

Mini Project #4

How Should a CUNY Employee Best Secure Their Retirement?

In this last project to wrap the semester, we are taking a dive into the wide world of financial data. Specifically, in this project we are going to analyze the two different retirement plans offered to CUNY employees and see how they differ. Is one better than the other? How do we even define better in this sense? Whats less risky, what will yield you more value over time on average? These questions we will aim to answer.

Tasks 1-3: Acquiring the Data

First to start off, we need to acquire our financial data that will serve as a basis on our calculations going forward. To do this we need to collect financial data covering these metrics:

- Wage growth
- Inflation
- US Equity Market total returns
- International Equity Market total returns
- Bond market total returns
- Short-term debt returns

To do this we are going to take advantage of the **AlphaVantage** and **FRED** APIs to acquire the time-series data. After its downloaded I will go over why I picked the specific funds that I did.

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US Equity Market Total Returns

For this metric, we are analyzing the **Vanguard Total Stock Market Index Fund ETF (VTI)**. Vanguard is one of the leading providers of ETFs and Mutual Funds in the market. For the sake of consistency in this analysis, all ETFs will be Vanguard provided funds. This ETF captures the total stock market as opposed to just top companies like an S&P 500 index would capture.

International Equity Market Total Returns

For this metric, we are analyzing the **Vanguard FTSE All World ex US ETF (VEU)**, which as the name suggests aims to capture the whole world stock market excluding the US. We already have the US captured in **VTI** so there is no need to overlap the US in a global metric.

Bond Market Total Returns

For bonds we are using **Vanguard Total Bond Market Index Fund Admiral Shares (VBTLX)**, this aims to capture a broad array of US bonds, short intermediate and long term bonds. Bonds are usually tied to interest rates and are generally a less risky option than stocks. However as the interest rate fluctuates it could cause a downturn in price, and with less risk also comes less reward.

Short-Term Debt Returns

Similarly, short-term debt returns is a type of bond investment that only focuses on short term investments. This is reserved for only the oldest of employees as it usually makes more sense to invest in longer term securities to increase the potential returns. Therefore this is the lowest risk and lowest return type investment. **For this we are using Vanguard Short-Term Bond Index Fund Admiral Shares (VBIRX).**

Inflation and Wage Growth

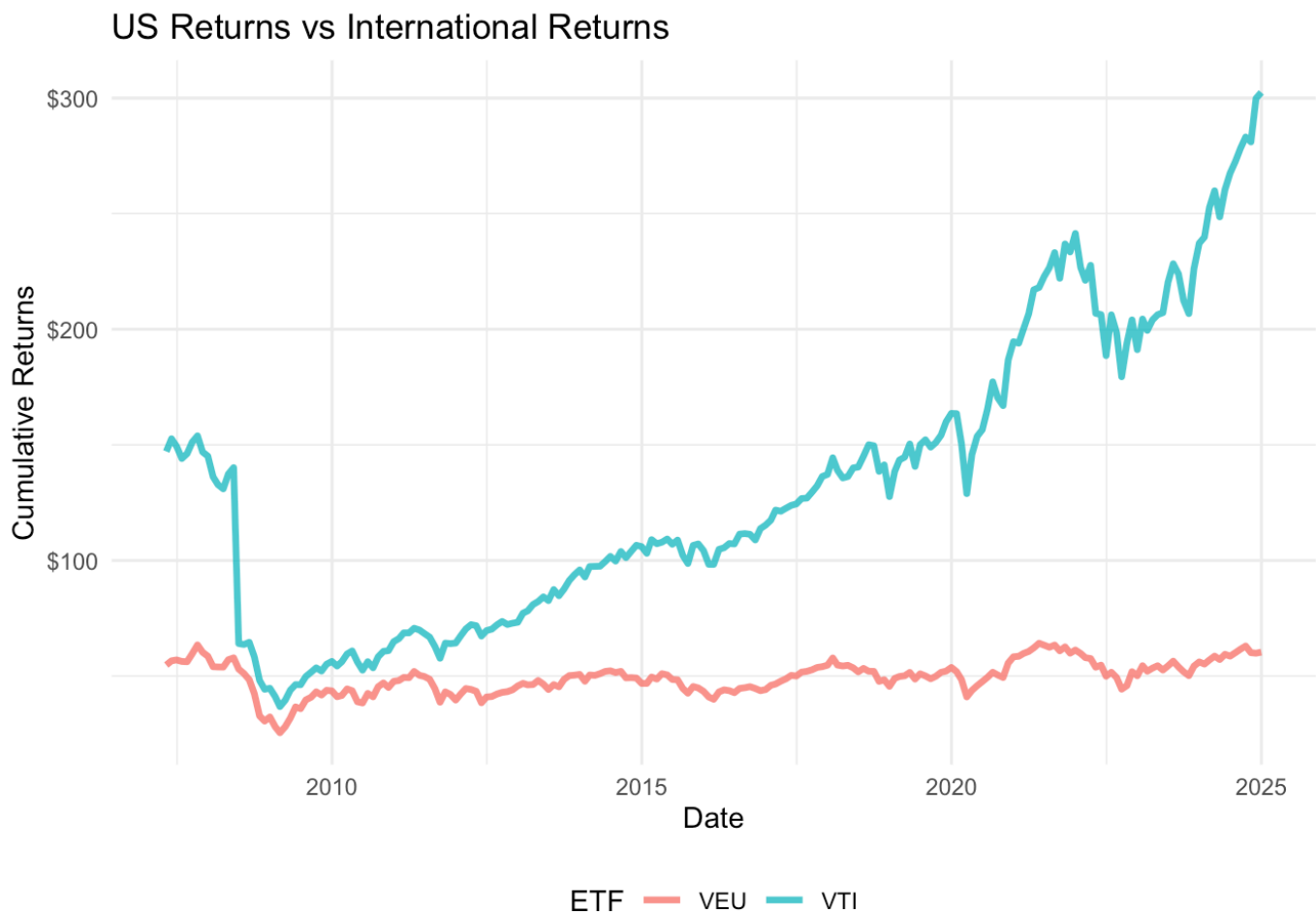
For these metrics we will take advantage of the FRED API to acquire data from the Federal Reserve Economic Data repository. For Inflation we will use a metric called the **Consumer Price Index (CPI)** which generally measures the cost of an

identical basket of goods year over year. Wage growth we will look at the running average of salary increase percentage over the last 12 months.

Task 4 - Analysis

Now that we have the data, there are a few things that might be interesting to take a look at. First its probably worth comparing how US returns compare to the rest of the world. Maybe it can give us some insight on American economic domination or lack thereof.

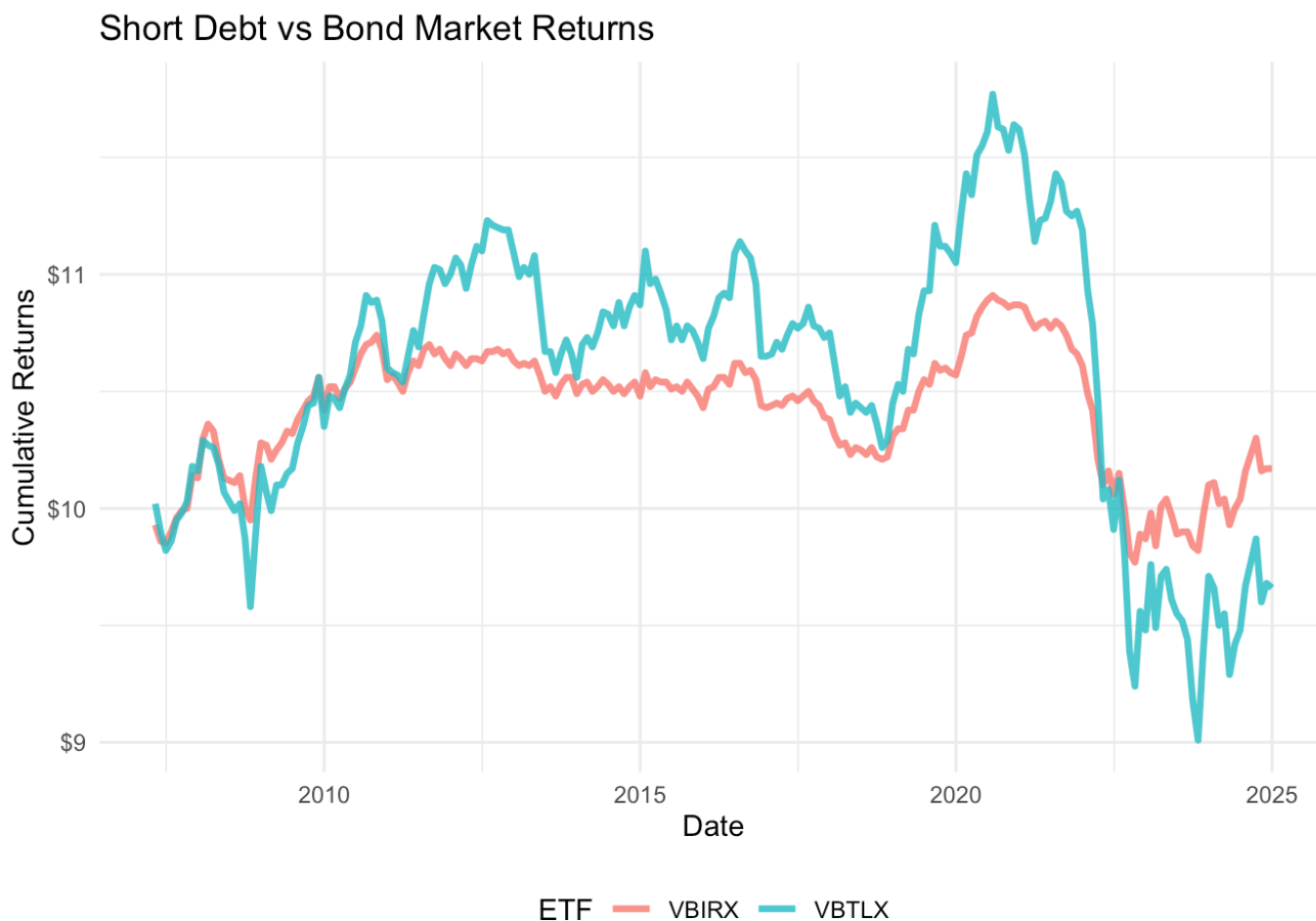
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While both economies were greatly affected by the 2008 financial crisis, it is actually quite wild to see how much the American market has pulled ahead over global competition.

Another thing worth looking at is the risk vs reward paradigm of bonds vs short term debt returns. Does this hold true?

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And our suspicions are confirmed. As we assumed **VBTIX** has higher highs and lower lows, where as **VBIRX** is less risky and doesn't fluctuate as much.

Lastly it might be interesting to see if wage growth is tied at all to inflation like it might be advertised. Generally companies try to account for inflation in annual salary adjustments, but how true is this in practice?

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```
[1] 0.9947642
```

To test this, I simulated to see if wages grew at the same rate as the CPI and overall it is extremely correlated. While wage growth may take some time to see

the effects in inflation due to weighted averaging it does generally match. As we see the correlation is near 1. I will also display the table if you want to take a look.

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entries

Search:

	date	wages_pct_change	CPI	CPI_pct_change	wages_pct_change
1	1997-12-31	4.7	161.8	0	
2	1998-01-31	4.7	162	0.1236093943139608	
3	1998-02-28	4.7	162	0	
4	1998-03-31	4.7	162	0	
5	1998-04-30	4.8	162.2	0.1234567901234498	
6	1998-05-31	4.9	162.6	0.2466091245376114	
7	1998-06-30	4.9	162.8	0.1230012300123106	
8	1998-07-31	5	163.2	0.2457002457002317	
9	1998-08-31	5	163.4	0.1225490196078536	
10	1998-09-30	5	163.5	0.06119951040391328	

Showing 1 to 10 of 323 entries

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[1] 6.745736

[1] 2.215023

Task 5 - Historical Battle

Now that we have looked into our data, its time to start the heavyweight battle between our retirement options, those being **Teachers Retirement System (TRS)** and **Optional Retirement Plan (OPR)**.

TRS is calculated as follows:

It is based off of the average of the the last 3 years of salary issued to the employee, or **Final Average Salary (FAS)**.

$$if(N < 20, .00167 * FAS * N)$$

$$if(N = 20, .00175 * FAS * N)$$

$$if(N > 20, (.035 + .02 * N) * FAS)$$

Its then adjusted for inflation.

$$Inflation = max(.01, min(.03, mean(CPI * .5)))$$

OPR is more convoluted and its asset allocation adjusts based on the employees age.

- Age 25 to Age 49:
 - 54% US Equities
 - 36% International Equities
 - 10% Bonds

- Age 50 to Age 59:
 - 47% US Equities
 - 32% International Equities
 - 21% Bonds
- Age 60 to Age 74:
 - 34% US Equities
 - 23% International Equities
 - 43% Bonds
- Age 75 or older:
 - 19% US Equities
 - 13% International Equities
 - 62% Bonds
 - 6% Short-Term Debt

Furthermore both the employee and employer contribute to the fund,

- \$45,000 or less: 3%
- \$45,001 to \$55,000: 3.5%
- \$55,001 to \$75,000: 4.5%
- \$75,001 to \$100,000: 5.75%
- \$100,001 or more: 6%

The employer contribution is fixed at:

- 8% for the first seven years of employment at CUNY.

- 10% for all years thereafter.

Using our historical data (2007-present), let's compare how these options would fare once an employee retires in this year of 2024 assuming they started in 2007.

For this we are assuming a starting salary of 50,000 and age between 25-49.

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[1] 1989.073
```

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[1] 281857.8
```

What we find is that by the time of retirement, approximately \$282,000 have accumulated in the ORP fund whereas the TRS will start to pay around \$2000 monthly. Given an annual withdrawal of 4% of ORP along with dividing that monthly that's about half of what TRS offers. This isn't that surprising because the longer you work the more you have to contribute to ORP, 17 years here perhaps not being long enough for ORP to overcome the potential TRS benefit.

Task 6 - Simulation Till Death

While it's useful to see how each retirement stacks up once an employee decides to end his career, what is more important is seeing how each fares during actual retirement. For this we're going to assume a retirement duration of 15 years. How does each plan fare after being used for 15 straight years? In this analysis we will assume rates are fixed, this isn't relevant for TRS but for ORP we will assume these market returns based on long run averages of our data.

US Returns - 7%

International Returns - 4%

Bonds - 2%

Short-Term Debt - 1%

TRS After 15 Years

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[1] 2540.296
```

After 15 years we find that the average monthly payment works to around \$2550.

ORP Fixed Simulation

For ORP we will conduct a fixed simulation, prefaced on the assumption of 4% withdrawals annually, a 2.5% annual inflation rate and a starting balance of \$290,000 as calculated previously.
av

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```
$final_balance
```

```
[1] 330501.4
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```
$total_withdrawn
```

```
[1] 208010.3
```

```
$funds_exhausted
```

```
[1] FALSE
```

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$withdrawals
```

```
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\$balances

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[9] 292532.5 292855.4 293179.7 293505.4 293808.4 294112.7 294418.4
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[17] 295033.8 295343.6 295654.7 295967.1 296281.0 296596.2 296912.8
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[25] 297525.5 297821.5 298118.7 298417.3 298717.2 299018.4 299320.9
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310969.8

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312999.2

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[89] 315227.8 315468.4 315709.9 315952.6 316196.3 316441.1 316687.0
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[113] 320648.3 320854.5 321061.7 321269.8 321478.7 321688.7 321899.5
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[121] 322293.8 322477.1 322661.2 322846.2 323031.9 323218.5 323405.9
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[129] 323783.2 323973.1 324163.8 324355.3 324516.8 324679.0 324841.9
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[137] 325169.9 325334.9 325500.7 325667.2 325834.5 326002.5 326171.2
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330141.2

[177] 330230.7 330320.6 330410.8 330501.4

While the monthly withdrawals start quite low, around \$1150, given we assume the market is always improving this method sees the overall wealth grow quite considerably until death. In an ever growing market 4% is probably a conservative withdrawal amount. However this isn't how the actual market performs, there are periods of growth and periods of recession. However according to this fixed rate analysis, ORP seems to be a clear winner here. This begs the question what if we weren't so lucky with market returns?

Task 7 - Bootstrapping

To account for the uncertainties of the market, and the many variables that go into an employees retirement fund, to do a more holistic analysis we will simulate a number of random scenarios to better capture the average performance of TRS and ORP respectively. This process has been abstracted into multiple functions that will run as many simulations as we like. You can take a look at the code but the important details is what has been randomized. We assume a death age of 80 in our simulations.

- Employees starting age: 22-63
- Starting Salary: 40,000-120,000
- Market Returns are randomized monthly based on the Asset, roughly.
 - US Returns (-15%, 15%)
 - Intl Returns (-10%, 12%)
 - Bonds (-1%, 2%)
 - Short-Term Debt (-.5%, 1.5%)

ORP Results

► Code

Show

10

 entries

Search:

	mean	lower_ci	upper_ci	exhaustion_l
1	639275.2161420322	0	5489143.723374311	
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6	639275.2161420322	0	5489143.723374311	
7	639275.2161420322	0	5489143.723374311	
8	639275.2161420322	0	5489143.723374311	
9	639275.2161420322	0	5489143.723374311	
10	639275.2161420322	0	5489143.723374311	

Showing 1 to 10 of 200 entries

Previous

1

2345...20Next

TRS Results

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Show

10

 entries

Search:

	mean	lower_ci	upper_ci	exhaustion_l
1	1289275.587030308	55996.8436865784	3957516.448667446	134

	mean	lower_ci	upper_ci	
2	1289275.587030308	55996.8436865784	3957516.448667446	11!
3	1289275.587030308	55996.8436865784	3957516.448667446	56
4	1289275.587030308	55996.8436865784	3957516.448667446	2
5	1289275.587030308	55996.8436865784	3957516.448667446	59
6	1289275.587030308	55996.8436865784	3957516.448667446	12
7	1289275.587030308	55996.8436865784	3957516.448667446	19
8	1289275.587030308	55996.8436865784	3957516.448667446	80
9	1289275.587030308	55996.8436865784	3957516.448667446	27
10	1289275.587030308	55996.8436865784	3957516.448667446	20!

Showing 1 to 10 of 200 entries

Final Analysis

From our simulations we can really see how TRS and ORP really differ on the big stage. While ORP does at times produce staggeringly high wealth, it also introduces an **exhaustion rate close to 40%!** This should be alarming to anyone looking for a secure retirement. There in lies the risk vs reward paradigm of ORP or investing in the market for anyone. While in the long term the market will go up, in the short-term anything can happen and all it takes is one bad year to see your net worth go to zero. While 4% withdrawal is generally a safe conservative bet, assuming average market returns of closer to 6%, this could be a problem in downturn years. A more variable withdrawal rate probably makes more sense

based on market conditions, be more conservative on poor years and less on big earning years.

TRS has much more consistent results by the nature of its plan. While it may never be able to reach the heights that can potentially yield from a bullish market it is definitely a more secure option. So the better plan? Well it really would depend person to person. If said employee is depending on this as their only assets through retirement, TRS is most likely the safer bet. However, if an employee has worked for a long time, and built a large ORP account, ORP is probably going to yield greater wealth and thus more inheritance money for said employees family once they die. The longer the tenure at CUNY the better the ORP option is, the potential returns will just be much higher. However, if the money is essential to post-retirement survival or the employees tenure is not as long so their investments are less cumulative and less secure then TRS is the better option.