# Financial Engine Experiments*

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## Contents



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# 1 Revisions

2000May09: Merged the desired output section into the write-up section, concentrating on desired English prose. Also, requested description of what experimental parameters to use, e.g., sending the script you used to run the experiments.
2000May08: Added section with instructions for charts, tables, and text.
2000May04: Added section with suggested timeline and brief description of paper write-ups.
2000May04: Added section listing people and related experiments.
2000May04: Added listings of papers in each experimental section.

# 2 Write-up

Our goal is to write a paper appropriate for a technical journal, not the popular press. An example is the journal version of Cooley, Hubbard, and Walz's work although I think it is a little light on the mathematical description of the calculations.

The paper will be broken into the following pieces:

- introduction (written by Jeffrey),
- previous work (brief) (written by Jeffrey),
- algorithm and data (written by Jeffrey),
- results,
- conclusions (written by Jeffrey).

The results section will be split into subsections, one for each set of experiments. The text should introduce the problem. For example, it should state the problem, explain why it is interesting, and perhaps claim that using historical returns is important for this problem. A review of previous work (if we know any) should be included. Next, present the data both in text and chart/tabular form. Finally,

interpret the data, trying to explain the trends and how it should influence the thinking of a financial planner.

## 2.1 Suggested Deadlines

**Friday:** Submit rough draft with data, charts, tables, and explanatory text. The material should be mostly finished except the formatting may require additional work. Hopefully, Jeffrey will specify the format for charts and tables today.

**Monday:** Submit less rough draft with formatting mostly finished. I guess Jeffrey will collect together the pieces to form a paper.

**Wednesday 8:30am:** Draft 0.99 is available on the WWW.

## 2.2 Instructions for Charts, Tables, and Text

I plan to use LaTeX to typeset the paper and MetaPost to produce the charts so I can easily produce mathematical equations, tables of contents, and HTML, PDF, and PostScript versions. Thus, please submit

- a text file containing your English prose,
- table data using tab-delimited text files, and
- chart data using tab-delimited text files with two columns and blank lines between different lines to draw.

To add comments to your document, e.g., indicating that a title should be italicized, use a line starting with a percentage sign % and ending at the line's end.

**Table Data** Please submit tabular data as tab-delimited files. Each line of the table should correspond to one line of the file. Separate adjacent columns of data using one and exactly one tab character. Hopefully, each line will have the same number of tabs.

If you want to see what your table will look like (before additional formatting applied by Jeffrey), try the following on a UNIX computer:

1. Using this Perl script to convert your tab-delimited file into LaTeX. (Be sure to make it executable using `chmod +x prepareTable.pl`.)

2. Copy the result into this LaTeX file.

3. Convert the LaTeX file into a PostScript or PDF file using `make sampleLaTeX.ps` or `make sampleLaTeX.pdf`. You will need this Makefile in your directory.

4. View the result, e.g., `gv sampleLaTeX.ps` or usergv sampleLaTeX.pdf.

**Chart Data** I plan to use MetaPost to create any necessary charts because the output is extremely precise and clean. See for example, pp. 2–3 of http://www.cs.trinity.edu/~joldham/1321

Please submit your chart data as two-column tab-delimited files with blank lines between the data for each line to draw. For example, to draw two lines we could submit

1926 *tab* 8.04
1927 *tab* -5.2
1928 *tab* 18.0

1926 *tab* 18.04
1927 *tab* -1.2
1928 *tab* 8.0

Please add comments regarding the chart's title; annotations of individual lines; the desired type of chart, e.g., bar chart or line chart; axes labels; etc.

## 2.3 English Prose Explaining Your Experiments

Please analyze your results. Among the questions to ask are:

- Are the results correct?
- What do the results say? I.e., summarize them.
- How should we interpret them? How would a financial advisor interpret them?
- Should we have run a different experiment? Should we run another experiment to confirm or deny a hypothesis we conjectured from the first round of experiments?

Write this in a style similar to Cooley, Hubbard, and Walz.

The prose probably should include a description of what experiments were run as briefly as possible but precisely enough so someone else with our code would be able to repeat the experiments. Sending me scripts to run the experiments would also help. Thanks.

# 3 Experiments and People

As far as I understand, these people are working on the following experiments.

| | |
|---|---|
| taxed vs. tax-deferred accumulation | Sara Meyer and Nathan Franklin |
| asset allocation formulae | Collin LeMaistre and John Healy |
| accumulation in an IRA | Danny Johnson and Brent Lew |
| college savings and education IRAs | Jason Meridth and Chris Mitchell |
| asset choice | Jeffrey D. Oldham and Craig Brandenburg |
| short-term saving | ¿Qwinby Swinson?, Scott Schaefer |

Unallocated people include Pete.

# 4 Experiments to Perform

We do not a priori know which experiments will yield interesting results. Perhaps only half will be interesting. That's research.

What follows are only suggestions for experiments. Feel free to modify them as appropriate.

## 4.1 Suggestions for Choosing Parameters

Cooley, Hubbard, and Walz avoided the problem of choosing specific values by using percentages. For example, their tables show the probability of success when withdrawing a fixed fraction of one's investment, avoiding the issue of the investment's size and the amount to withdraw.

We might be able to use the same methodology. For example, for withdrawal problems, we can specify an initial investment of, e.g., \$1 000 000 and try withdrawing $\$1000000 * 3\%/12$ each month. For accumulation problems, we might specify investment increments as a percentage of the desired target. For example, we could use a desired target of \$1 000 000 and specify monthly investment increments of $\$1000000 * 2\%/12$.

## 4.2 Taxed vs. Tax-deferred

Most retirement savings occurs in tax-deferred accounts, e.g., 401(k), 403(b), I-RAs, so income taxes and capital gains taxes are not paid while the money is accumulating in exchange for paying a significant penalty for early withdrawal. Young people face many simultaneous financial demands including saving for retirement, purchasing a house, saving for college education, and paying for children, complicating the decision whether money should be saved in a taxable account or a tax-deferred account. In this experiment, we explore the cost of this indecision. How much smaller is one's retirement income when not using a tax-deferred account?

accumulation problem

| | |
|---|---|
| initial investment | $0 |
| investment increment | try various positive percentages |
| increment by inflation? | ¿try both? |
| desired investment target | try $1 000 000 per discussion above |
| financial target inflation | yes |
| time frame | 20, 25, and 30 years |
| increment time frame | ¿1 month? |
| asset allocation | fixed |
| asset allocation percentages | try what you want, perhaps similar to Cooley, Hubbard, and Walz |
| taxes | try both taxed and tax-free |
| capital gains tax rate | 20% |
| ordinary income tax rate | 28% |
| asset-holding time | ¿perhaps 60 months? |
| monthly rate modification | perhaps try 0%, -0.03%, -0.10% |

### 4.2.1 References

article discussing portfolio turnover rate and its tax implications. apparently one of few articles noting the effect of taxes on portfolios [JA93].

discusses effects of choosing tax-deferred vs. taxed [GR96].

effect of taxes and inflation [SM95].

## 4.3 Asset Allocation Formulae

Bergen has written several papers advocating asset allocation formulae that vary with a person's age. Conceptually, as retired people age, their investments shrink and also their ability to earn additional income through work decreases. Thus, asset allocation formulae move from more aggressive, e.g., stocks, to less aggressive, e.g., bonds.

In this experiment, we compare the results of using a fixed asset allocation with using three different age-varying formulae for a person approaching retirement. To perform a fair comparison between the fixed asset allocation(s) and the age-varying allocations, we should probably choose fixed asset allocations using values that are close to the average of the age-varying allocation throughout the timeframe. For example, if an age-varying formula moves an allocation from 80% to 50% through the timeframe, it might be a good idea to compare against a fixed allocation of 65%. I do not feel strongly about this; if you have better ideas, use them.

withdrawal problem

| | |
|---|---|
| initial investment | $1 000 000 per discussion above |
| investment increment | try various negative percentages |
| increment by inflation? | ¿try both? |
| desired investment target | $0 |
| financial target inflation | no |
| time frame | 20, 25, and 30 years |
| increment time frame | ¿1 month? |
| asset allocation | fixed vs. age-varying |
| taxes | tax-free |
| monthly rate modification | perhaps try 0%, -0.03%, -0.10% |

### 4.3.1 References

Perold and Sharpe discuss different asset allocation formulae including constant proportion [PS95].

## 4.4 Retirement Accumulation Using an IRA

The annual IRA limit of $2000 has remained unchanged since 1981. In this experiment, we address the issue of how much retirement money one can accumulate using only IRAs during one's working life.

1999 January, Representative McCollum introduced House Resolution 188 of the 106th U.S. Congress to index the annual IRA contribution for inflation. (See Section 2 of the bill in Thomas.) It would be interesting to show the change in accumulation when the annual contribution is indexed for inflation.

accumulation problem

| | |
|---|---|
| initial investment | $0 |
| investment increment | $2000 per year |
| increment by inflation? | try both |
| desired investment target | ¿unimportant? |
| financial target inflation | ¿unimportant? |
| time frame | 20, 25, and 30 years |
| increment time frame | 12 months |
| asset allocation | fixed, try something similar to Cooley, Hubbard, and Walz |
| taxes | tax-free |
| monthly rate modification | perhaps try 0%, -0.03%, -0.10% |

## 4.5 Saving for College

Many parents face the task for saving for a child's college education while simultaneously saving for retirement, purchasing housing, and raising the child. Exacerbating the task is the fact that this savings is taxed as it accumulates. (The newly-enacted Education IRAs permit savings only $500 per child per year, an amount significantly smaller than college expenses.) In this experiment, we address the amount of money to save to pay for college expenses.

According to the College Board, the average four-year public and private budgets are $10,909 and $23,651, respectively (source: *Trends in College Pricing*, Table 3, College Board). In the experiment, we simulate the necessary monthly savings to accumulate four times these annual amounts.

| accumulation problem | |
|---|---|
| initial investment | \$0 |
| investment increment | try various amounts |
| increment by inflation? | yes |
| desired investment target | $4 * 10,909$, $4 * \$23,651$ |
| financial target inflation | yes |
| time frame | 18 (birth of child), 13 (enters kindergarten), and 4 years (enters high school) |
| increment time frame | 1 month |
| asset allocation | fixed and age varying |
| taxes | taxed |
| capital gains tax rate | 20% |
| ordinary income tax rate | 28% |
| asset-holding time | ¿perhaps 36 months? for the longest timeframe |
| monthly rate modification | perhaps try 0%, -0.03%, -0.10% |

Asset allocation: Most financial writers recommend starting with an aggressive asset allocation and modifying it as the child nears entering college. See, e.g., Figure 7 of Vanguard's "Plain Talk" booklet on financing college. Modify the `assetAllocation` formulaes to reflect these recommendations. Perhaps the two assets to consider would be large-company stocks and U.S. Treasury bills since very short duration assets are recommended while the child is in high school. Contrast these age-varying formulae with one or two fixed asset allocations. Most financial writers would say that one's college savings should be moved to cash during the last two years of high school and during college to prevent the risk of losing all the savings. However, maintaining a fixed asset allocation and assuming the risk of a sharp decrease in its value may be better than the decrease in the investment's value by gradually moving to less risky assets through time.

Criticisms: College costs seem to increase faster than inflation. If you are willing to do some programming, modify the program to run experiments where college expense inflation increases faster than the consumer-price inflation index by fixed amounts. See Table 5 and Figure 4 of the College Board's *Trends in College Pricing* to estimate how much higher. It might be useful to modify only the financial target, not the monthly investment increment, which presumably increases at a rate similar to one's salary increase. Thus, modify `InflateTarget` in the `investment` class.

When simulating with taxes, the asset allocation is basically ignored during the asset-holding period. Using too long an asset-holding period (compared with the timeframe) will eliminate the effect of the age-varying formula. I do not have

recommendations what values to use.

### 4.5.1 References

Maria Crawford Scott writes about gradually changing the asset allocation as the child ages but does not show many numerate examples [Sco96b].

### 4.5.2 Education IRAs

Education IRAs permit saving $500 per year in a tax-free account. Simple math shows that even saving for eighteen years will not yield any significant fraction of college expenses. The real advantage of the Education IRAs that the saved money is never taxed, not when contributed and not when withdrawn. Assuming the maximum contribution limit of $500 does not change (a safe assumption since the normal IRA contribution limit has not changed since 1981), what percentage of a student's four-year college expenses could be paid using an Education IRA?

accumulation problem

| | |
|---|---|
| initial investment | $0 |
| investment increment | $500 per year |
| increment by inflation? | no |
| desired investment target | $4 * 10,909$, $4 * \$23,651$ |
| financial target inflation | yes |
| time frame | 18 (birth of child), 13 (enters kindergarten), and 4 years (enters high school) |
| increment time frame | 1 year |
| asset allocation | ¿fixed and age varying? |
| taxes | tax-free |
| monthly rate modification | perhaps try 0%, -0.03%, -0.10% |

Performing this experiment may require modifying the statistics object to record the average and standard deviation of four-year college expenses and the average and standard deviation of the fraction of the expenses that the Education IRA would pay.

More more information on Education IRAs, see Section 3 of IRS Publication 590, *Individual Retirement Arrangements (IRAs) (Including Roth IRAs and Education IRAs)*.

## 4.6 Importance of Different Asset Choices

Cooley, Hubbard, and Walz considered only large-company stocks and long-term corporate bonds (with one additional table that incorporate U.S. Treasuries), ignoring the other asset classes. One question to explore is whether using other asset classes affects the results. There are too many different combinations of assets to try them all. Instead, we might try substituting one asset for one of Cooley, Hubbard, and Walz's assets to look at the effects. One possibility is replicating the experiments of Cooley et al., substituting

- small-company stocks for large-company stocks,
- long-term government bonds for long-term corporate bonds,
- intermediate-term government bonds for long-term corporate bonds, or
- U.S. Treasury bills for long-term corporate bonds.

There is probably a better experiment, but I do not know what it is.

### 4.6.1 References

different assets' influence on mutual fund returns [IK00].

## 4.7 Short-Term Saving

Financial writers usually recommend investing in stocks and long-term bonds only if the money is needed at least five years in the future. Thus, they are recommending trading-off the possibility of higher returns for decreasing the risk of not meeting one's financial target. Instead of making this blanket statement, we seek to simulate the return-risk trade-off.

We consider saving for various short-term financial goals using different assets. For example, if one saves 8% of one's financial target each month for twelve months using large-company stocks, what is the probability of reaching the target?

| accumulation problem | |
|---|---|
| initial investment | $0 |
| investment increment | various percentages of the goal |
| increment by inflation? | yes |
| desired investment target | try $1 000 000 per the discussion above |
| financial target inflation | yes |
| time frame | 12, 24, and 60 months |
| increment time frame | 1 month |
| asset allocation | fixed, try 100% in all asset classes |
| taxes | taxed |
| capital gains tax rate | 20% |
| ordinary income tax rate | 28% |
| asset-holding time | short compared with timeframe |
| monthly rate modification | perhaps try 0%, -0.03%, -0.10% |

Criticism: As written in the experiment on college expenses, the asset allocation is basically ignored during the asset-holding period. Since we are using such a short timeframe, perhaps we should just ignore taxes? What do you think?

### 4.8 References

> [Stocks are] *extremely* risky in the short term. Investing in the stock market for the short term is a fool's errand. People should plan to stay with a stock investment a rock-bottom minimum of five years. But risk means nothing except in a comparative sense. And stocks and bonds are, at the very least, equally risky over the long term.

James K. Glassman, author of the book *Dow 36,000: The New Strategy for Profiting from the Coming Rise in the Stock Market*, as quoted in [gla00, p. 3].

## 5 Other Quotations and Miscellanea

> [Risk is defined] as the variation in returns over time. Standard deviation is a common way to measure volatility. Stocks have a standard deviation of roughly 20 percentage points, which means that two-thirds of the time, stock returns will vary by 20 points from their long-term average of about 11% a year—or in a range from -9% to 31%. That's very scary in the short term. But if you hold them for 15 years,

> the standard deviation drops down to about 2%, which means that two-thirds of the time the average annual return for 15-year periods varies between 9% and 13%.

James K. Glassman, author of the book *Dow 36,000: The New Strategy for Profiting from the Coming Rise in the Stock Market*, as quoted in [gla00, p. 3].

Historical return information before 1926 available in [CA39].

Capital gains tax rates through the years and how to compute them [Lin87].

Additional work on probability of success in retirement:

- nonmathematical treatment with a handful of scenarios and no probabilities [Sco96a]
- similar to CHW but was a few variations [Ben94]

# References


[Ben94] William P. Bengen. Determining withdrawal rates using historical data. *Journal of Financial Planning*, 7(1):171–180, October 1994.

[CA39] Alfred Cowles 3rd and Associates. *Common-Stock Indexes*. Number Monograph No. 3 in Cowles Commission for Research in Economics. Principia Press, Inc., Bloomington, IN, second edition, 1939.

[gla00] As investors reappraise risks, stock prices will go higher, Spring 2000. http://www.vanguard.com/educ/newsstnd/ITV/2000Spring/-pointcounter.html#counter.

[GR96] William Ghee and William Reichenstein. The after-tax returns from different savings vehicles. *Financial Analysts Journal*, 52(4):62–72, July/August 1996.

[IK00] Roger G. Ibbotson and Paul D. Kaplan. Does asset allocation policy explain 40, 90, or 100 percent of performance. *Financial Analysts Journal*, 56(1):26–33, January/February 2000.

[JA93] Robert H. Jeffrey and Robert D. Arnott. Is your alpha big enough to cover its taxes? *The Journal of Portfolio Management*, 19(3):15–25, Spring 1993.

[Lin87] Lawrence B. Lindsey. Capital gains rates, realizations, and revenues. In Martin Feldstein, editor, *The Effects of Taxation on Capital Accumulation*, National Bureau of Economic Research Project Report, pages 69–97. The University of Chicago Press, Chicago, 1987.

[PS95] André F. Perold and William F. Sharpe. Dynamic strategies for asset allocation. *Financial Analysts Journal*, 51(1):149–160, January–February 1995. Also published in January–February 1988, pp. 16–27.

[Sco96a] Maria Crawford Scott. Living off retirement savings in a world of uncertain return patterns. *AAII Journal*, 18(7):8–11, August 1996.

[Sco96b] Maria Crawford Scott. Saving and investing to meet the expenses of your child's education. *AAII Journal*, 18(7):21–23, August 1996.

[SM95] Laurence B. Siegel and David Montgomery. Stocks, bonds, and bills after taxes and inflation. *The Journal of Portfolio Management*, 21(2):17–25, Winter 1995.