Duration-Based Valuation of Corporate Bonds*

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1. Introduction

- **Fact:** Secular decline in discount rates (or expected returns);
- **Problem:** These ex post positive returns realizations complicate the evaluation of asset pricing models;
- **Existing literature:** Uses a standard definition of excess return relative to the Treasury bill rate;
- **Ideia:** Decompose corporate bond and equity index returns into duration-matched government bond returns and the excess returns over this duration-matched counterfactual;
- **Results:**
  - Compensation for credit and liquidity risk account for 9% (37%) of standard excess returns for investment-grade (high-yields) corporate bonds;
  - The long-term Treasury return accounts for the remaining 91% (63%);
  - The realized risk premium for bearing credit and liquidity risks is small, statistically indistinguishable from zero;
  - Duration adjustment resolves the CAPM’s failure to price corporate bonds.

2. Data

- From 1986 to 2020 (419 months):
    - 1986 - 1997: Lehman/Warga Fixed Income database;
    - 1997 - 2020: Bank of America Merill Lynch.

- Corporate bonds characteristics:
    - U.S. dollars;
    - Senior secured or senior unsecured in priority;
    - Nonconvertible;
    - Semiannual coupon payments in cash;
    - Exclude maturity over 30Y and less than 1Y to maturity;
    - Credit Rating (Moody's, S&P, Merill Lynch):
        - Investment-Grade (IG): BBB- and higher;
        - High-Yield (HY): BB+ and lower;
    - Sorted into (market) value-weighted portfolios by credit rating category.

- Zero-coupon risk-free yields: Federal Reserve, Gurkaynak et al. (2007).

2. Data: Summary Statistics

Table 1: Summary Statistics

Panel (A): Credit Rating Portfolio Characteristics

Rating	Yield	Spread	Duration	Bond Count
AA	5.43	0.83	6.74	150
A	5.74	1.10	6.90	614
BBB	6.41	1.76	6.67	879
BB	7.83	3.31	5.42	348
B	10.10	5.61	4.91	428
IG	6.00	1.36	6.80	1,677
HY	9.66	5.16	5.09	932

- Yield and Spread - the difference between yield-to-maturity and the duration-matched Treasury yield - are value-weighted averages in percentage terms. Duration is also a value-weighted average.

2.1. Decomposition of Bond Returns

- Return of a corporate bond:

$$r_{i,t} = \frac{P_{i,t} + AI_{i,t} + C_{i,t}}{P_{i,t-1} + AI_{i,t-1}} - 1, \tag{1}$$

- Macaulay Duration:

$$\text{Dur}_t = \sum_{k=1}^{\infty} w_{t,k} t_k, \tag{2}$$

$$\text{Dur}_{i,t} = \frac{1}{2P_{i,t}} \left[\sum_{k=1}^{K} \left(t_k \times \frac{\frac{C_i}{2}}{(1 + \frac{y_{i,t}}{2})^{t_k}} \right) + t_K \times \frac{100}{(1 + \frac{y_{i,t}}{2})^{t_K}} \right], \tag{3}$$

2.1. Decomposition of Bond Returns

- Monthly return on the *k*-period zero-coupon Treasury bond:

$$r_{b,t+1,k} = \frac{\exp\left(-t_{k-1} y_{b,t+1,k-1}\right)}{\exp\left(-t_k y_{b,t,k}\right)} - 1, \qquad (5)$$

- Duration-matched Treasury return:

$$r_{i,t+1}^{Tsy} = \sum_{k=1}^{K} w_{i,t,k} r_{b,t+1,k}. \qquad (4)$$

- Duration-adjusted return:

$$r_{i,t}^{DurAdj} = r_{i,t} - r_{i,t}^{Tsy}. \qquad (6)$$

3.1 Results: Decomposition of Corporate Bond Returns

Table 2: Decomposition of Corporate Bond Returns

Panel (A): Return Decomposition

		Standard Approach		Duration-Adjusted Approach		
Rating	Return $r_{i,t}$	T-Bill $r_{f,t}$	Excess $r_{i,t} - r_{f,t}$	Treasury $r_{i,t}^{Tsy}$	Excess $r_{i,t}^{DurAdj}$	Log(Excess) $\log(1 + r_{i,t}^{DurAdj})$
AA	0.598	0.253	0.344	0.573	0.025	0.020
A	0.598	0.253	0.345	0.577	0.020	0.014
BBB	0.622	0.253	0.369	0.572	0.050	0.038
BB	0.703	0.253	0.450	0.540	0.164	0.140
B	0.660	0.253	0.407	0.525	0.135	0.095
IG	0.608	0.253	0.355	0.576	0.032	0.023
HY	0.692	0.253	0.439	0.530	0.162	0.126

- Compensation for credit and liquidity risk account for 9% (37%) of standard excess returns for investment-grade (high-yields) corporate bonds;
- The realized risk premium for bearing credit and liquidity risks is small, statistically indistinguishable from zero;

3.2. Results: Failure of Equity Factors to Price Corporate Bonds

- They do not claim that the CAPM is the best model for corporate bonds;
- Its simplicity helps clarify their contribution to studying the impact of duration adjustment in asset pricing tests.

$$r_{i,t} - r_{f,t} = \alpha + \beta(r_{SP500,t} - r_{f,t}) + \varepsilon_{i,t}, \tag{16}$$

Table 3: CAPM Regressions of Corporate Bond Returns

Panel (A): Corporate Bonds Returns

Rating	AA	A	BBB	BB	B
β	0.054	0.074	0.148	0.253	0.326
	(2.11)	(2.61)	(4.28)	(5.96)	(6.84)
α	0.305	0.290	0.261	0.265	0.169
	(3.89)	(3.66)	(3.03)	(2.95)	(1.47)
Adj. R^2	0.023	0.043	0.146	0.328	0.345
Mean $\|\alpha\|$	0.258				
GRS p-value	0.0003				

- CAPM is unable to price corporate bonds, particularly in the investment-grade rating categories.

3.2. Results: Failure of Equity Factors to Price Corporate Bonds

- They do not claim that the CAPM is the best model for corporate bonds;
- Its simplicity helps clarify their contribution to studying the impact of duration adjustment in asset pricing tests.

$$r_{i,t}^{DurAdj} = \alpha + \beta(r_{SP500,t} - r_{f,t}) + \varepsilon_{i,t}$$

Table 3: CAPM Regressions of Corporate Bond Returns
Panel (C): Duration-Adjusted Returns

Rating	AA	A	BBB	BB	B
β	0.069	0.095	0.171	0.263	0.336
	(3.12)	(3.37)	(3.99)	(5.02)	(5.65)
α	-0.025	-0.049	-0.075	-0.029	-0.110
	(-0.60)	(-0.97)	(-0.97)	(-0.31)	(-0.89)
Adj. R^2	0.107	0.148	0.228	0.291	0.271
Mean $\|\alpha\|$	0.058				
GRS p-value	0.360				

- The CAPM does not exhibit the same failure for the duration-adjusted returns;
- The adjusted R^2 coefficient shows substantial improvement for the investment-grade categories.

4. “Duration-Adjusted CAPM”

- An important development over their sample period is the <u>shift in the correlation</u> between equity market and Treasury returns from positive to negative around the year 2000, see Campbell et al. (2020):
  - 1986 - 2000: Corr(Equity Market Return, Treasury returns) = Positive;
  - 2001 - 2020: Corr(Equity Market Return, Treasury returns) = Negative.

- This shift could have an important effect on the ability of the CAPM to price corporate bonds;

- <u>Results</u>: Depending on the correlation between Treasury and equity returns, the CAPM is unable to explain
  - Corporate bond excess returns relative to Treasury bills (2001-2020);
  - Or it is unable to explain duration-adjusted returns (1986-2000).

- <u>Extension</u>: This results suggest a natural extension of the CAPM into duration-matched Treasury and dividend risk components that should capture these distinct risks in the corporate bond portfolios.

4.1. "Duration-Adjusted CAPM": Decomposition of Equity Index Returns

- Gordon growth equation express the value of the index as follows:

$$S_t = D_t \int_0^\infty e^{(g-\mu)\tau} \mathrm{d}\tau = \frac{D_t}{\mu - g}, \tag{7}$$

- Dividend yield is equal to the difference between its expected return and dividend growth:

$$\frac{D_t}{S_t} = \mu - g. \tag{8}$$

- Present value of the *m*-th dividend strip is given by:

$$\mathcal{P}_{t,m} = D_t e^{(g-\mu)m}. \tag{9}$$

- This implies a weighting scheme for the m-th dividend strip value as:

$$w_{t,m} = \frac{\mathcal{P}_{t,m}}{S_t} = (\mu - g)e^{(g-\mu)m}. \tag{10}$$

4.1. “Duration-Adjusted CAPM”: Decomposition of Equity Index Returns

- They use the concept of Macaulay Duration to characterize the duration of stock index, see Binsbergen (2021):

$$
\begin{aligned}
Dur_t &= \int_0^\infty w_{t,m} m \mathrm{d}m, \\
&= \int_0^\infty (\mu - g) e^{(g-\mu)m} m \mathrm{d}m \\
&= \frac{1}{\mu - g},
\end{aligned}
\tag{11}
$$

- They convert the continuous-time weighting in equation (10) to a monthly weighting as follows:

$$
\begin{aligned}
w_{t,n} &= \int_{n-1}^{n} w_{t,m} \mathrm{d}m, \\
&= \int_{n-1}^{n} (\mu - g) e^{(g-\mu)m} \mathrm{d}m \\
&= e^{(g-\mu)(n-1)} - e^{(g-\mu)n},
\end{aligned}
\tag{12}
$$

4.1. “Duration-Adjusted CAPM”: Decomposition of Equity Index Returns

- Duration-matched Treasury return:

$$r_{Tsy,t+1} = \sum_{k=1}^{\infty} w_{t,k} r_{b,t+1,k}, \tag{13}$$

- They calculate the dividend yield in the data as:

$$dy_t = \frac{\sum_{n=t-11}^{t} d_n}{S_t}, \tag{14}$$

- Duration-adjusted stock return:

$$r_{DurAdj,t+1} = r_{s,t+1} - r_{Tsy,t+1}. \tag{15}$$

4.2 Results: “Duration-Adjusted CAPM”

- Panel A reveals a remarkable improvement in the ability to explain corporate bond returns, especially at the high end of the credit quality spectrum:

$$r_{i,t} - r_{f,t} = \alpha + \beta_{Dur}(r_{Tsy,t} - r_{f,t}) + \beta_{Risk}(r_{SP500,t} - r_{Tsy,t}) + \varepsilon_{i,t}, \tag{17}$$

Table 5: Duration-Adjusted CAPM Regressions of Corporate Bond Returns

Panel (A): Corporate Bond Returns

Rating	AA	A	BBB	BB	B
β_{Tsy}	0.291	0.304	0.328	0.328	0.325
	(10.81)	(9.80)	(8.07)	(9.29)	(8.52)
β_{DurAdj}	0.075	0.095	0.164	0.260	0.326
	(3.76)	(3.75)	(4.55)	(6.10)	(7.05)
α	0.116	0.107	0.118	0.205	0.170
	(1.95)	(1.68)	(1.45)	(2.30)	(1.46)
Adj. R^2	0.626	0.565	0.410	0.362	0.343
CAPM Adj. R^2	0.023	0.043	0.146	0.328	0.345
Incremental R^2	0.603	0.522	0.264	0.034	-0.002
Mean $\|\alpha\|$	0.143				
GRS p-value	0.029				

4.2 Results: “Duration-Adjusted CAPM”

- Panel C shows that the duration-adjusted CAPM explains a larger proportion of the duration-adjusted corporate bond returns than the CAPM:

$$r_{i,t}^{DurAdj} = \alpha + \beta_{Tsy}(r_{Tsy,t} - r_{f,t}) + \beta_{DurAdj}(r_{SP500,t} - r_{Tsy,t}) + \varepsilon_{i,t}$$

Table 5: Duration-Adjusted CAPM Regressions of Corporate Bond Returns
Panel (C): Duration-Adjusted Returns

Rating	AA	A	BBB	BB	B
β_{Tsy}	-0.026	-0.009	0.037	0.080	0.100
	(-0.96)	(-0.30)	(0.95)	(2.05)	(2.09)
β_{DurAdj}	0.060	0.085	0.158	0.247	0.314
	(3.47)	(3.60)	(4.32)	(5.59)	(6.28)
α	0.050	0.034	0.032	0.117	0.078
	(1.34)	(0.76)	(0.47)	(1.50)	(0.69)
Adj. R^2	0.357	0.365	0.399	0.461	0.434
CAPM Adj. R^2	0.107	0.148	0.228	0.291	0.271
Incremental R^2	0.250	0.217	0.171	0.170	0.163
Mean $\lvert\alpha\rvert$	0.062				
GRS p-value	0.131				

5. “Duration-Adjusted Bond Market CAPM”

- To assess the role of market segmentation, or the importance of including information specific to the corporate bond market in the model,
- They construct a “duration-adjusted bond market CAPM” in the same spirit as the duration-adjusted CAPM.

$$r_{i,t} - r_{f,t} = \alpha + \beta_{Tsy}(r_{Tsy,t} - r_{f,t}) + \beta_{DurAdj}(\underline{r_{CBI,t}} - r_{Tsy,t}) + \varepsilon_{i,t}$$

Table 5: Model Performance in the Time Series - Credit Rating Portfolios

Panel (A): Corporate Bond Returns

	CAPM			Dur.-Adj. CAPM			Dur.-Adj. Bond CAPM			Bai et al. (2019) Model		
	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2
AA	0.341	3.44	0.011	0.082	0.93	0.558	-0.002	-0.10	0.897	0.108	2.46	0.851
A	0.298	2.72	0.040	0.039	0.36	0.488	-0.066	-3.35	0.953	0.011	0.30	0.898
BBB	0.257	2.00	0.211	0.054	0.35	0.403	-0.038	-1.31	0.961	-0.032	-0.56	0.829
BB	0.178	1.41	0.494	0.135	0.85	0.497	0.124	3.72	0.901	0.027	0.84	0.875
B	0.092	0.58	0.491	0.112	0.61	0.490	0.106	2.57	0.904	-0.082	-1.56	0.928
Mean Abs. Value	0.233	2.03	0.249	0.084	0.62	0.487	0.067	2.21	0.923	0.052	1.14	0.876
GRS p-Value	0.008			0.157			0.011			0.002		

5. "Duration-Adjusted Bond Market CAPM"

- They conduct the pairwise model comparison tests following Barillas et al. (2020). The test fails to reject that any model performs significantly better than the others;

$$r_{i,t}^{DurAdj} = \alpha + \beta_{Tsy}(r_{Tsy,t} - r_{f,t}) + \beta_{DurAdj}(\underline{r_{CBI,t}} - r_{Tsy,t}) + \varepsilon_{i,t}$$

Table 5: Model Performance in the Time Series - Credit Rating Portfolios
Panel (C): Duration-Adjusted Returns

	CAPM			Dur.-Adj. CAPM			Dur.-Adj. Bond CAPM			Bai et al. (2019) Model		
	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2
AA	-0.040	-0.56	0.376	0.025	0.31	0.433	0.010	0.46	0.857	-0.078	-2.50	0.581
A	-0.096	-1.21	0.388	-0.027	-0.29	0.430	-0.054	-2.91	0.939	-0.172	-3.82	0.673
BBB	-0.134	-1.11	0.467	-0.024	-0.17	0.517	-0.034	-1.11	0.964	-0.217	-3.23	0.680
BB	-0.127	-0.97	0.543	0.041	0.28	0.609	0.107	3.41	0.930	-0.130	-1.75	0.821
B	-0.189	-1.10	0.507	0.014	0.08	0.574	0.082	1.89	0.929	-0.232	-2.39	0.874
Mean Abs. Value	0.117	0.99	0.456	0.026	0.22	0.513	0.057	1.96	0.924	0.166	2.74	0.726
GRS p-Value	0.485			0.219			0.011			0.000		

6. Final Remarks

- They explore the importance of evaluating corporate bond returns in excess of their duration-matched government bond counterfactuals;

- We show that adjusting for the effects of duration has important implications for the measurement of risk premia and the evaluation of asset pricing tests;

- Duration adjustment makes a significant difference in the performance of well-known risk factors and reinforces its importance in building factor models;

- In particular, while the CAPM struggles to price unadjusted investment-grade corporate bond returns, they find that it lines up quite well with duration-adjusted returns;