f* (F = EV/AS) is easy to understand:

   average PV / average successful PV

F can be used in a non-complicated, straight forward fashion to calculate the optimum future well commitment each project.

W= CA x F / WL

Useful tools need to be transparent so they are easy to understand and calculate.

## Summary and Conclusions:

2. Optimal *f* is based on objective performance of prior wells vs Kelly Criterion which is based on subjective estimates of size, chance, cost and value.

When good analogs are available estimates can be calibrated to prior performance.

## Summary and Conclusions:

3. The Optimal *f* is based on worst loss rather than well cost and at risk of an unexpected larger loss.
   You may want to apply a risk aversion factor as a percent of the capital available.

Every situation is unique and therefore you should be prepared for an anomalous outcome, either good or bad.

## REFERENCES cited in the manuscript:


- AAPG Wiki, Uncertainties impacting reserves, revenue, and costs: Lognormality and log probability paper, <http://wiki.aapg.org/Uncertainties_impacting_reserves,_revenue,_and_costs> Accessed May 21, 2017.
- Kelly, J. L., Jr., 1956, A new interpretation of information rate: Bell System Technical Journal, v. 35, p. 917–926.
- MacKay, J. A., 2015, Comparing the results of the Kelly Criterion and risk aversion: Quick look practical alternatives to portfolio optimization: Gulf Coast Association of Geological Societies Transactions, v. 65, p. 273–280.


References from the paper.

## REFERENCES cited in the manuscript:


- MacKay, J. A. and Citron, G. P., 2016, Utilizing the Kelly Criterion to select the best projects when capital is temporarily constrained. Gulf Coast Association of Geological Societies Transactions, v. 66, p. 257–262.
- McLane, M.A., and Gouveia, J., 2015, Validating Analog Production Type Curves for Resource Plays, SPE paper 175527 MS, 23 pages.
- Vince, R., 2015, Optimal f :Calculating the expected growth-optimal fraction for discretely-distributed outcomes, <http://ralphvince.com/optimalf.pdf> Accessed May 21, 2017.
- Wei, R., 2012, Testing Kelly Criterion and Optimal f in R, <https://alphaism.wordpress.com/2012/04/13/testing-kelly-criterion-and-optimal-f-in-r/ > Accessed May 21, 2017.

# Optimal *f* : A Capital Management Tool for Multi-Well Drilling Commitment Decisions

Rose & Associates

James A. MacKay
Gary P. Citron

Thank you

www.roseassoc.com

The speaker, James MacKay, can be contacted at jamesmackay@roseassoc.com.