Advances in Portfolio Allocation Models: Lessons from the Past Decade

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Outline

1. Introduction
    - Current portfolio and ALM issues
    - Protecting investors during an economic storm

2. What's new in asset allocation and asset-liability management
    - Dynamic portfolio optimization
    - Consistent approach for deploying capital – Kelly strategy
    - Protect capital -- add drawdown constraints -- Ulcer index
    - Multi-regime models via hidden Markov models

3. Commodity/managed futures perform well during crash periods
    - Why? Drivers of performance
    - Passive indices (long only versus long-short and relative value)
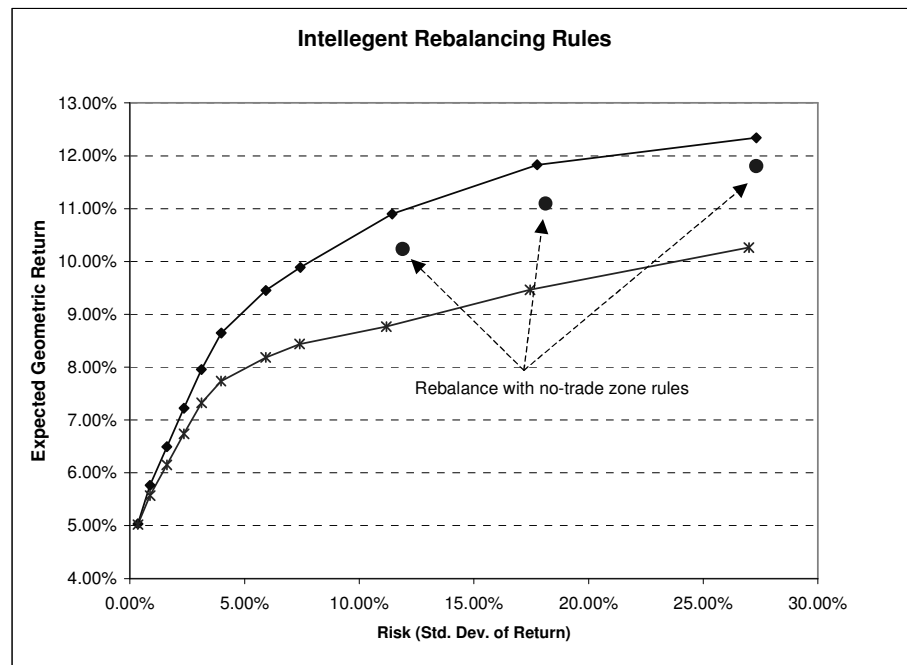
4. Integrating regimes for equity and commodity tactics
    - Advantages of relative value
    - Downside risk protection

5. Conclusions -- challenges

Multi-Period Asset Allocation Models

- Advantages
  - Greater realism (transaction costs, contribution, borrowing)
  - Addresses temporal issues (short vs. long horizons)
  - Greater performance (rebalancing gains)

Intellegent Rebalancing Rules

Rebalance with no-trade zone rules

X-axis: Risk (Std. Dev. of Return)
Y-axis: Expected Geometric Return

Lessons from 2008/2009 Crash

1. You thought that you were diversified!

    –   Most funds lost substantial capital (stocks, bonds, hedge funds)

2. Many portfolio optimization models failed to protect capital

    Why?

    > Static view of the world – constant correlations and volatility
    > Poor estimate of expected returns
    > Too slow to act – difficult for many institutional and individual investors
    > Regulations, committee structure delays decision making
    > Behavior considerations

Protecting Capital in Anticipation of a "Storm"

- Ultra-conservative (Japanese pensions and regulated European Institutions) leading to under performance

- Reduce capital dynamically
  - Requires flexible, dynamic portfolio optimization
  - May be a false alarm

- Hold assets (or tactics) that perform well during turbulent periods
  - Short bias funds (expensive)
  - Historically high performers during crashes
    - Commodity/managed futures

Enormous Range of Solutions for Long-term Investors

- German Life Insurers - 90%+ fixed income, 10%- real estate & Equity, only few alternatives
- Japanese pension plans – 70-90% fixed income, 10-30% equities, dose of alternatives,
- Leading U.S. university endowments

Why such differing asset allocations?

FIGURE 1
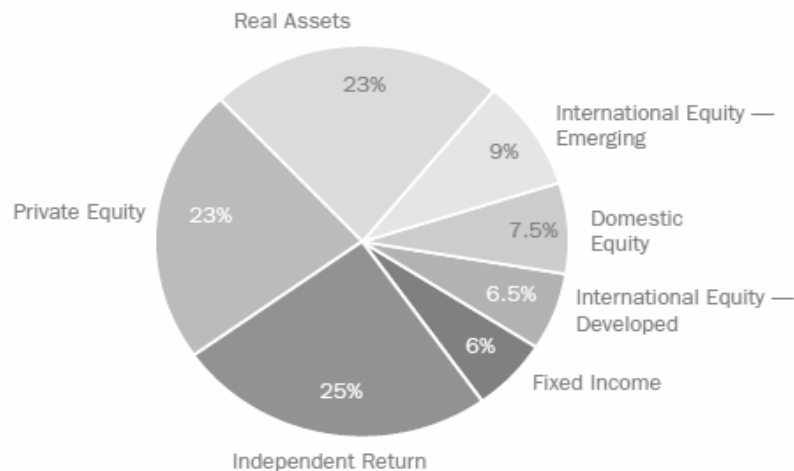
Princeton University Policy Portfolio
June 30, 2010

Real Assets 23%

International Equity — Emerging 9%

Domestic Equity 7.5%

International Equity — Developed 6.5%

Fixed Income 6%

Independent Return 25%

Private Equity 23%

TABLE 2

Asset Allocation
June 30, 2010

Allocation	Policy Target	Actual
Domestic Equity	7.5%	5.2%
International Equity		
Developed Markets	6.5%	3.4%
Emerging Markets	9.0%	5.7%
Independent Return	25.0%	20.2%
Private Equity	23.0%	37.2%
Real Assets	23.0%	21.6%
Fixed Income	6.0%	2.5%
Cash	0%	4.2%

Check out PE

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Disadvantages of Trend to Illiquid Assets

- Hard to maintain portfolio at policy targets
  - Lower rebalancing gains
  - Portfolio risks are affected by market moves

- Difficult to develop an dynamic asset allocation policy
  - Many investors failed to protect capital from large drawdowns in 2008 – still below previous high water mark, even after exceptional performance since March 2009 (except for Aug/Sept 2011)
  - For pension plans and related investors with contribution requirements, surplus protection is easier with liquid assets

- Cash requirements can cause a problem (e.g. to pay operating budgets) during crash periods – critical for leading universities
  - Cannot readily sell assets during fire sale – take Harvard U. example
  - Borrowing may be expensive

In contrast, we will take advantage of liquid assets
and dynamic portfolio optimization

What's New in Portfolio Optimization?
Motivation: Do not Assume Fixed Correlations over Time

Exhibit 7

Estimated Correlation Matrix for Asset Returns from a ALM Study for a Large Public Pension Plan

These results do not properly Model Contagion during Market Crashes

Correlation Matrix

Class	Liquidity	Fixed Income	Real Estate	Global Equity	Absolute Equity	Private Equity
Liquidity	1.00					
Fixed Income	0.30	1.00				
Real Estate	0.25	0.40	1.00			
Global Equity	0.10	0.01	0.40	1.00		
Absolute Return	0.00	0.60	0.30	0.35	1.00	
Private Equity	0.15	-0.10	0.50	0.80	0.10	1.00

Note: Correlation between global equity and fixed income = 0.01
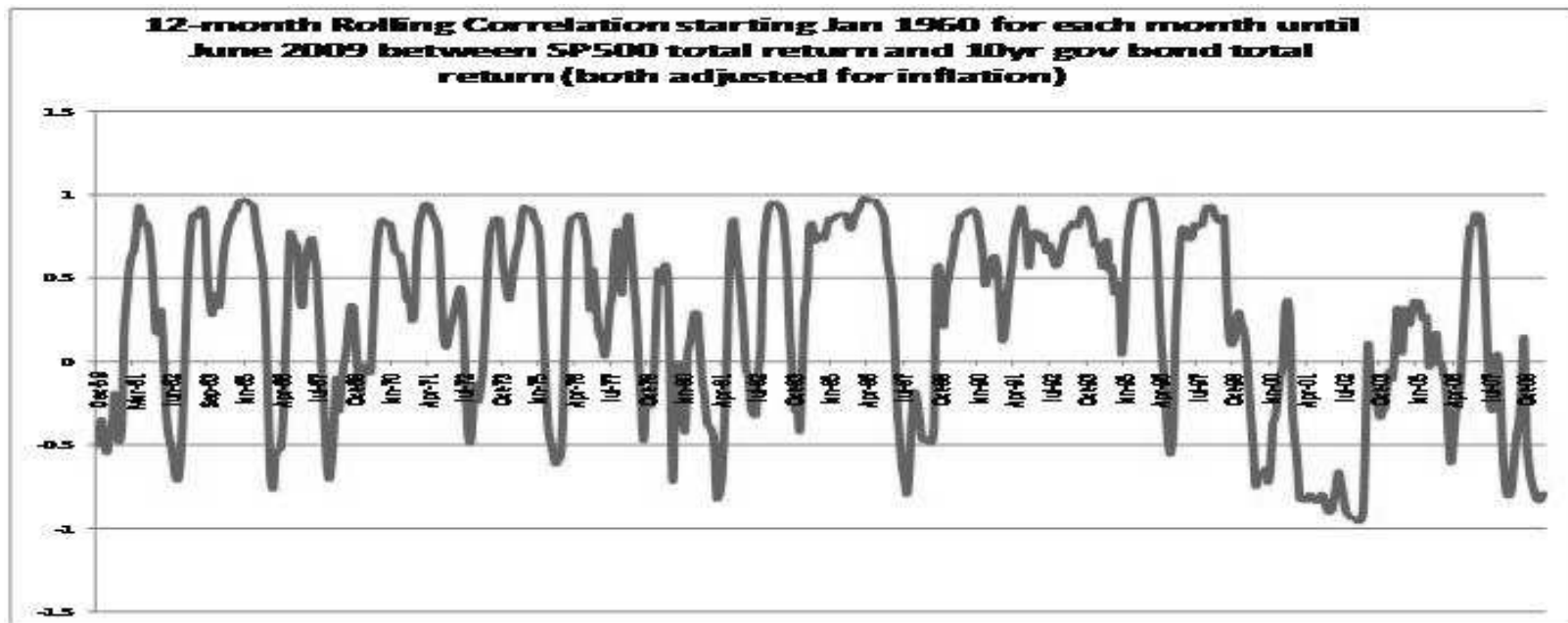
Multi-Period Portfolio Models

- Historical correlations change over time
- Severe limitations of single-period Markowitz portfolio models

1- Year Correlations
S&P 500 vs.10-Yr Bonds
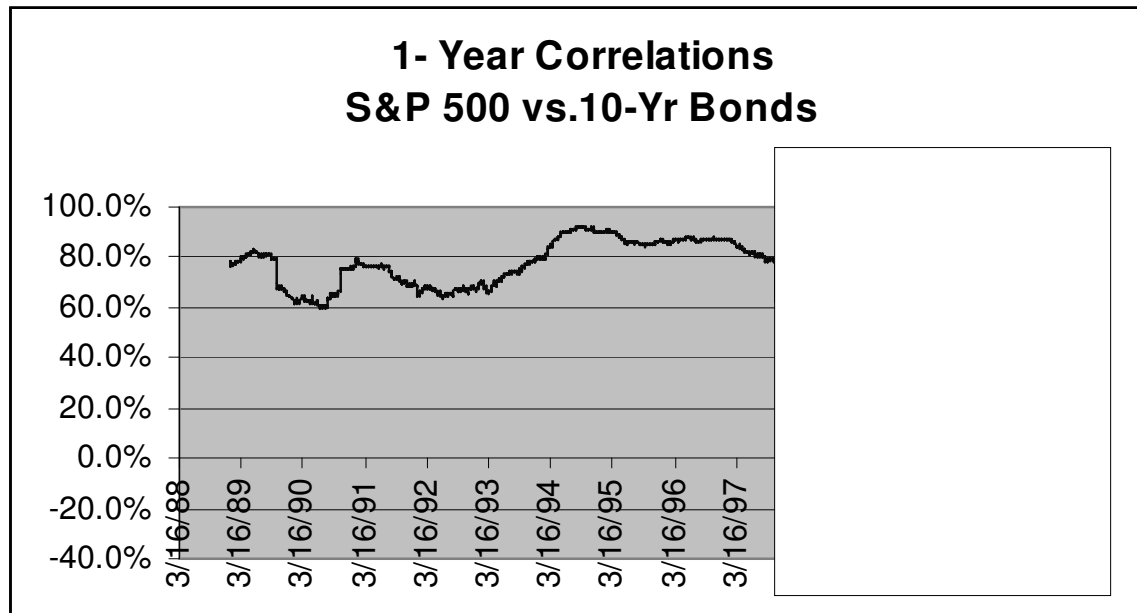
so?

Optimizing Assets: Multi-Period Portfolio Models

- Historical correlations change over time
- Severe limitations of static portfolio models

12-month Rolling Correlation starting Jan 1960 for each month until June 2009 between SP500 total return and 10yr gov bond total return (both adjusted for inflation)

Every recession shows negative correlation between equity and government bond returns

Addressing Dynamics:
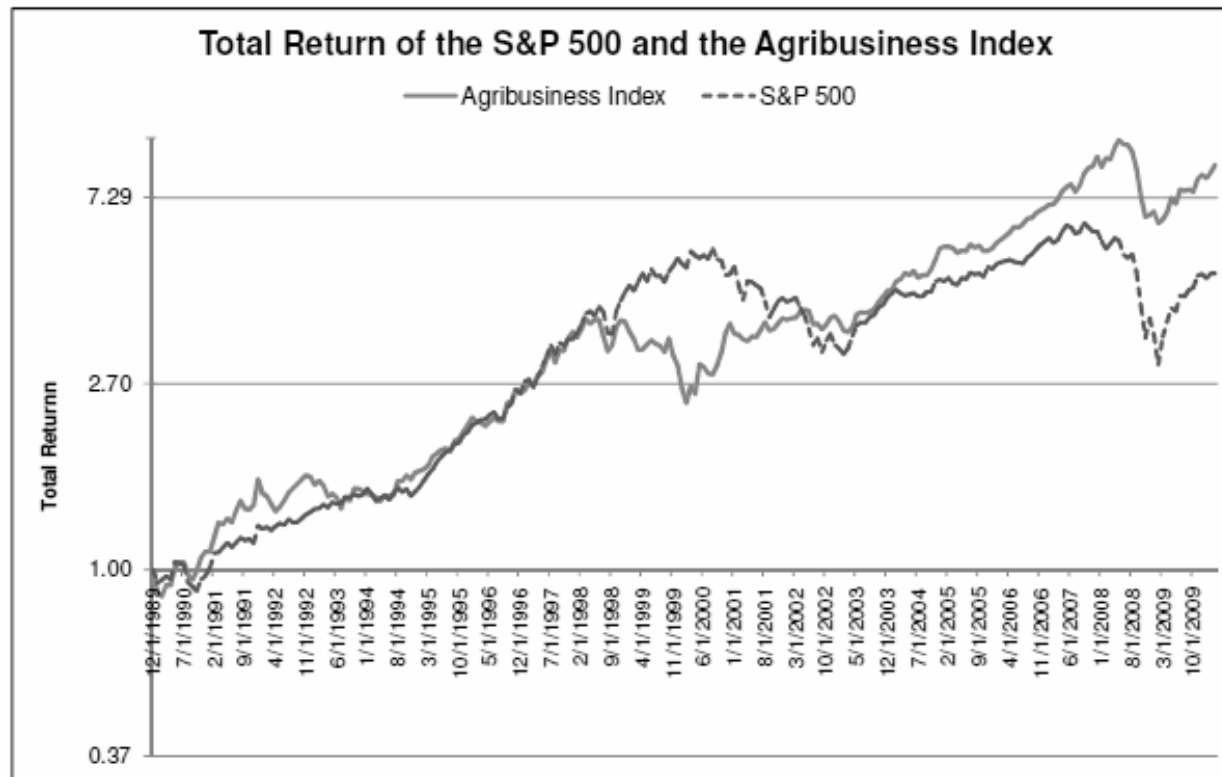# Regimes via Hidden Markov Model (HMM)

The Business cycle in the agri sector follows a Markov Chain.
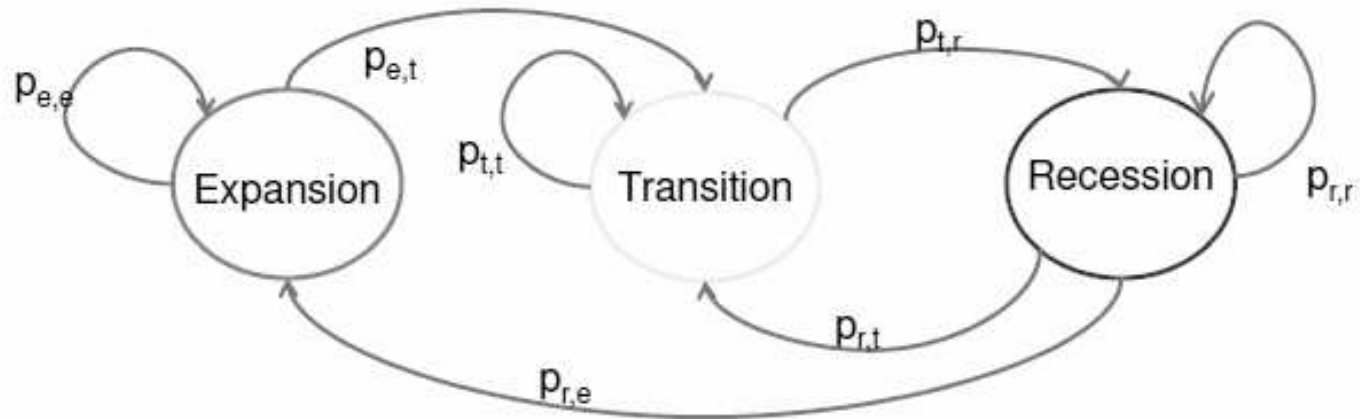
Distinctive patterns due to classical asset pricing formula: Fair price = risk adjusted discount of future earnings (cash flows)

Regimes via Hidden Markov Model (HMM) – An Application

The monthly returns of the agri index and the S&P 500 can help us determine business cycles in the agribusiness sector.

Total Return of the S&P 500 and the Agribusiness Index

May be better to purchase firms with commodity exposure than commodities directly (must be careful regarding shape of futures curve – lose when contango (upward sloping curve) occurs

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Regimes via Hidden Markov Model (HMM) – An Application

An Application · **HMM Calibration Results**

- HMM calibration results using S&P 500 and cap-weighted Agribusiness Index monthly total returns.
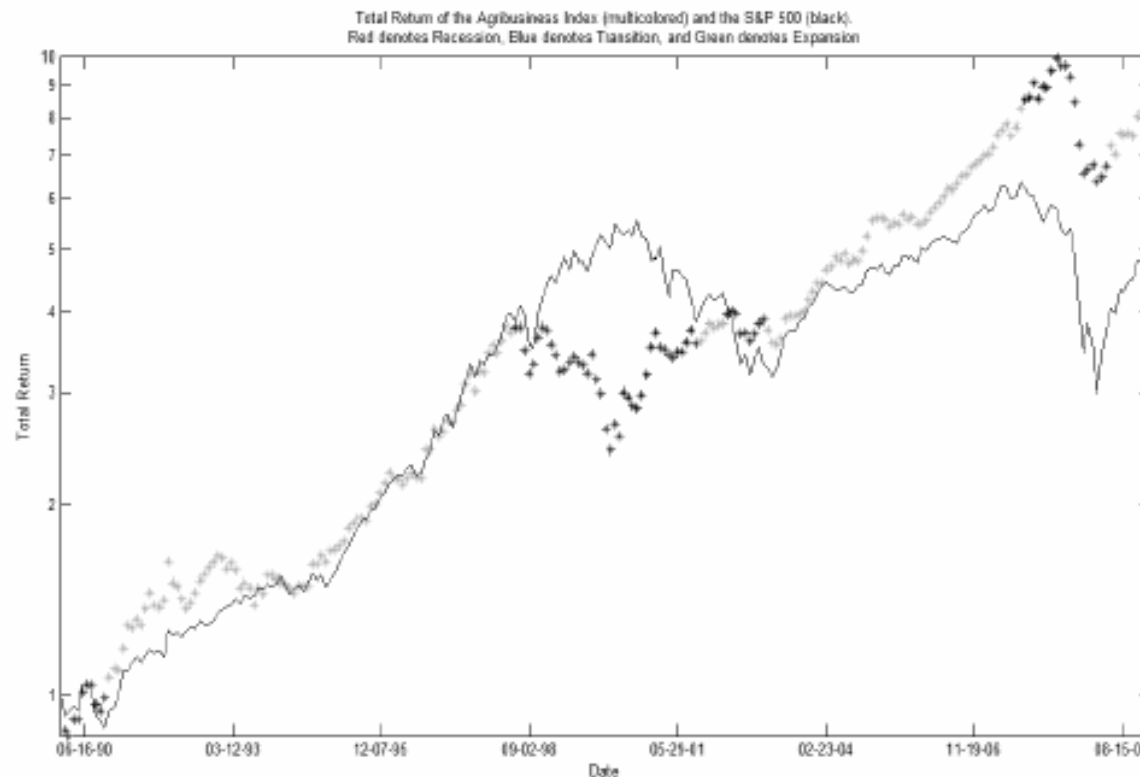- Sample data from January 1, 1990 to March 31, 2010.

Transition Probability Matrix

	Regime 1	Regime 2	Regime 3
Regime 1	0.979	0.021	0
Regime 2	0	0.676	0.324
Regime 3	0.076	0.078	0.846

	Mean $(\mu_{k,A}, \mu_{k,M})^T$	Covariance $\begin{pmatrix} \sigma_A^2(k) & \sigma_{M,A}(k) \\ \sigma_{M,A}(k) & \sigma_M^2(k) \end{pmatrix}$	Correlation
Expansionary Period → Regime 1	$\begin{bmatrix} 1.53\% \\ 1.50\% \end{bmatrix}$	$\begin{bmatrix} 0.11\% & 0.06\% \\ 0.06\% & 0.08\% \end{bmatrix}$	0.647
Transition Period → Regime 2	$\begin{bmatrix} 2.48\% \\ -1.59\% \end{bmatrix}$	$\begin{bmatrix} 0.25\% & -0.02\% \\ -0.02\% & 0.13\% \end{bmatrix}$	-0.139
Recessionary Period → Regime 3	$\begin{bmatrix} -1.22\% \\ -0.32\% \end{bmatrix}$	$\begin{bmatrix} 0.30\% & 0.25\% \\ 0.25\% & 0.51\% \end{bmatrix}$	0.629

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Regimes via Hidden Markov Model (HMM) – An Application

Total Return of the Agribusiness Index (multicolored) and the S&P 500 (black).
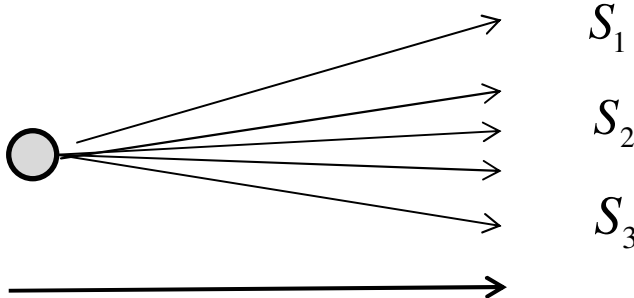Red denotes Recession, Blue denotes Transition, and Green denotes Expansion

- Red denotes market recession, Blue denotes market transition, and Green denotes market expansion in the agribusiness sector.

- The regimes' persistence is gives us comfort that the chosen variables may indeed hold some information on the business cycles of the agribusiness sector.

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Dynamic Optimization via Hidden Markov Model

- Single period – 5 day look ahead
- Depict scenarios for three regimes: {growth, transition, low}
- Number of scenarios depends upon transition matrix

- Maximize E [U(w)], where U() is log-optimal utility function

- $$\sum_{s} \pi_s \ln(w_s)$$ subject to $$w_s = \sum_{j} r_{j,s} * x_j$$

S_1

S_2 + drawdown constraints

S_3

Apply HMM to SP500: Three Regimes and 10 Sectors[*]

* Data is back-tested only. All investors should be aware that future results may not be the same as historical performance.

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Performance Evaluators for Dynamic Asset Allocation

- Traditional measures
  - Geometric returns, Sharpe ratio
  - Issue – ignores correlation, drawdown, and re-balancing gains

- Importance of drawdown
  - Capital growth theory requires modest drawdown values
  - Kelly strategy and siblings
  - Critical for overlay strategies

- Alternatives
  - Max drawdown
  - Return /drawdown
  - Ulcer index (downside risk below high watermark) – duration and depth
  - Return/Ulcer

Performance SP500: (1/1995 to 9/2011) via Regimes[*]

	SP500	HMM	
Return	8.10%	9.16%	
Volatility	19.79%	8.33%	
Sharpe Ratio (Rf=3%)	0.26	0.74	
Max drawdown	54.72%	10.72%	
Return/Max DD	0.15	0.85	
Ulcer	20.27%	3.34%	
UPI (Rf=3%)	0.25	1.84	
Corr(HMM,SP500 Return)		0.37	

These results allow us to add commodities and managed futures as an overlay to improve performance (low drawdown values for equities)
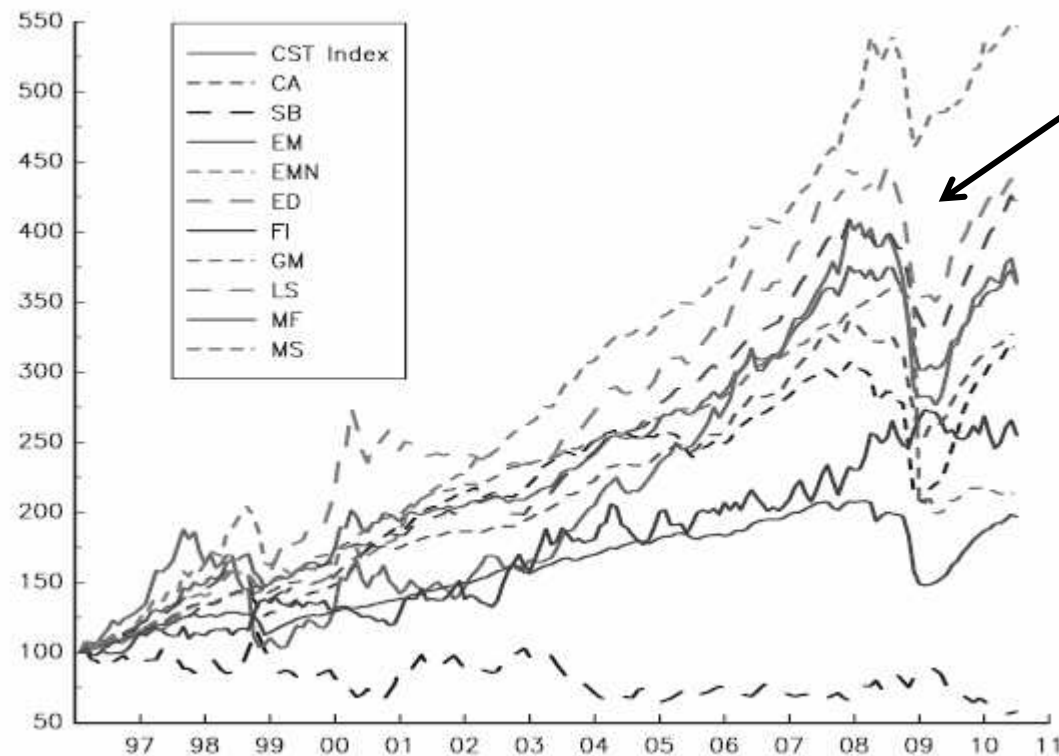
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Discovering Assets that Perform Well during Crashes "Hedge" Funds?

Where is the diversification in a crash?

Figure 1: CSFB/Tremont strategy indices

Large drawdowns

Managed futures are scalable (no or small leverage costs)

Commodity/Managed Futures versus Other Hedge Funds (1995-2010)
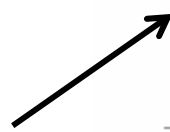
Large draw-downs

Table 1: CSFB/Tremont single strategy indices descriptive statistics

Hedge Funds strategy	Ann. Ret	Ann. Vol	Skew	Kurtosis	Max DD	Start MDD	End MDD
Convertible arbitrage	7.65%	7.18%	-2.72	15.70	-32.86%	Oct-07	Dec-08
Dedicated short bias	-2.92%	16.92%	0.75	1.62	-53.54%	Aug-98	Apr-10
Emerging markets	7.76%	15.43%	-0.76	4.85	-45.15%	Jul-97	Jan-99
Equity market neutral	5.10%	10.75%	-11.86	156.44	-45.11%	Jun-08	Feb-09
Event driven	10.20%	6.09%	-2.55	13.86	-19.15%	Oct-07	Feb-09
Fixed income arbitrage	4.98%	6.02%	-4.25	28.06	-29.03%	Jan-08	Dec-08
Global macro	12.32%	10.18%	-0.02	3.40	-26.78 %	Jul-98	Sep-99
Long/short equity	9.95%	10.02%	0.00	3.53	-21.97 %	Oct-07	Feb-09
Managed futures	6.12%	11.79%	0.02	0.07	-17.74 %	Mar-95	Nov-95
Multi-strategy	7.89%	5.45%	-1.78	6.29	-24.75 %	Oct-07	Dec-08

Global macro and managed futures – did well during 2008 crash period as compared with other hedge funds

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Commodity/Managed Futures perform well during Turbulent Periods

Currency overlays – well known tactic for global institutional investors

•Most Liquid Markets

- Currencies
- government bonds
- equities
- Commodities (in many cases)

Highly scale-able for institutional investors

•Provides counterpoint to illiquid assets

•Easy to go short or long

•Approach is efficient as an overlay to protect capital

Commodities are becoming popular by institutional investors

"Institutional investors have poured hundreds of billions of dollars into commodities in recent years, as emerging markets—especially China—consume a rising share of the world's natural resources, and miners, farmers and drillers scramble to keep pace.

As of July, institutional and individual investors had $431 billion plowed into commodities, up from $376 billion at the end of 2010 and $141 billion at the end of 2006, according to Barclays Capital. The investments have gone into an array of instruments, including exchange-traded products and investments linked to commodity indexes."

Wall Street Journal Sept 15, 2011

Performance Drivers for Commodities

- Take advantage of regime changes   *Go with the flow*
  - Trend following
  - Momentum

- Behavior characteristics of commodities
  - Diffusion of information – role of momentum
  - Shortages will correct only gradually -- momentum
  - Inventory theory --- backwardation[*] occurs when inventory is low
  - Excess return for take opposite position from hedgers

- Rebalance portfolio on a recurring basis
  - Rebalancing gains highest during crash periods
  - Overall portfolio has improved returns via managed futures as overlays

  - * Downward sloping futures curve

Role of Rule-based Indices

1. Serves as benchmark for active managers – pay only for excess performance, perhaps

2. Provides option to employ index for ultra-large funds and for investors without special expertise

   active versus passive decision

   PU: 37% PE versus 23% target?

3. Assists with asset allocation

   rebalance to policy targets, for example, for out-of-kilter situations
   Reduce risks during drawdown periods

4. Explains the drivers of performance for active managers

Example
Relative Value Commodity Index (DPT/FTSE [*])

- ***Goal:*** Achieve performance of median (or better) of a well defined group of active managers. Similar in spirit to traditional index funds (equities and fixed income).

- **Return from futures markets as ADDITIONAL returns via overlays**

- Performance elements

  1. Return of individual tactics – best when regime changes occur (crashes)
  2. Return on margin capital – need to protect capital during crashes
  3. Re-balancing gains – highest volatility during crash periods

  *DPT and FTSE are in final negotiations regarding the launch of a series of dynamic managed futures and commodity indices

Long-only Commodity Indices can have large draw-downs, especially during crashes

Ten Year Comparison of Commodity Index Returns (July 2001 – August 2011)
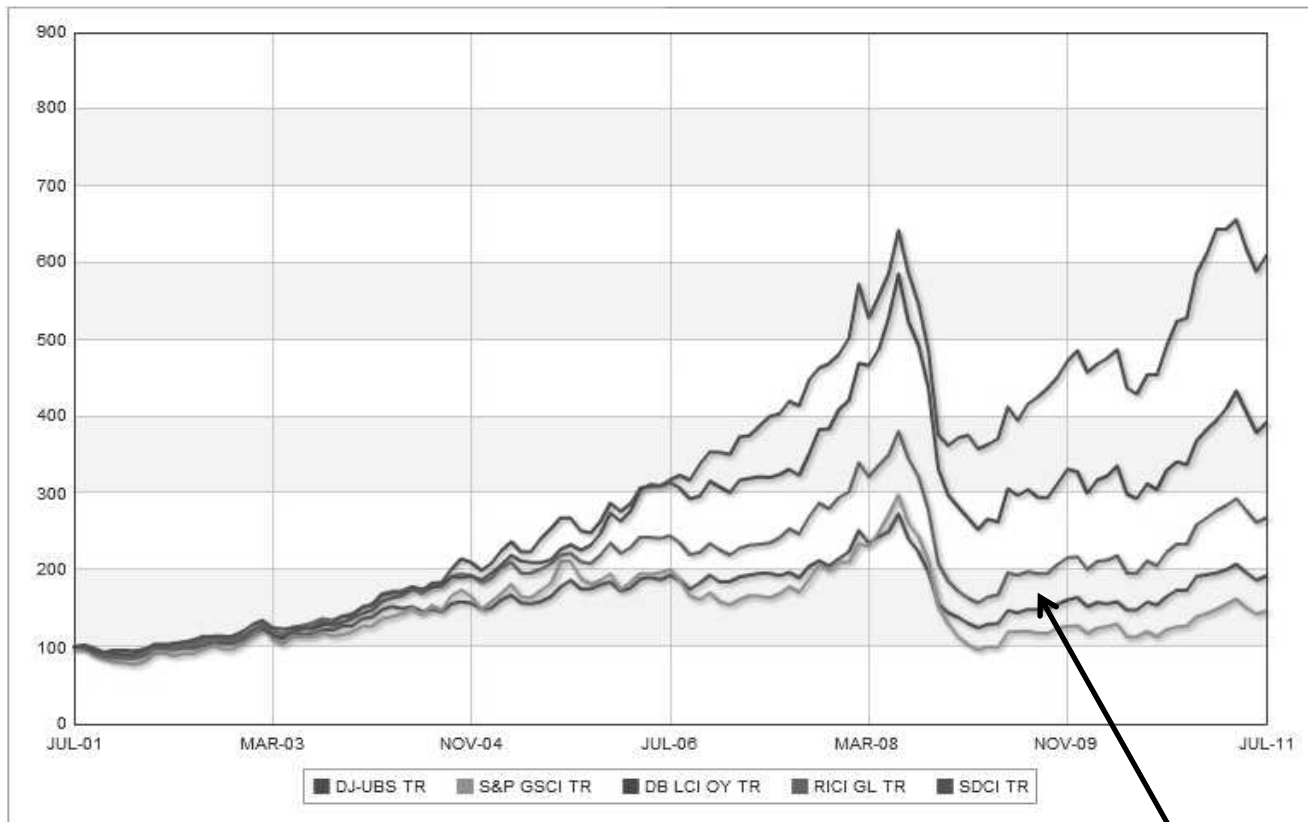
Benchmarks
S&P GSCI Commodity Index (GSCI®) Total Return
Dow Jones-UBS Commodity Index Total Return[SM]
Deutsche Bank Liquid Commodity Index-Optimum Yield Total Return[TM]
Rogers International Commodity Index - Total Return[SM]

Large draw-downs during equity crash

# Relative Value Index Based on Futures Curve and Momentum -DPT/ (FTSE)

- Policy rules
  - 26 futures
  - Empirical test : Jan 1998 ~ Jun 2011
  - Lookback period for ranking : 65 business days
  - Go long highest price momentum, go short lowest momentum
  - Futures curve -- go long in backwardation, go short in contango
  - Rebalancing period – weekly
  - Long by Short : 10 long, 6 flat, 10 short – equal weight

- Descriptions of performance
  - Futures curve and momentum tactics
  - Combination of two strategies
  - Integrate with regimes for equity

Commodities in Index

Commodities are highly liquid and trade extensively
(easy to go long and short), ultra low trading costs!

|	
BOZ1	SOYBEAN OIL FUTR Dec11
C Z1	CORN FUTURE Dec11
CCZ1	COCOA FUTURE Dec11
CLV1	WTI CRUDE FUTURE Oct11
CTZ1	COTTON NO.2 FUTR Dec11
DAX1	MILK FUTURE Nov11
FCU1	CATTLE FEEDER FUT Sep11
HGZ1	COPPER FUTURE Dec11
HOV1	HEATING OIL FUTR Oct11
JOX1	FCOJ-A FUTURE Nov11
KCZ1	COFFEE 'C' FUTURE Dec11
LBU1	LUMBER FUTURE Sep11
LBX1	LUMBER FUTURE Nov11
LCV1	LIVE CATTLE FUTR Oct11
LHV1	LEAN HOGS FUTURE Oct11
LMAHDS03 index	LME ALUMINUM 3MO ($)
LMNIDS03 index	LME NICKEL 3MO ($)
LMPBDS03 index	LME LEAD 3MO ($)
LMSNDS03 index	LME TIN 3MO ($)
LMZSDS03 index	LME ZINC 3MO ($)
NGV1	NATURAL GAS FUTR Oct11
PAZ1	PALLADIUM FUTURE Dec11
PLV1	PLATINUM FUTURE Oct11
S X1	SOYBEAN FUTURE Nov11
SBH3	SUGAR #11 (WORLD) Mar13
SMZ1	SOYBEAN MEAL FUTR Dec11
W Z1	WHEAT FUTURE(CBT) Dec11

Wealth Path of Momentum [*]
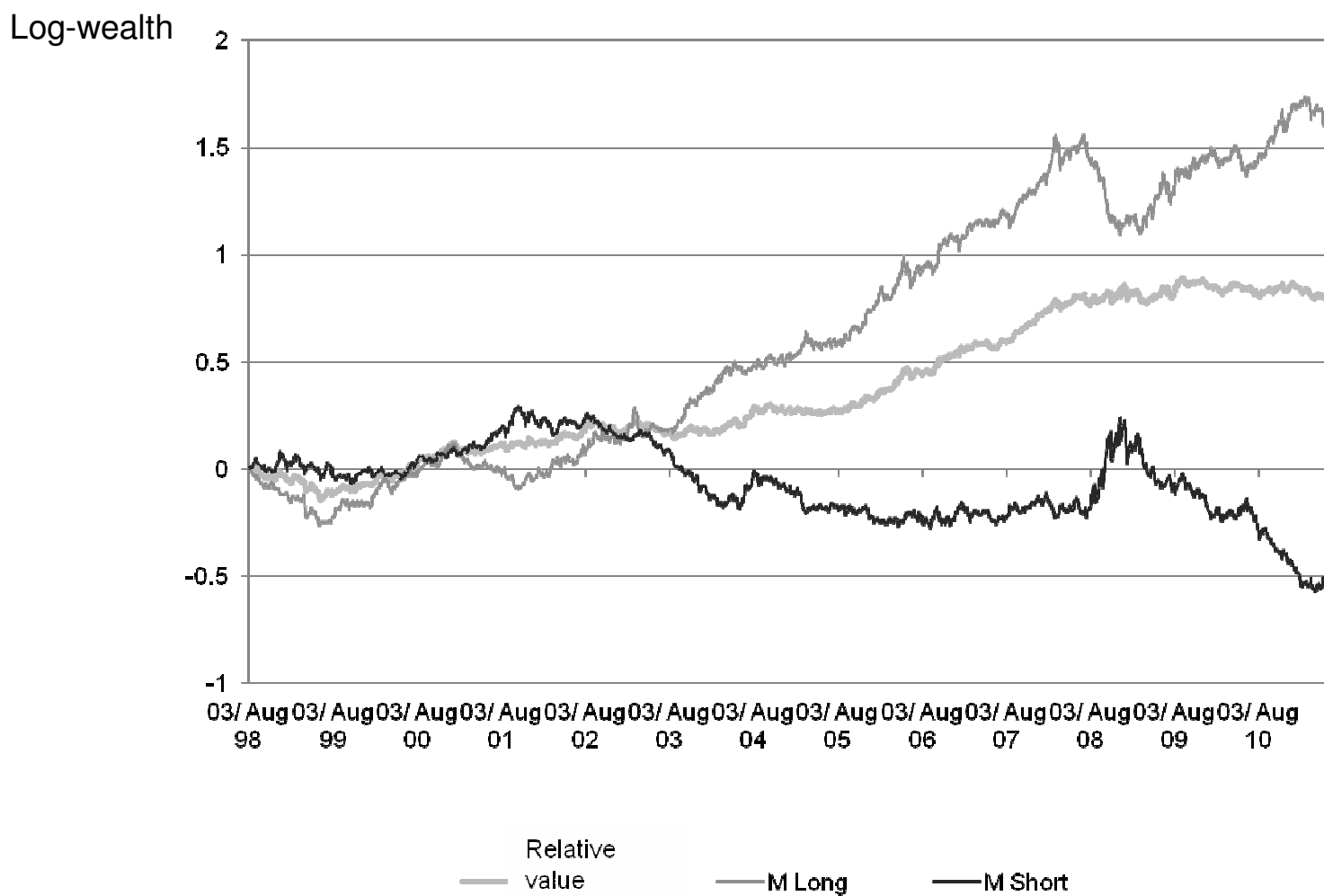
* Data is back-tested only. All investors should be aware that future results may not be the same as historical performance.

Wealth Path of Futures [*]

Log-wealth

Legend: Relative value · FC Long · FC Short

* Data is back-tested only. All investors should be aware that future results may not be the same as historical performance.

Wealth Path of Combining Commodities and HMM Tactics *

Log wealth
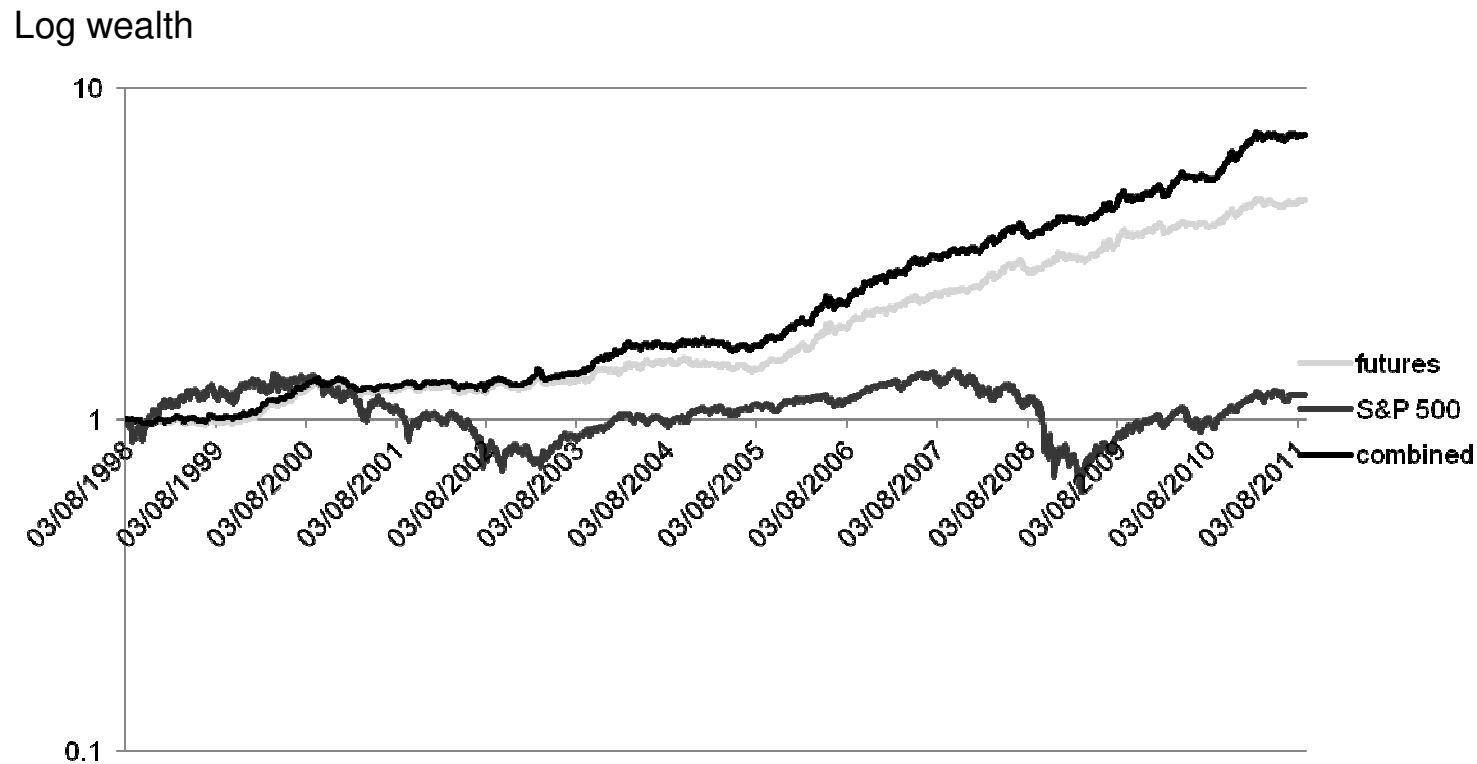
Avoids large drawdown values during crash periods –
critical as an overlay strategy

Data is back-tested only. All investors should be aware that future results may not be the same as historical performance.

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Performance Summary 1998 to 2011 [*]

| Aug. 1998 – Jun 2011	SP500	DPT Equity-regimes + Commodities 40% commodities 30% equities	Commodities only		Equity only -- regimes	
			40%	60%	30%	60%
Geo. Return	1.23%	12.83%	10.43%	16.9%	2.18%	4.29%
Volatility	21.23%	8.7%	8.25%	12.37%	2.54%	5.07%
Sharpe ratio**	-0.08	1.13	.90	1.124	-.32	.255
Drawdown	56.78%	8.8%	8.8%	12.96%	3.26%	6.47%
Ret/Drawdown	0.02	1.457	1.18	1.30	.669	.66
Ulcer Index	24.47%	2.06%	2.15%	3.2%	.7%	1.5%
Ret/Ulcer	-0.07	6.22	4.86	5.28	2.94	2.86
Corr w/ SP500	1.00	.08	-.017	-.017	.33	.33
		2% fee	2% fee	2% fee	no fees	no fees

**3% risk free rate

Data is back-tested only. All investors should be aware that future results may not be the same as historical performance.

Conclusions/Challenges

- Protect capital in anticipation of an economic storm
  - Apply protective tactics – may be costly
  - Dynamic portfolio optimization via multiple regimes

- Include commodity/managed futures and other overlays to traditional asset allocation
  - Examples
    - Duration enhancing overlay for pension plans – protect surplus
    - Commodity/managed futures to provide improved diversification
  - Requires strict risk management of drawdown
  - Takes advantage of volatility and regime shifts during crash periods

- Dynamic optimization takes advantage of liquidity and flexibility

Linking Stochastic Programs and Policy Simulators
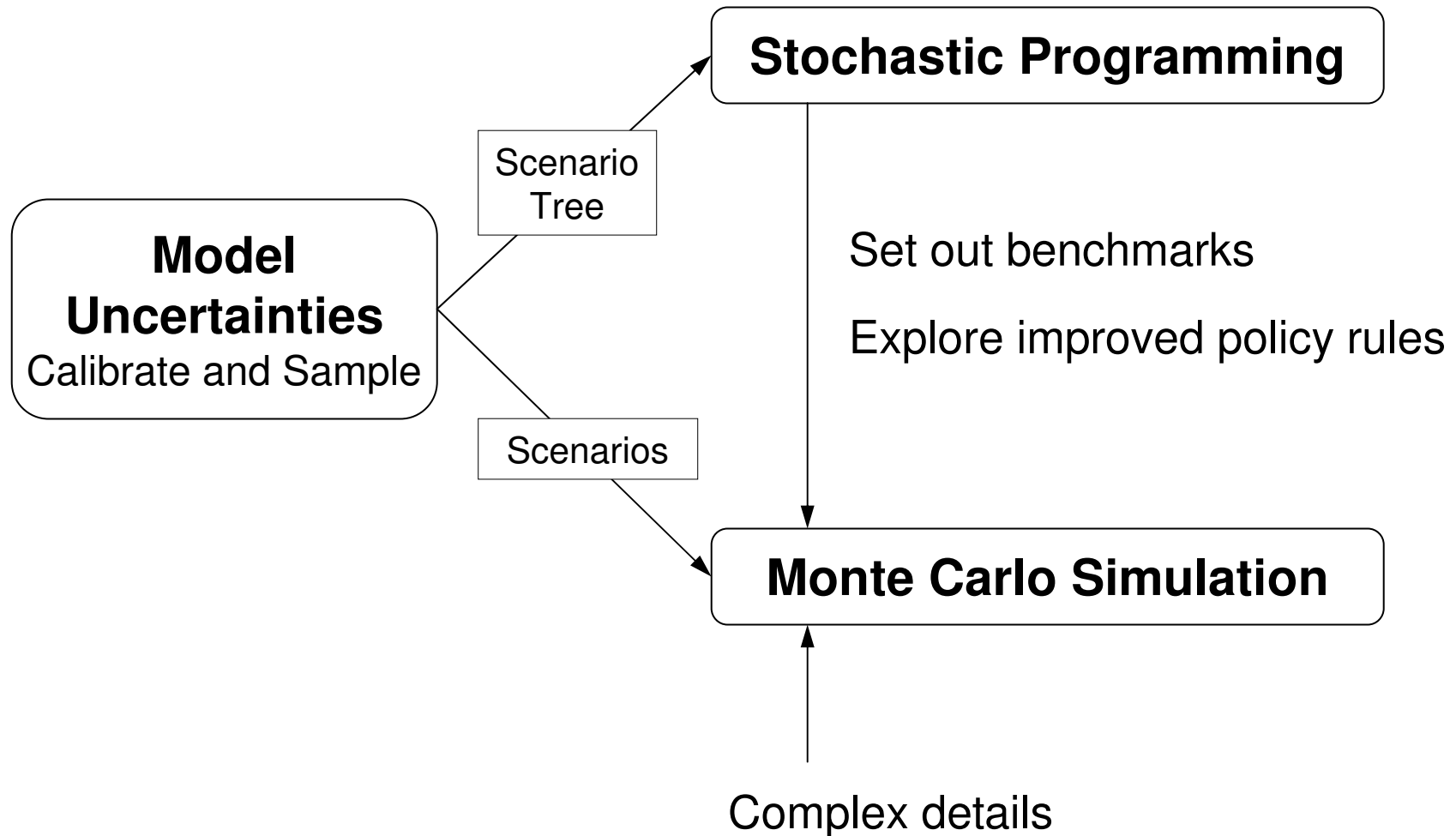
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Mulvey (sample):

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- "Assisting Defined-Benefit Pension Plans," *Operations Research*, October 2008, 1066-1078, (with K. Simsek, Z. Zhang, F. Fabozzi, and W. Pauling), **56**, 5.

- "Improving Investment Performance for Pension Plans", *Journal of Asset Management*, July 2006. **7**, 93-108 (with K. Simsek, Z. Zhang).

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