Final Report

Portfolio Modelling Project—Yale Endowment

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Yale Endowment Introduction

6.8%

Investment Return
(in fiscal year 2020)

$ 31.2B

Total endowment fund
amounted

$ 2.8B

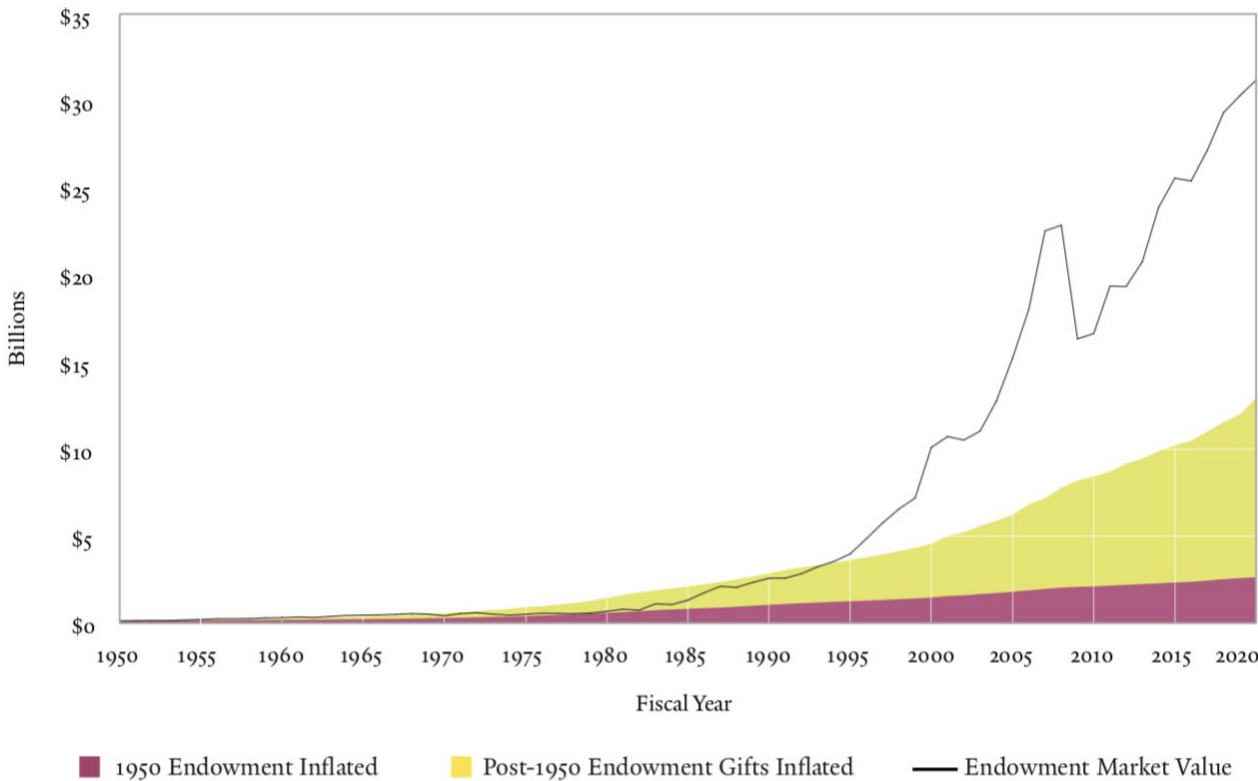Spending from Yale
Endowment

11.0%

Yale Endowment's
Objective

Endowment Growth Outpaces Inflation 1950–2020

Billions

$35

$30

$25

$20

$15

$10

$5

$0

1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020

Fiscal Year

■ 1950 Endowment Inflated   ■ Post-1950 Endowment Gifts Inflated   — Endowment Market Value

Capital Market Expectation

Equity(1.82%)

- Similar to the performance in 2010(Morgan Stanley)

- expecting 5% 10-year expected nominal return

Bond(47.50%)

- 10-year outlook for U.S. aggregate bonds also declined by nearly a percentage point, to 0.8% on a nominal basis(BlackRock)

Alternative(47.69%)

- Gold price decreases, Commodity price continue to recover
- Housing market is still hot, but there are signs that it's beginning to cool off

Cash(3%)

Asset Allocation
Decision
Equity Section

Health Care	Technology	Consumer Discretionary	Consumer Staples	Logistics	Energy/ Clean energy and sustainability	Electric/ EV
25%	20%	10%	10%	5%	10%	20%

Example Stocks: MRK, CVS, MSFT, NVDA, UL, KHC, FDX, CVX, TSLA

Equity Section(Applying Black-Litterman)

	Expected benchmark returns, no opinions	Analyst opinion, delta		Monthly returns adjusted for opinions		Opinion-adjusted optimized portfolio	Portfolio benchmark, no opinions
JNJ	0.731%	0%		0.984%		3.42%	5.20%
MRK	0.435%	0.565%		1.061%		18.66%	2.54%
LLY	0.520%	0%		0.768%		1.78%	2.70%
ABBV	0.769%	0%		0.970%		1.56%	2.37%
AMGN	0.684%	0%		1.025%		0.98%	1.49%
TMO	0.709%	0%		0.991%		1.82%	2.77%
ILMN	0.878%	0%		1.290%		0.50%	0.76%
IDXX	0.667%	0%		0.910%		0.43%	0.65%
UNH	0.703%	0%		0.922%		2.99%	4.55%
CVS	0.673%	0%		0.999%		0.90%	1.36%
REGN	0.423%	0%		0.545%		0.49%	0.75%
RMD	0.375%	0%		0.560%		0.31%	0.47%
MSFT	1.086%	0.41%		1.584%		31.18%	26.73%
ORCL	0.670%	0%		0.887%		1.98%	3.02%
FTNT	0.926%	0%		1.255%		0.39%	0.60%
NLOK	0.647%	0%		1.019%		0.12%	0.18%
NVDA	1.901%	0%		2.304%		4.18%	6.36%
INTC	0.669%	0%		0.856%		1.77%	2.69%
AVGO	0.956%	0%		1.206%		1.62%	2.47%
AMD	1.781%	0%		2.486%		1.00%	1.53%
XLNX	0.722%	0%		0.954%		0.30%	0.46%
NOW	0.907%	0%		1.183%		1.01%	1.54%
HPQ	0.819%	0%		1.024%		0.26%	0.40%
ETSY	1.290%	0%		1.593%		0.21%	0.32%
MCD	0.495%	0%		0.677%		1.47%	2.23%
NKE	0.781%	0.22%		1.202%		5.57%	2.86%
DPZ	0.504%	0%		0.678%		0.14%	0.22%
BBWI	1.275%	0%		1.422%		0.14%	0.21%
PG	0.354%	0%		0.526%		2.74%	4.17%
PM	0.816%	0%		1.053%		1.21%	1.84%
UL	0.359%	0%		0.542%		1.13%	1.72%
KHC	0.955%	0%		1.134%		0.36%	0.55%
NWL	0.817%	0%		1.080%		0.08%	0.12%
FDX	1.103%	0%		1.455%		0.48%	0.73%
ARCB	0.907%	0%		1.161%		0.02%	0.03%
HUBG	0.612%	0%		0.804%		0.02%	0.03%
CVX	0.862%	0%		1.167%		1.63%	2.48%
TSLA	3.568%	0%		4.135%		6.28%	9.55%
RACE	0.761%	0%		0.989%		0.42%	0.63%
F	0.618%	0%		0.745%		0.46%	0.70%

Bond Section

Due to high inflation and economic downturn in the next 3-5 years, we consider global corporate bonds and global Treasury bonds

	Selected Bond ETF	Benchmark
TIPX	The SPDR Bloomberg Barclays 1-10 Year TIPS ETF	the Bloomberg Barclays 1-10 Year U.S Government Inflation-Linked Bond Index
BWX	The SPDR Bloomberg Barclays International Treasury Bond ETF	the Bloomberg Barclays Global Treasury exit Capped Index
CWB	SPDR Bloomberg Barclays Convertible Securities ETF	the Bloomberg Barclays U.S. Convertible Liquid Bond Index

Bond Section(Applying Black-Litterman)

Black Litterman - Bond

Anticipated benchmark return	0.92%	<-- =11%/12		
Current T-bill rate	0.02%			
Normalizing factor	4.69	<-- {=(B2-B3)/MMULT(MMULT(B8:D8,B12:D14),TRANSPOSE(B8:D8))}		

	TIPX	BWX	CWB	
Market cap (million $)	908.56	977.9	7100.32	
Benchmark proportions	10.1%	10.9%	79.0%	

Variance-covariance matrix

	TIPX	BWX	CWB	With normalizing factor
TIPX	0.0001	0.0001	0.0001	0.07%
BWX	0.0001	0.0008	0.0003	0.18%
CWB	0.0001	0.0003	0.0029	1.13%

Check: The expected return of the benchmark?	0.92%	<-- {=MMULT(B8:D8,F12:F14)}

Optimal portfolio		
TIPX	10.11%	<-- {=MMULT(MINVERSE(B12:K21),M12:M21-B3)/SUM(MMULT(MINVERSE(B12:K21),M12:M21-B3))}
BWX	10.88%	
CWB	79.01%	
Sum of proportions	100.0%	

Alternative Selection

Generally uncorrelated with public markets, meaning that adding alternatives to a portfolio can increase diversification and reduce overall portfolio volatility

GLD	The SPDR Gold Shares	gold bullion, determined by market forces in the 24-hour global OTC market for gold
RWR	The SPDR Dow Jones REIT ETF	the Dow Jones U.S. Select REIT Index

Black Litterman - Alternative

Anticipated benchmark ret	0.92%			
Current T-bill rate	0.02%			
Normalizing factor	3.84	<-- {=(B2-B3)/MMULT(MMULT(B8:C8,B12:C13),TRANSPOSE(B8:C8))}		

	RWR	GLD
Market cap (million $)	1831.57	55455.3
Benchmark proportions	3.2%	96.8%

Variance-covariance matrix

	RWR	GLD		With normalizing factor	
RWR	0.0049	-0.0001		0.03%	<-- {=(MMULT(B12:C13,TRANSPOSE(B8:C8))*B4)+B3}
GLD	-0.0001	0.0025		0.95%	

Check: The expected return of the benchmark?	0.92%	<-- {=MMULT(B8:D8,F12:F14)}

Additional check: Optimal portfolio		
RWR	3.20%	<-- {=MMULT(MINVERSE(B12:C13),F12:F13-B3)/SUM(MMULT(MINVERSE(B12:C13),F12:F13-B3))}
GLD	96.80%	
Sum of proportions	100.0%	

	Expected benchmark returns, no opinions	Analyst opinion, delta, δ		Returns adjusted for opinions					Opinion-adjusted optimized portfolio		Portfolio benchmark, no opinions
RWR	0.03%	0.19%	RWR	0.23%	<-- =A25+B12/$B$12*$B$25				14.02%	GM	3.20%
GLD	0.77%	0.00%	GLD	0.77%	<-- =A26+B13/$B$12*$B$25				85.98%	HD	96.80%
expected RWR return	0.225%			0.23%				sum	100.00%		

Final Portfolio

👍 Target return: 0.917% (11%/12)

	short sales allowed (optimized)	Black Litterman	Optimized	black Litterman	Optimized	Black Litterman
Portfolio mean	3.66%	2.10%	0.59%	0.59%	0.65%	1.25%
Portfolio sigma	3.59%	3.29%	4.35%	4.37%	2.12%	4.37%
Sharpe ratio	101.65%	63.36%	13.11%	13.11%	29.75%	28.21%

	Optimized	Black Litterman
Equity	10%	1.82%
Alternative	37%	47.69%
Bond	50%	47.50%
Cash	3%	3.00%
Sum	100.00%	100.00%
Portfolio annual return	11%	11%

Thanks

For Your Attention