Brown University Endowment Portfolio Allocation Report
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FIN 218F Portfolio Financial Modeling
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Executive summary

The main objective for this report is to construct a most optimized portfolio for Brown University Endowment for the next 3-5 years. Brown Endowment has $4.7 billion asset under management (AUM) as of FY2020. During our modeling time frame, it has a return objective of 7.5% and a maximal risk tolerance of 19.25%. It also faces the liquidity constraint to have at least 40% of liquid assets and the asset allocation constraint to not investing in any security in the field of fossil fuels.

For the next 3-5 years, we expected the capital market to start with a bull following the global recovery of the pandemic and gradually revert to its long-term average. For fixed incomes, we believed the overall return to be positive but low. For equities, we strategically overweighted securities of developed markets and within cyclical sectors. Five of our most favorable sectors were Consumer Discretionary, Financials, Healthcare, Communication Services, and Energy. For alternatives, we believed in the potential of agriculture fields as well as industrial metals and REITs of data centers and healthcare.

For our modeling process, in order to have a diversified portfolio to hedge risks, we narrowed down our security selection from the initial number of 115 to 72 and finally to 34 through constructing correlation matrices by asset class and by sector and excluding one of each pair of securities with high correlations based on their historical returns and risks for the last 5 years. Then, we built 4 models of variance-covariance matrices and applied each of them to the processes of constrained optimization (not allowing short sale and having reasonable exposure to all asset classes) and unconstrained optimization (allowing short sale) and got 8 different optimal asset allocation accordingly. In order to make a more reliable estimate for future returns, we also used Black-Litterman model to generate the tracking matrix and estimate the benchmark-implied return for each of the 34 securities we selected. Finally, we used Sharpe ratio as our evaluation criteria and decided that the asset allocation decision based on the Black-Litterman model to be the most optimal and reliable.

1. About Brown University Endowment

1.1 Return objective

In pursuing the mission of maintaining and enhancing the University's long-term financial security, the Investment Committee of the Corporation of Brown University has set its long-term investment return goal at 5.5% above the Higher Education Price Index (HEPI). The HEPI is an inflation index created specifically for higher education institutions, and it is expected to rise to 2.2% in the fiscal year 2021 as the Common fund forecasted. Since 2021 is the time just after a series of large economic stimuli and at the beginning of the signal of tapering sent by the Fed, the inflation rate may experience substantial variation in the short run. For the next 3-5 years, we expect the inflation rate to gradually converge to the Federal Reserve's 2% target. Therefore, the minimum return objective for Brown University Endowment will be 7.5%.

Brown University's investment policy has fixed the spending range of its endowment to 4.5%-5.5% over the last 12 quarters and set the long-term goal of reaching a more sustainable spending rate to 4.5%. Also taking into account the external management fee of 1% (industry average), we can see that Brown University Endowment aims to achieve a net growth rate of 2% in the long-term.

1.2 Risk tolerance

As the University is expected to experience at least 165 million financial losses due to the Covid-19 pandemic, the endowment will serve an increasingly important role in supporting students, maintaining education and research budgets, and protecting public health. Since the establishment of the endowment, Brown has always had a relatively conservative and attitude to its spending and operation compared to its Ivy league peers. Therefore, in the coming years, in order to preserve the endowment's value and achieve sustainable growth, it is reasonable to see Brown show a tendency to have relatively higher risk aversion. Benchmarking other university endowments with similar asset sizes, we choose the 1st quartile of the risk tolerance range (18%-25%) to be Brown's maximal risk tolerance, which is 19.75%.

1.3 Constraints

Liquidity Constraint: As of FY20, "both the Corporation-designated funds and donor-restricted endowment funds contain investments with liquidity constraints, of which $1,910,536 (dollars in thousands) can be liquidated on a daily to quarterly basis". Therefore, given the $4.7 billion AUM of Brown Endowment, at all time at least 40% of the Endowment asset should be liquid (can be actively traded) to meet ad-hoc operational and financial needs of Brown University.

Asset Allocation Constraint: As the world shifts to sustainable energy sources, Brown Endowment started to liquidate its existing investments in fossil-fuel based energy several years ago and finished the liquidation during FY20. Placing high values on Environmental, Social, and Corporate Governance (ESG) criteria, the endowment also decided not to make any new investments in fossil fuels thereafter.

2. Capital Market Expectation

We believe the global economy is approaching the mid-cycle recovery, as shown by the peaks in fiscal and monetary policy support as well as a potentially transitory surge in inflation. We expect global growth to gradually slow down, maintaining a still above-average growth rate in 2022 but returning to the historical average in 5 years.

2.1 Fixed Income:

The US 10-Year Treasury yield is expected to experience only slimmer growth, floating around 1.6% in the next 3-5 years, as both Goldman Sachs and JP Morgan cut their forecast following the Fed sending signals of tapering in August **(See Exhibit 1)**. When factoring in the still-above-the-target inflation rate in the short run, the real yield for the US 10-Year Treasury is negative. Therefore, we are strategically underweight in US Treasuries and prefer Treasury Inflation-Protected Securities (TIPS) instead. For the next 3-5 years, although the interest rate is assessed to be meaningfully higher than today's near-zero level, the overall fixed income return is expected to be positive but low. The improving consumer solvency and the lagging emerging markets economic recovery may make both the securitized assets and the emerging market bonds more attractive and have higher yields.

2.2 Equity:

Taking climate change mitigation into our expected returns consideration and given the greater geopolitical uncertainties, we tend to prefer developed market (DM) securities over emerging market (EM) securities. We favor both U.S. small-cap and large-cap equities, since small-caps tend to benefit more from the recovery of domestic activities brought by the increased vaccination rollout; Meanwhile, the higher quality large-caps can maintain more stable earnings and counter small-caps' high volatility. As the economic recovery trends spread globally, we expect cyclical sectors to outperform defensive sectors, but still need some exposure to the defensive sectors as the economic growth gradually reverts to its longer-term mean.

2.3 Alternatives

We expect robust recovery and outstanding performance in the commodity markets for the next 3-5 years. The strong demand and the expected depreciation of the U.S. dollar support the rise in agricultural prices. The substantial multi-year infrastructure expenditure proposed by the Biden Administration could also generate upward pressure on the prices of industrial metals. Nearly every REIT sector achieved positive returns in 2021 so far, and we believe this upward trend should continue in the following years since the global REITs valuation are still relatively low and the industrial and business conditions are expected to improve.

3. Outlook of Sectors

We focused our equity investment in 5 sectors that we believed to have the potential to outperform the market for the next 3-5 years, namely Consumer Discretionary, Financials, Healthcare, Communication Services, and Energy.

Consumer Discretionary

Returning to work on site after the epidemic should greatly increase the frequency of using cars, which leads to the increase of both auto buying and maintenance rates. The dealer industry, diversified consumer service industry, restaurant, and hotel industry will also grow retaliatory as the epidemic improves and the tourism industry recovers. In addition, since the epidemic has caused many companies to carry out the digital revolution and focus on online sales and development, we keep our optimistic view toward e-commerce and internet retailing.

Financials

The financial sector has outperformed S&P 500 and Nasdaq during the past year. The favorable cyclical tailwind of rising interest rates should further increase its profitability, especially for banks, although it could take some time to happen as the Fed may not achieve its target Federal Fund rate until mid-2022. Also, the accelerated digital transformation of the financial sector during the pandemic provides it with more opportunities, such as mobile payments and Fintech in general.

Healthcare

From a long-term perspective, the healthcare sector has great potential for market outperformance due to the intensified global aging problem and a growing middle-aged population, especially in the EM. With the advent of the era of longevity, people have to coexist with diseases for much longer times, which generates extensive demand for drug treatments and medical care. The COVID-19 pandemic has also raised health awareness for all generations. Therefore, although facing the risks of tighter regulation and high R&D expense, we continue to hold a favorable stance toward the medical device and pharmaceutical stocks.

Communication Services

The stay-at-home behavior associated with the pandemics dramatically increased the demand for social media and other streaming entertainment services. With the permanent shifts in consumer behavior and the evolving structural transformation within the industry, these companies could still maintain their advantageous position post-pandemic. Moreover, the continued expansion of 5G technology should open up more markets for both interactive media services and telecommunication services, further driving growth within the sector.

Energy

While it takes time, the global clean energy transition and the path to net-zero carbon emission should boost the renewable energy sector in the long-term. Led by the spreading popularity of electric vehicles (EV), we are also strategically overweight the tech stocks that are involved in the research and development in EV batteries and other clean energy sources such as hydropower, biofuels, wind power, and solar power.

4. Asset Allocation Decision

4.1 Process of Narrowing down our securities

Having Brown's objectives and constraints in mind, we carefully selected 14 to 17 equity securities from each of the five preferred sectors we mentioned before and within each focused on 2-3 favorable subsectors. In order to construct a diversified portfolio under our market expectations, we also choose 40 securities from fixed-income and alternatives to finally make up our initial selection of 115 securities. Especially for fixed incomes, we include TIPs, emerging market investment grade corporate bond, mortgage-backed securities, and money market fund in order to make our portfolio more various while achieving Brown's liquidity requirement. We follow Brown's spirit and make sustainability as the prerequisite when selecting securities, therefore not only paying more attention to clean energy and the agriculture fields, but also avoiding involving in any heavy industries or fossil fuel companies.

By using stock price downloader, we calculated the monthly return according to the monthly prices of these 115 securities in 5 years from October 1, 2016 to September 1, 2021. We built the Correlation and Triangular Correlation Matrices of Equities for each of the 5 preferred sectors and used the conditional formatting to highlight and then remove one of each pair of securities having covariances greater than 0.6. We applied the same process for fixed incomes and alternatives, which helped us screen out the appropriate 72 securities as results. **(See Exhibit 2. This is an example of how we mark the correlation higher than 0.6 in triangular correlation matrix and screen out 6 out of 15 securities from financial sectors.)**

In addition, we put together all these 72 securities left and did the Correlation and Triangular Correlation Matrices again but applying stricter criteria this time. Specifically, we removed one of each pair of securities with correlation greater than 0.55 to further narrow down the securities. Within sector, we also analyzed the individual Sharpe ratio (risk-adjusted return) for all equities. When finding abnormal values, such as the one that contains extremely high standard deviation that did not match its average return, we deleted them after the research of their fundamental information. This is how we finally got our 34 securities as our results to help our client get a diversified but concise portfolio.

4.2 Constrained and Unconstrained Optimization

Using the 34 securities we finally selected, we created 4 different models of covariances-variance matrix, including the Sample variance-covariance matrix, variance-covariance using Single Index model, covariances-variance matrix with Constant Correlation method, variances-covariance matrix model with Shrinkage method. For each of these 4 models, we performed both the constrained and unconstrained optimization and derived eight portfolio allocation decisions in total. For each of them, we calculated the monthly (annualized) portfolio return, monthly (annualized) standard deviation, and Sharpe ratio to make comparison.

For the unconstrained optimization, since we assumed short sale was allowed, all our four models produced super high Sharpe ratio. As shown in **Exhibit 3**, the Sample variance-covariance matrix one performed the best, having a Sharpe ratio of 112%, and the Single Index model one performed the second best, having a Sharpe ratio of 103%. However, since Brown University Endowment followed long-term development strategy and did not allow short selling for such a long period of 3-5 years, we decided to further constraint our portfolio allocation to eliminate short sales.

For the constrained optimization, as Brown University Endowment became relatively more sensitive to risk compared to pre-pandemic level, we believed it is necessary to let our portfolio have enough exposure to fixed incomes and alternatives, instead of overly relying on equity investment. Therefore, we made several constraints by using Excel Solver to adjust the weights appropriately. Specifically, we set the weights of all fixed incomes and alternatives to be greater than 2% and the weights of all equities to be greater than 1%. Then, we set five security-specific constraints to guarantee having enough exposure the securities we believed to have greater risk-adjusted returns: we set the weights of The Home Depot, Inc (HD), Netflix, Inc (NFLX), Vanguard Short-Term Inflation-Protected Securities Index Fund ETF Shares (VTIP), Vanguard Mortgage-Backed Securities Index Fund ETF Shares (VMBS), and American Tower Corporation (AMT) to be greater than 5%. As shown by **Exhibit 4**, the portfolio using the Shrinkage method variances-covariance matrix had the best performance, with a Sharpe ratio of 83%. This meant that our portfolio of 34 securities could generate 83% of excess return per unit of risk.

4.3 Black-Litterman Model:

We also applied the Black-Litterman model to reverse the optimization process we did above in order to produce an estimate not relying solely on historical average returns and risks. Based on our capital market expectations for the next 3-5 years, we set the capitalization-weighted benchmark return for our 34 securities to be 1% per month. With 0.02% monthly risk-free rate and using the shrinkage method variance-covariance matrix, we computed the expected return for each security implied by the benchmark and found a majority of them being significantly lower than their historical means. We believe that in 3-5 years, security returns tend to convert to their long-term means, and for securities with large Sharpe ratio (higher risk-adjusted return), it is very likely that their future returns exceed their historical averages. Therefore, in this model, we made moderate upward adjustment to securities with Sharpe ratio greater than 25% together with some slight adjustment for fixed income and alternatives in general; then, we used the tracking matrix to compute our opinion-adjusted expected return for each security and applied Merton Proposition 1 again to get the optimized portfolio allocation accordingly.

In order to further validate our portfolio allocation decision, we decided to set our final portfolio allocation to be the weighted average of our opinion-adjusted optimized portfolio and the implied benchmark portfolio, using a confidence factor of 0.7. Finally, based on our opinion-adjusted expected returns and our final portfolio allocation, we achieved an annualized return of 19.97% and an annualized standard deviation (risk) of 8.68% **(See Exhibit 5 and 6)**.

5. Conclusion

Since we are constructing portfolio for Brown University Endowment for the next 3-5 years and it is impossible to do short sale for such a long period of time, the portfolio allocations suggested by unconstrained optimization are actually inappropriate. Therefore, all we left to do is to compare our four models of constrained mean-variance optimizations with the portfolio allocation we created using the Black-Litterman approach. Using Sharpe ratio as our evaluation criterion, we realized that the Sharpe ratio for constrained optimization methods were in the range of 61% to 83%, with the shrinkage method one doing the best.

However, since the Black-Litterman model was not simply using the historical average returns but involved both our opinions and the benchmark implied results for future returns, we think using Black-Litterman model was a more reliable estimate for the future. Also, the 19.97% return and 8.68% risk both match Brown University Endowment's return and risk objectives, which were 7.5% and 19.75% respectively; The Sharpe ratio for the portfolio allocation using Black-Litterman model was 66%, which was also within the above-mentioned range. Therefore, we recommend the Brown University Endowment to manage its $4.7 billion asset following the portfolio allocation based on our Black-Litterman model, that is to invest about 67% in equities, 25% in fixed incomes, and 8% in alternatives.
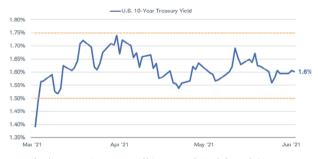
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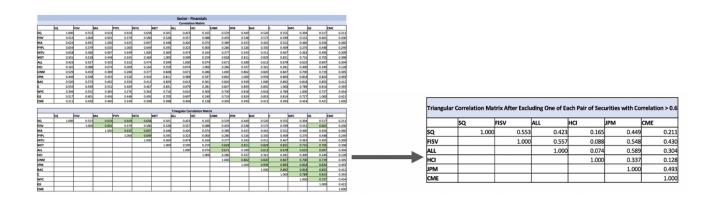
Appendix

Exhibit 1:

Ten-year Treasury yields have been rangebound

Source: Bloomberg. US Generic Govt 10 Year Yield (USGG10YR Index). Daily data as of 6/1/2021. **Past performance is no guarantee of future results.**

Exhibit 2: Illustration of narrowing down securities

Triangular Correlation Matrix After Excluding One of Each Pair of Securities with Correlation > 0.6

	SQ	FISV	ALL	HCI	JPM	CME
SQ	1.000	0.553	0.423	0.165	0.449	0.211
FISV		1.000	0.557	0.088	0.548	0.430
ALL			1.000	0.074	0.589	0.304
HCI				1.000	0.337	0.128
JPM					1.000	0.493
CME						1.000

Exhibit 3: Unconstrained optimization results

Sample Variance-Covariance Matrix		Single-index Model		Constant Correlation Method		Shrinkage Method	
Monthly Portfolio Return	1.040%	**Monthly Portfolio Return**	1.023%	**Monthly Portfolio Return**	2.490%	**Monthly Portfolio Return**	1.285%
Annualized Portfolio Return	**12.48%**	**Annualized Portfolio Return**	**12.28%**	**Annualized Portfolio Return**	**29.87%**	**Annualized Portfolio Return**	**15.42%**
Monthly Portfolio Variance	0.008%	**Monthly Portfolio Variance**	0.009%	**Monthly Portfolio Variance**	0.095%	**Monthly Portfolio Variance**	0.017%
Monthy Std Deviation	0.91%	**Monthly Std Deviation**	0.97%	**Monthy Std Deviation**	3.07%	**Monthly Std Deviation**	1.31%
Annualized Std Deviation	**3.16%**	**Annualized Std Deviation**	**3.36%**	**Annualized Std Deviation**	**10.65%**	**Annualized Std Deviation**	**4.54%**
Sharpe ratio	**112%**	**Sharpe ratio**	**103%**	**Sharpe ratio**	**80%**	**Sharpe ratio**	**96%**

Exhibit 4: Constrained optimization results

Sample Variance-Covariance Matrix		Single-index Model		Constant Correlation Method		Shrinkage Method	
Monthly Portfolio Return	2.281%	Monthly Portfolio Return	2.159%	Monthly Portfolio Return	2.178%	Monthly Portfolio Return	2.181%
Annualized Portfolio Return	27.38%	Annualized Portfolio Return	25.91%	Annualized Portfolio Return	26.14%	Annualized Portfolio Return	26.17%
Monthly Portfolio Variance	0.113%	Monthly Portfolio Variance	0.087%	Monthly Portfolio Variance	0.127%	Monthly Portfolio Variance	0.068%
Monthly Std Deviation	3.36%	Monthly Std Deviation	2.95%	Monthly Std Deviation	3.56%	Monthly Std Deviation	2.61%
Annualized Std Deviation	11.64%	Annualized Std Deviation	10.22%	Annualized Std Deviation	12.34%	Annualized Std Deviation	9.03%
Sharpe Ratio	67%	Sharpe Ratio	73%	Sharpe Ratio	61%	Sharpe Ratio	83%

Exhibit 5 and 6: Black-Litterman Model results

Expected benchmark returns, no opinions	Analyst opinion, delta	TICKER	Monthly return adjusted for opinions	Opinion-adjusted optimized portfolio	TICKER	Portfolio Benchmark, no opnion	Asset Class	Opinion and Confidence-adjusted portfolio	Broad Asset Class weight
0.68%	0.30%	CMG	2.75%	1.00%	CMG	1.04%	Equities	1.01%	67.28%
2.93%	0.50%	TSLA	5.61%	2.70%	TSLA	15.70%		6.60%	
0.80%	0.00%	VWAGY	2.29%	0.45%	VWAGY	3.16%		1.26%	
0.56%	0.50%	HD	2.20%	4.66%	HD	7.04%		5.37%	
0.50%	0.30%	NKE	1.90%	2.52%	NKE	4.71%		3.18%	
0.29%	0.00%	FISV	1.35%	0.21%	FISV	1.47%		0.59%	
1.14%	0.50%	HCI	2.08%	4.24%	HCI	19.32%		8.76%	
0.23%	0.00%	CME	0.66%	0.20%	CME	1.43%		0.57%	
0.24%	0.50%	VEEV	1.96%	1.80%	VEEV	0.90%		1.53%	
0.37%	0.70%	ABT	1.87%	8.23%	ABT	4.20%		7.02%	
0.50%	0.00%	EW	2.15%	0.20%	EW	1.42%		0.56%	
0.22%	0.30%	BIO	1.67%	1.37%	BIO	0.45%		1.09%	
0.44%	0.30%	PKI	2.40%	1.53%	PKI	0.43%		1.20%	
0.20%	0.50%	RMD	1.26%	3.00%	RMD	0.77%		2.33%	
0.38%	0.50%	TMUS	1.55%	4.42%	TMUS	3.20%		4.06%	
0.68%	0.50%	NFLX	2.17%	2.45%	NFLX	5.49%		3.36%	
0.44%	0.00%	TWTR	1.08%	0.14%	TWTR	1.00%		0.40%	
0.61%	0.00%	TCEHY	1.45%	1.63%	TCEHY	11.52%		4.60%	
0.18%	0.50%	NEE	1.30%	6.22%	NEE	3.14%		5.30%	
0.45%	0.00%	NRG	1.98%	0.03%	NRG	0.20%		0.08%	
0.56%	0.50%	ENPH	2.98%	0.31%	ENPH	0.42%		0.34%	
0.32%	0.50%	BEP	1.77%	3.88%	BEP	0.20%		2.78%	
0.79%	0.50%	CRM	2.74%	3.10%	CRM	5.45%		3.81%	
0.43%	0.50%	FTNT	2.24%	1.60%	FTNT	0.98%		1.42%	
0.63%	0.00%	FSELX	2.52%	0.02%	FSELX	0.14%		0.05%	
0.06%	0.03%	VTIP	0.21%	17.38%	VTIP	1.02%	Fixed Income	12.47%	25.23%
0.05%	0.01%	BNDX	0.24%	2.39%	BNDX	2.35%		2.38%	
0.01%	0.02%	VMBS	0.06%	14.18%	VMBS	0.34%		10.02%	
0.16%	0.01%	IBND	0.64%	0.50%	IBND	0.00%		0.35%	
0.14%	0.70%	AMT	1.44%	7.08%	AMT	2.45%	Alternatives	5.69%	7.49%
0.25%	0.01%	FPI	1.25%	0.03%	FPI	0.01%		0.02%	
0.42%	0.01%	GMRE	1.83%	0.03%	GMRE	0.02%		0.03%	
0.29%	0.30%	CPER	1.09%	2.31%	CPER	0.01%		1.62%	
0.22%	0.01%	VAMO	0.62%	0.18%	VAMO	0.00%		0.13%	

γ, opinion confidence	0.7
Monthly Portfolio Return	1.66%
Annualized Portfolio Return	19.97%
Monthly Portfolio Variance	0.06%
Monthly Portfolio Sigma	2.50%
Annualized Portfolio Sigma	8.68%
Sharpe Ratio	66%