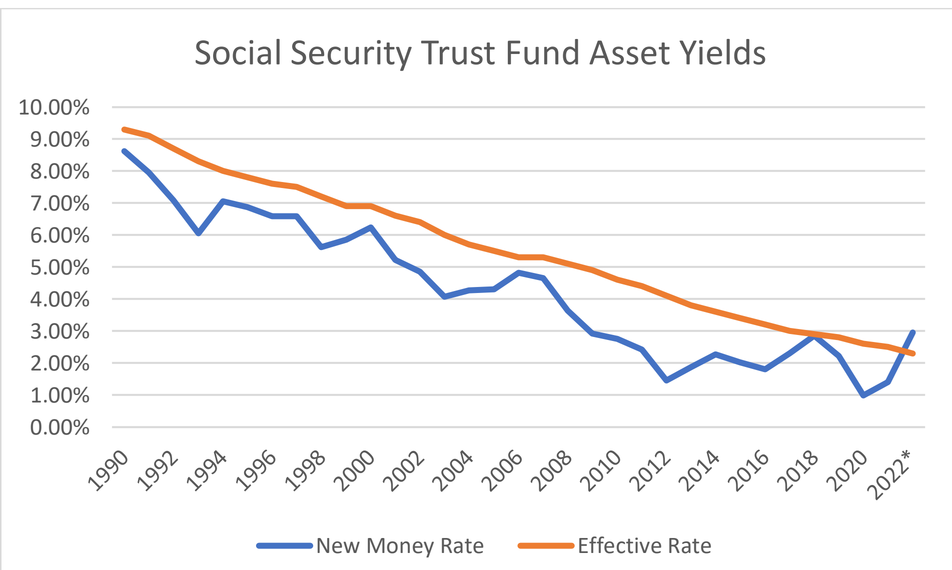
Social Security's Interest Rate Risk
By Matt Farmer

Introduction

The Social Security program provides income to millions of Americans and is the largest social program in the United States. The program invests in interest generating bonds which help fund the program. Its trust funds can be thought as reserves that are set aside today to pay future benefits. The Social Security Administration is responsible for managing the program and the Social Security Board of Trustees oversee the program. As discussed in my previous paper the Social Security trust funds are underfunded and projected to run out in 2035 (SSBT, 2022). There are various key drivers causing insolvency. They include the retiring baby boom demographic, political unresponsiveness, lower fertility rates and interest rates. The interest rate risk component will be the focus of this paper.

Social Security invests in special issue bonds whose yields are based on average market yields of public treasuries (42 U.S.C. § 401(d)). Social Security has seen its new-money yields, the interest rate earned on recently purchased investments, decline since 1990's. In turn, its total portfolio yield (called the "effective yield) also declined. The chart below illustrates the decline in new money rates and subsequently the decline in effective portfolio yields. The decline in interest rates is especially problematic for Social Security because it is long-term in nature which means it will be more sensitive to interest rate changes. The reasoning is compounding. For example, a $100 investment yielding 4% each year in perpetuity will be worth $219 in 20 years but only $149 if it compounds 2% each year.



Source: SSA Historical Interest Rates, https://www.ssa.gov/OACT/ProgData/intRates.html & SSA Effective Interest Rates, https://www.ssa.gov/OACT/ProgData/effectiveRates.html

Social Security typically limits its investments' maturities to no longer than 15 years. This means if Social Security had invested in longer term investments before the 2000s, it would have been less exposed to declines in interest rates. One way to manage interest rate risk is to duration match the liabilities and assets. The duration of an asset portfolio represents the projected change in value after a slight change in interest rates relative to the portfolio's price. In a similar fashion, the liability duration is the projected change in the liability value due to slight interest rate changes. In general, longer-term assets and liabilities have higher durations, again, due to compounding (substitute the 20-year asset for a 1-year in the prior example to drive home this point). If the asset duration and the liability duration are similar, projected changes in asset prices due to interest rates will offset changes in liability values. To achieve this, Social Security would need to invest in longer term assets to better align with the nature of its liabilities.

In this paper, I estimate the asset duration of Social Security's portfolio as of December 31st, 2022. In addition, I estimate the liability duration based on Social Security projections provided in the Board of Trustees' 2022 annual report. The remainder of the paper will be as follows;

- The Background section will discuss Social Security and its investment strategy. In addition, I will also explain duration's conceptual meaning.
- I will describe the process of estimating asset and liability duration in the methods section.
- Lastly, I will analyze results as well as discuss implications of investing in longer term assets.
- In addition, I have attached an excel file deriving my duration calculations and there is an appendix with supplementary material.

Background

As discussed previously Social Security invests in special issue treasury securities whose yields are based on a weighted average of current market treasury rates (OCA(a)). The asset types are either special issue bonds (maturities longer than 1 year) and certificates of indebtedness. Certificates of indebtedness are shorter term and can be acquired daily. They have a maturity of June 30th (OCA(b)). On the other hand, special issue bonds can only be purchased on June 30th of each year (OCA(b)). An interesting feature of the Special Issue bonds is that investment yields do not vary based on maturity date. In general, yields will generally be higher as the maturity becomes longer due to risk and investor preferences. To further complicate matters, the yield curve as of 12/31/2022 is inverted which means longer term assets unintuitively have lower yields than shorter term bonds (U.S. Department of the Treasury). In general, the yield curve should be upwards sloping in typical economic conditions.

One important controversy surrounding Social Security is the trust funds directly lend to the federal government by investing in US debt securities. The justification of surpluses have been debated throughout the program's existence. Opponents argue excessive surpluses facilitate the government's ability to conduct spending. Taking away social security surpluses will not necessarily cut spending as the US government will need to pay its bills somehow (either by borrowing from someone else or raising taxes). In addition, the alternative to setting up reserves would be a pure pay-as-you go system where payroll taxes are used to pay current benefits. The payroll tax rate would need to be reset on a frequent basis to ensure enough taxes are coming into the system to pay benefits. Let's look at how this should play out with the baby boomers. As the baby boomers retire and begin collecting benefits, the working age population would decrease. Taxes will need to increase to cover benefits. This will result in the younger generations footing the bill for the baby boomers. However, if policymakers phase in a tax increase over time, a reserve (which earns interest) could be built up over time to ease the cost. Further, the not-yet-retired baby boomers would share in the funding cost. Alternatively, one could also tinker with the benefits side, but the same dynamics will play out.

Let us move on to duration and interest rate risk. Duration can be given two interpretations. Some consider it the weighted average length of investment/liability where weights are based on time value of money[1]. Duration can also represent the first derivative of an asset/liability due to interest rate changes relative to its current price. Put another away, duration is the projected change in valuation as a percentage of its price due to small changes in interest rates. Thus, higher durations represent increased sensitivity to interest rates. The connection between these two interpretations is that longer-term assets (first interpretation) will be more sensitive to interest rates due to the nature of compounding (second interpretation).

Now becomes time to show why duration can be useful. As discussed in the introduction, Social Security has been a victim of the decreasing rates that occurred since the 1990s. The assets in the trust fund yield less, which, reduces the amount of income supporting the program. To value Social Security, one may value it as the difference between the value of its assets less the value of its liabilities. A common valuation technique is to assume an asset's price (or liability's value) is equal to the discounted value of its future cash flows. Future cash flows are multiplied (or "discounted") by a factor based on interest rates. This is the backbone of time-value of money. As a simple numerical example, if an asset generates $105 in one year and the prevailing interest rate is 5%, this asset would be worth 100 today. This is because investors would be indifferent in purchasing this asset or investing $100 at a rate of 5%.

Let's now return to Social Security's valuation. This valuation is naturally sensitive to interest rates. A decrease in interest rates will increase both assets and liabilities values. However, it is unclear if the assets or the liabilities will win out. This is where duration comes in. Duration measures the how much assets/liabilities values are expected to increase if interest rates decrease slightly all relative to its initial price. Thus, if the duration of the assets is close to the liability duration, the net valuation should not change significantly. This concept discussed is known as Reddington Immunization (Redington, 1952). Since Social Security does not typically invest in assets with maturities longer than 15 years, and the long-term nature of benefits provided (payable from retirement to death), I hypothesize that the asset duration is lower than the liability duration. If true, the program is at risk to declines in interest rates. This is relevant in 2023 as interest have drastically increased since the pandemic.

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[1] Time value of money is the concept that money today is worth more than the same sum of money at a future date. Further it seeks to equate money from different time periods with the use of compound interest.

Methods

Table 1: Trust Fund Investments Held type of investment type, interest rate, and trust fund As of 12/31/2022, $ Thousands Investment type	Rate (%)	Maturity	Total	OASI	DI
Special Issue Bonds	0.75%	2024 - 2033	154,108,805	149,314,072	4,794,733
	0.75%	2034 - 2035	5,827,743	-	5,827,743
	1.38%	2024 - 2027	193,319,460	193,319,460	-
	1.50%	2024 - 2033	128,370,581	126,961,797	1,408,784
	1.50%	2034 - 2036	5,770,906	-	5,770,906
	1.75%	2024 - 2028	197,781,329	197,781,329	-
	1.88%	2024 - 2031	204,358,272	204,358,272	-
	2.00%	2024 - 2030	207,724,400	207,724,400	-
	2.25%	2024 - 2034	616,204,857	595,265,151	20,939,706
	2.50%	2024 - 2026	178,490,956	178,490,956	-
	2.88%	2024 - 2025	175,088,265	167,840,027	7,248,238
	2.88%	2026 - 2031	21,744,708	-	21,744,708
	2.88%	2032	3,624,119	1	3,624,118
	2.88%	2033	176,889,560	176,889,560	-
	3.00%	2024 - 2033	187,586,862	172,664,326	14,922,536
	3.00%	2034 - 2037	11,458,162	-	11,458,162
	3.25%	2024	153,311,163	153,311,163	-
Certificates of indebtedness	3.88%	2023	54,125,901	44,376,263	9,749,638
	4.00%	2023	72,467,687	72,467,687	-
	4.25%	2023	81,696,507	71,154,194	10,542,313
Total amount invested			**2,829,950,243**	**2,711,918,658**	**118,031,585**

In this section I will first discuss the data used, then move on to the formulaic calculation of duration. We will finish this section with methodology descriptions of determining the liability and asset cash flows respectively. The data was sourced from the Social Security Administration's website. Each month the Social Security summarizes its current asset portfolio. Table 1 is the SSA's portfolio summary which can be seen above. The SSA provides the yield, range of maturity years, asset type (special issue bond or short-term certificates) and book values for each asset subgrouping. The problem is a range of maturity years is not granular enough to precisely calculate duration. To determine the allocation for each maturity year within each asset sub-group, annual transaction data from the SSA's website were also downloaded which provides enough granularity to re-construct Social Security's portfolio. The projection tables from the Social Security's Board of Trustees' 2022 annual report (SSBT, 2022) were needed to project the liability cash flows. Below is a description of the tables used.

- Tables IV.B1: Provides annual income rates and cost rates. Income rates are calculated as the sum of projected payroll taxes, interest earned and taxation of benefits all as a percent of projected taxable payroll. Cost rates are presented as a percent of taxable payroll and the components are scheduled benefits and other administrative costs.
- Table VI.G6: Provides economic projections over 75 years for key economic variables. This table houses projected taxable payroll.
- Table IV.A1: Provides trust fund income and cost projections for 10 years. This table was used to validate the liability cash flows calculation.

Duration for both assets and liabilities was calculated using Modified Duration as follows. In the appendix, I derive Modified Duration based on first principles.

$$duration = \frac{\sum_{k=0}^{n} k \times CF_k \times \nu^{k+1}}{\sum_{k=0}^{n} CF_k \times \nu^k}$$

$CF_k = cash\ flow\ received\ (distributed)\ at\ time\ k$

$\nu \quad is\ common\ actuarial\ notation\ and\ is\ pronounced$ nu.

$Nu\ is\ the\ discount\ factor\ applied\ to\ cash\ flows, thus\ \nu^k = (1 + i_{0\to k})^{-k}$

$Where\ i_{0\to k}\ is\ the\ annualized\ yield\ that\ could\ be\ earned\ today\ on\ a\ k - year\ investment\ (also\ called\ a\ spot\ rate)$

In this analysis the interest rate used to calculate duration was 4%. This is based on subjective judgement of the author using the assumptions of 2% real growth plus 2% long run inflation. In the appendix, I provide alternative discount rates of 3% and 5%. Further, all duration calculations were calculated with a valuation date of December 31st, 2022. Note that the "price" of asset portfolio will be different than the book value price cited in table 1. The book value represents the price at the time of purchase whereas the market price reflects current market conditions. The 4% yield assumes that special issue bonds would be priced at 4% in the market.

In insurance, the liability cash flow represents the net cash flows distributed (received) to service a policyholder. It excludes asset cash flows and change in reserves. It excludes the former because it is generated from the insurance company's assets and excludes the former because the change in reserves line is not a cash flow. In Social Security, the liability cash flow was the sum of benefits and expenses less taxes collected. Taxes in this context are like premiums which are included in the liability cash flow for insurance companies. To project liability cash flow, income rates and cost rates were multiplied to projected taxable payroll. I used an adjusted income rate to project income which excludes interest earned on investments. The liability cash flows for each year was determined as projected taxable payroll multiplied by the difference between the adjusted income rate and the cost rate. For years after 2031, rates and taxable payrolls were only provided every 5-years (2035, 2040, 2045…). As such, I assumed rates in between years would be equal to the previous segment point (in essence 2039 liability cash flow would use 2035's values). In addition, the 2022 report's projections, unsurprisingly, start at 2022. 2022 was excluded to be consistent with the valuation date. Therefore, the elevated COLA of 8.7% was not factored into this projection as inflation was underestimated in the 2022 report. The liability duration was calculated using a projection period of 15 years, 30 years, and 50 years.

As discussed previously, the SSA provided portfolio summary was not granular enough. I determined the current portfolio by leveraging Social Security's transactions history from 2009 to 2022. This was done by adding all the acquisitions of assets with the same asset types, coupon rates, and maturity years less the redemptions over the period 2009 to 2022. I assumed that all assets paid semi-annual coupons and matured in the middle of the year. Thus, an asset projected to mature in 2024 would have a maturity length of 1.5 years as of 12/31/2022. The equation shared above was modified such that each k represented half-years. The coupon frequency is consistent with special issue bond in the real world (OCA(b)). Based on the transaction data, bonds and certificates of indebtedness can be redeemed at any time throughout the year but their stated maturity date is always June 30th.

Analysis

Below, table 2, presents the results of the asset-liability calculations. The units for duration are per 100% in interest rates. Here is a possible interpretation of the results: a 0.1% increase in interest rates is projected to decrease the asset portfolio value by 0.515% (5.15/1000). As discussed in the methods section, I included three versions of the liability duration: One using 15 years, 30 years and 50 years of projections. The projection period used to calculate liability duration can be subjective. For instance, to justify 15 years, some may argue for a short term focus due to impending trust fund depletion in 2035 (SSBT, 2022). As for justifying 30 years, one can argue that the current projection period is too long, especially when considering how other countries assess solvency (Turner, 2017) which justifies the 30-year methodology. The 50-year projection period may be justified by the fact it is a common period for testing the solvency of life insurance liabilities. Regardless of the method, Social Security's asset duration is less than its liability duration for all three scenarios. This indicates that a small decrease in interest rates will reduce the net value of the program (a small rise in rates increases value) because Social Security's liability valuation will be more sensitive. Ideally, asset managers attempt to immunize their portfolios from changes in interest rates as discussed in the Background section.

One area to note is that asset duration and liability duration are not one to one here because the amount of assets is less than the present value of liabilities. This is because the program is underfunded which means there are not enough assets to pay future liabilities. In dollars, a 5% increase in asset valuation would be globally less than a 5% increase in the liability valuation[2]. In table 3 below, I have summarized the projected absolute valuation sensitivity for Social Security assets and liabilities from a 0.1% decrease in interest rates. Using the 30-year projection, a 0.1% decrease in rates is projected to decrease the net value by slightly over $41 billion.

[2] As an example, 5% reduction in $100 is less than a 5% reduction in $200.

Table 2: Asset - Liability Match with 4% Interest Rate			
	15-Year	30-Year	50-Year
Asset Duration	5.15	5.15	5.15
Liability Duration	8.08	15.73	26.38

Table 3: Asset - Liability Sensitivity with 4% Interest Rate			
$ Billions	15-Year	30-Year	50-Year
Asset Sensitivity	13,242	13,242	13,242
Liability Sensitivity	28,091	54,689	91,756
Delta	(14,849)	(41,447)	(78,514)
Estimated Impact (0.1% Decrease)	**(14.85)**	**(41.45)**	**(78.51)**

If Social Security invests in longer term assets, its asset duration will be more in line with the liability duration. In turn Social Security will be less sensitive to future interest rate changes. As indicated by the results, liability duration is subjective and there is not an absolute solution for how the investment strategy should be revised. However, regardless of the results Social Security is at risk of losing value if interest rates decrease. This is especially relevant today because interest rates are at their highest levels since the Great Financial Crisis. My argument would not be relevant in the low-rate environment experienced in the years after the Financial Crisis since interest rates were near 0. The trust funds were not realistically exposed to significant downside interest rates. However, that is not the case today and Social Security could lose value if interest rates decline which is plausible if a recession occurs in 2022. Overall, Social Security should not be an interest rate speculator and should hedge against downside interest rate shocks.

One problem with my argument is there is no term risk-premium for Social Security assets. Term risk premium assumes that longer term assets should be higher yielding than short term assets. For instance, all the bonds that Social Security acquired on June 30th, 2022, had the same yield of 3%. Perhaps the treasury rate calculation should be reset to be based market public treasury rates by maturity date. In addition, in contrast to the term risk-premium, the yield curve is currently inverted. This means if Social Security invests in a 30-year bond rather than say a 3-year bond, it will receive a lower yield (3.97% vs. 4.22% as of 12/31/2022 based on US treasuries) (U.S. Department of the Treasury). However, by investing in the short-term bond the trust fund it is more exposed to reinvestment risk. When the bond matures in 3-years the proceeds are reinvested at the future rate environment. No one really knows what the rates will be in 3-years, and they could be significantly lower. Whereas if Social Security invests in longer term bonds, it will more closely match the nature of its liabilities which makes it less exposed to interest rate risk. As I will say again, Social Security is not meant to be an interest rate speculator.

In addition, my argument is complicated by the fact the trust funds can redeem assets at any time to pay benefits. This fact makes the maturity date a bit arbitrary. Further as mentioned previously, the liabilities are more sensitive because Social Security does not have enough assets to support itself (SSBT, 2022). This could also represent an opportunity for policymakers. If policymakers were to increase funding while interest rates are up, they could hedge the program by making the net value of Social Security less sensitive to interest rates. However, there are conflicting economic factors as raising taxes when the economy is on poor footing may be controversial. In addition, it would require the US government to be able to pay the interest on the additional funding since Social Security invests in government debt.

Further, there has been debate about whether Social Security should build up reserves (Martin & Weaver, 2005). As alluded to in the background section, Social Security invests in government securities which means it lends to the federal government. Further, opponents of surpluses argue that by lending to the government it promotes wasteful government spending. The key to overcoming this issue is for the government to invest in value-creating projects. If the government completes projects where the return on investment is higher than the cost of borrowing, it is conducting arbitrage because the returns will pay for the debt.

Since the government is not a for-profit machine, its ROI need not be calculated on a pure accounting basis. For instance, there is value in improving people's lives that may not directly tie to GDP. Many will argue that the government is inefficient and cannot possibly generate value. While this line of thinking may have some merit, as seen by lack of regulation of the US airlines, the 2008 bailouts and the government's failure to contain drugs overdoses. Further, perhaps the most damning evidence is that trust in US institutions is at an all-time low (Jones, 2022). However, this is not an absolute if you look back at history. In the 1900s, monopolies were broken up by the government, in the 1940s, the US mobilized its population to fight the Nazi's in Europe, and in the 2000s, the US PEPFAR program was instrumental in reducing AIDs. If you go way back to the 1800s, the Jefferson administration purchased the middle of the modern United States for $15 million ($400B in today's dollars) (History.com, 2009). While there are a fair share of mistakes and atrocities in US history, to say the US is incapable of completing worthwhile projects is incorrect.

While investing in longer term assets can reduce interest rate risk, the government projects Social Security indirectly finances may not be long term in nature. However, that can change. By completing long term strategic projects, more value could be generated by the government. For instance, the government could invest in public health such as counteracting the obesogenic environment or reducing smoking prevalence among poor people. These investments would be inherently long term. For instance, the negative effects of smoking from high smoking prevalence in 1940s took over 20 years to materialize into noticeable increased lung cancer deaths (Case & Deaton, 2020). In addition, the US could invest more heavily in Microchip production to reduce its dependence on Taiwan. It could also invest in the technology needed to scale the recent nuclear fusion breakthrough in a California experiment. In this experiment, researchers were able to achieve a net energy gain using nuclear fusion technology (apparently it is similar how the sun works) (Stallard, 2022). Investing in long-term policies would require a drastic paradigm shift for how things get done in Washington as the time frame in Washington typically only extends to the next election cycle. If the US government can successfully invest in worthwhile long-term projects, it can generate value and stimulate growth. This growth is what funds the interest it pays on the treasuries, or at least according to the Sallow's definition (Faivre, 2020). This natural interest theory does not fully hold up in practice as their other factors affecting long term interest rates including demographics, inflation, technological progress and federal budgets (Faivre, 2020). However, the proposals suggested also target some of these areas in addition to economic growth. Investing in longer term special issue treasury securities may reduce the interest rate risk underlying Social Security. While there are limitations to this proposal, at the very least Social Security should have the ability to hedge against downside interest rate risk in light of a potentially volatile interest rate environment.

Appendix

Modified Duration Derivation

$$Let\ V = valuation\ of\ an\ asset\ generating\ annual\ cash\ flows$$

$$CF_k = Cash\ flow\ in\ year\ k$$

$$v^k is\ discount\ factor\ for\ future\ projected\ cash\ flows\ recieved\ in\ year\ k.$$

$$v^k = (1+i)^{-k}\ where\ i\ is\ constant\ (4\%\ baseline)$$

$$V = \sum_{k=1}^{n} CF_k \times v^k = \sum_{k=1}^{n} CF_k \times (1+i)^{-k}$$

$$\frac{\partial V}{\partial i} V = \sum_{k=1}^{n} -k \times CF_k \times (1+i)^{-k-1}$$

$$Duration = \frac{1}{V} \times \frac{\partial V}{\partial i} V$$

$$=> Duration = \frac{\sum_{k=1}^{n} -k \times CF_k \times (1+i)^{-k-1}}{\sum_{k=1}^{n} CF_k \times (1+i)^{-k}} = \frac{\sum_{k=1}^{n} -k \times CF_k \times (1+i)^{-k}}{\sum_{k=1}^{n} CF_k \times (1+i)^{-k+1}} = \frac{\sum_{k=1}^{n} -k \times CF_k \times v^k}{\sum_{k=1}^{n} CF_k \times v^{k-1}}$$

The negative sign is omitted in practice. It is important to remember that increases in interest rate will reduce the value of cash flows received in the future.

Alternative Interest Rates

Below tables 4 and 5 summarize the asset – liability match using two alternative interest rates to calculate duration. The alternative interest rates were 3% and 5%.

Table 4: Asset - Liability Match with 3% Interest Rate

	15-Year	30-Year	50-Year
Asset Duration	5.31	5.31	5.31
Liability Duration	8.32	16.50	28.46

Table 5: Asset - Liability Match with 5% Interest Rate

	15-Year	30-Year	50-Year
Asset Duration	5.00	5.00	5.00
Liability Duration	7.84	14.96	24.34

Convexity

Another interest rate hedging concept is convexity. Where modified duration ties to the first derivative of asset values, convexity ties to the second derivative. Convexity represents how duration is expected to change due to small interest rate changes. Duration is fundamentally a linear approximation to how much the portfolio value should change as interest rates change which limits its accuracy to slight changes in interest rates. However, the valuation of future cash flows is not linear relative to interest rates in nature. Thus, convexity is leveraged to manage a portfolio's interest rate risk as it allows asset managers to better immunize the portfolio to swings in interest rates. The convexity derivation is as follows.

$$V = \sum_{k=1}^{n} CF_k \times v^k = \sum_{k=1}^{n} CF_k \times (1+i)^{-k}$$

$$\frac{\partial V}{\partial i} V = \sum_{k=1}^{n} -k \times CF_k \times (1+i)^{-k-1}$$

$$\frac{\partial^2 V}{\partial i^2} V = \sum_{k=1}^{n} k \times (k+1) \times CF_k \times (1+i)^{-k-2}$$

$$Convexity = \frac{1}{V} \times \frac{\partial^2 V}{\partial i^2} V = \frac{\sum_{k=1}^{n} k \times (k+1) \times CF_k \times (1+i)^{-k-2}}{\sum_{k=1}^{n} CF_k \times (1+i)^{-k}} = \frac{\sum_{k=1}^{n} k \times (k+1) \times CF_k \times v^{k+2}}{\sum_{k=1}^{n} CF_k \times v^k}$$

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