Fixed income market

EE431

Semester 2/2017

Kittichai Saelee

Part 1: Financial markets

- Fixed income market (Debt)
- Capital stock market (Equity)

Topics

- Bond pricing and yield to maturity
- Bond risks and measuring price risk.
- Bond price and interest rate determination
- Risk and term structure of interest rates

Reading lists

- Required text:

  Mishkin Ch 4 – Ch 6 (required!)

  Fabozzi Ch 2 - **Ch** 5 (optional, a bit more finance)

This lecture

- What is bond?
- Time value of money and Bond valuation

What is Bond?

- Bond is a type of credit contract that can be traded in the secondary market.
- Credit contract specifies the followings.
  - Principal amount (loan value)
  - Dates of periodic payment
  - Maturity date (length of the contract)
- Details in the contract must be standardized for every units of bond issued.
  - Bank loans are tailored-made contract.

What is Bond?

- Bond can be issued by both government and private firms.
  - Government bond; Corporate bond
- They must go though usual underwriting process by investment bank.
  - Valuation, rating (credit quality), and other due diligences required by SEC.
- In Thailand, government bond has dominated the overall bond market.
  - Thai Government has been running deficit since after the financial crisis in 1997.

Standard features of BOND

- Bond specifies the following things
  - Periodic cash-flow payments that bond holder will receive.
  - Maturity date (last date of the contract)

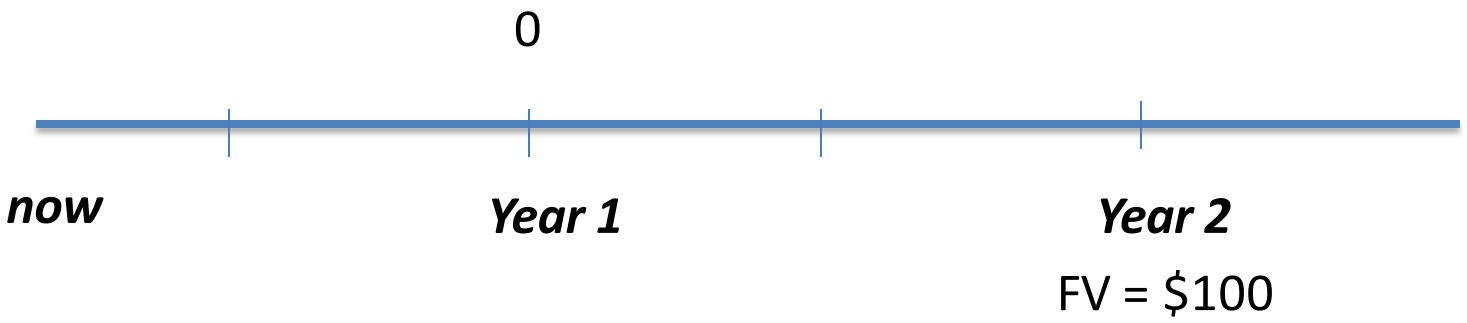
- There are three common types of (plain vanilla) bond
  - Zero-coupon bond
  - Coupon bond
  - Perpetual bond

Zero-coupon bond

- Zero-coupon bond has the following features.
  - Maturity date given.
  - At the maturity date, holder of the zero-coupon bond is expected to receive one single payment in terms of the face value of the bond (FV).
  - In practice, zero-coupon bond is commonly issued with short maturity date, and typically called discount bond.

Zero-coupon bond

- A 2-year zero-coupon bond with its face value of $100.

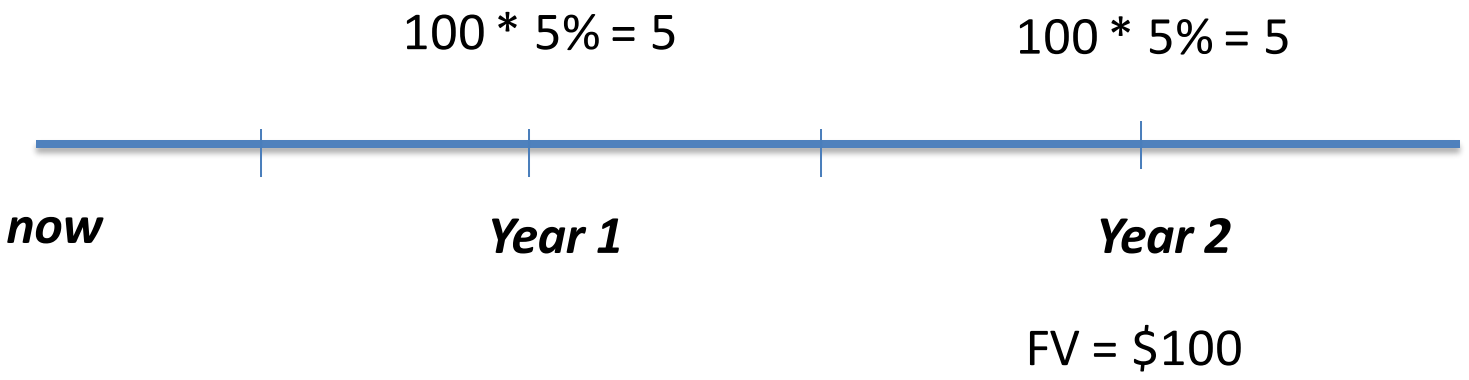


Coupon bond

- Coupon bond has the following features.
  - Maturity date given.
  - Holder of the coupon bond is expected to receive coupon payment in each period, depending on the payment schemes.
  - Coupon payment is typically set c% (per period) of the face value.
  - At the maturity date, bond holder will get back the face value, together with the last coupon payment

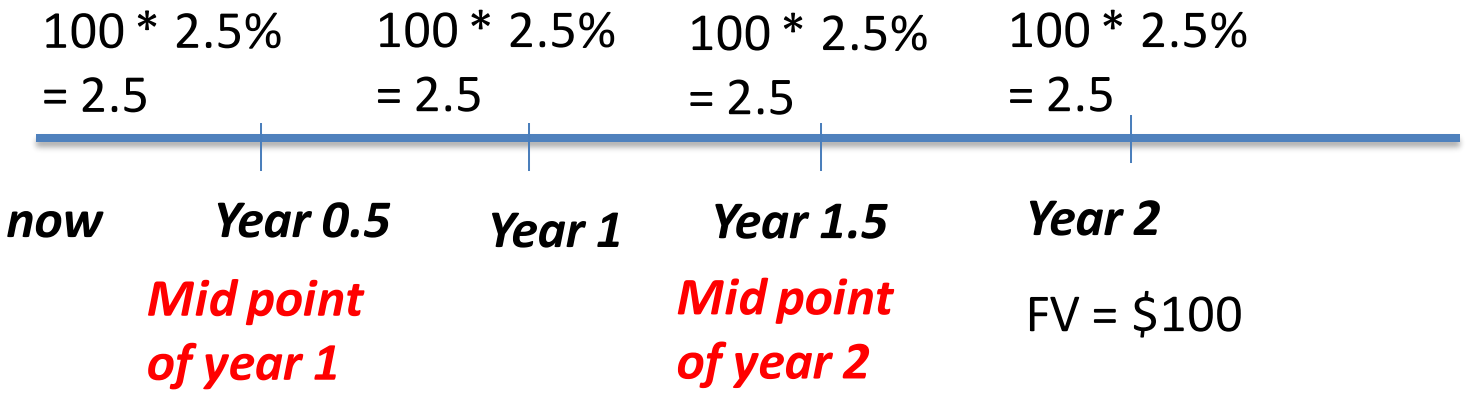
Coupon bond 1

- A 5% p.a. 2-year coupon bond with annual payment and the face value of $100.



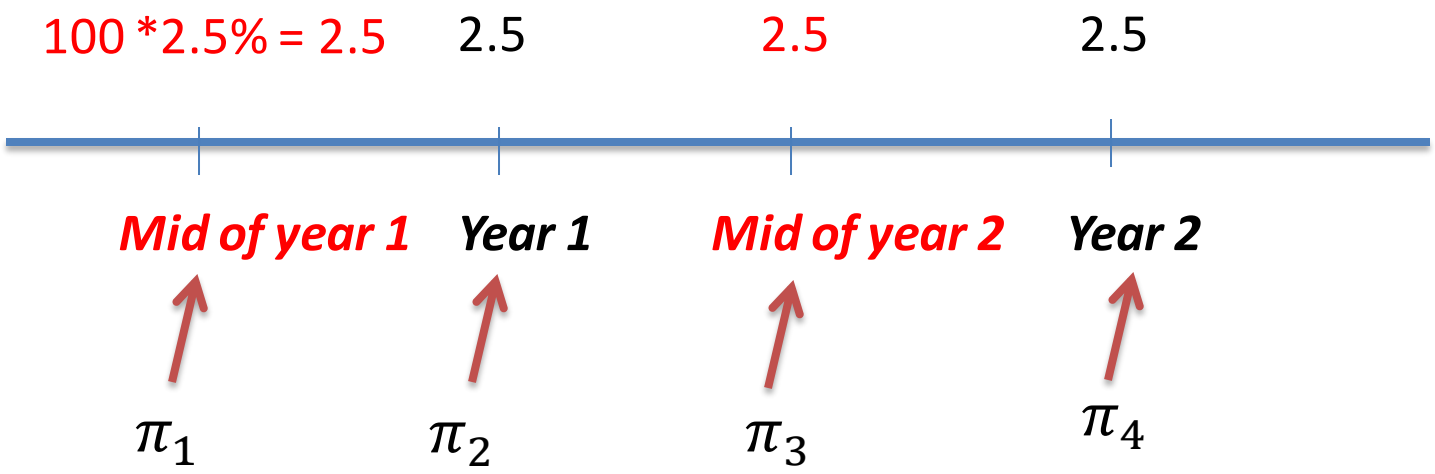
Coupon bond 2

- A 2-year coupon bond with 5% p.a. coupon rate, semiannual payment and the face value of $100.



coupon bond 3

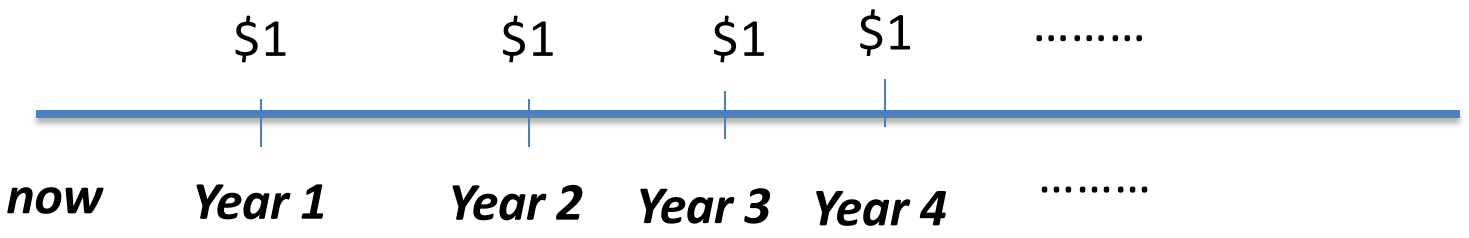
- A 2-year inflation-index bond with semi-annual payment has 5% coupon rate and the face value of $100



$$Cashflow\ at\ the\ Maturity\ date\ = FV * (1+\pi_1)(1+\pi_2)\,(1+\pi_3)\,(1+\pi_4)$$

Perpetual bond

- Perpetual bond is rare. It has the following features.
  - No maturity date; bond issuer keeps paying fixed amount of money forever.
  - Typically, the amount of fixed payment is very small.



Maturity date and Time to maturity

- Maturity date is the date on calendar when the debt contract is ceased to be expired.
- Time to maturity is the number of periods (years,quarters,days) from now until the maturity date.
- So, when one says a 2-year bond, this means bond with 2 year remained from now until the maturity date. (our previous examples also refer to this definition.)

This lecture

- What is bond?
- Time value of money and Bond valuation

Bond valuation

- Bond is a type of financial asset.
- Holder of a bond expects to receive payments from the bond issuer, or periodic cash flow.
- In general, valuation of an asset (not specific only to bond) is the same as the valuation of cash flow.
- What is the principle of cash flow valuation then?

Time value of money

- Summing up all the cash flows, but how?
- Direct sum?
- Question: Do you think that $1 today is worth equally to $ 1 that you will be receiving 10 years from now?
- Timing of the cash flow received matter!!

Principle of asset (bond) valuation

- Asset value = sum of the present value of all the remaining cash flows.
- Present value of cash flows is the value of cash flow adjusted by (subjective) discount rate (r), i.e. $\frac{CF_k}{(1+r)^k}$

Principle of asset (bond) valuation

- Valuation in current date (t=0) of an asset with remaining cash flows $\{CF_k\}_{k=1}^{T}$ in each period (for the total of T periods) is given by

$$V_{t=0} = \frac{CF_1}{1+r} + \frac{CF_2}{(1+r\ \ )^2} + \cdots + \frac{CF_T}{(1+r\ \ )^T}$$

Example 1:
Discount bond with FV = 100

- Cash flow is $100
- T = 2.
- If the market discount rate is 5% p.a., the value of cash flow, measured in terms of present value is

$$\frac{100}{(1+\mathbf{0.05})^2} = \$90.70$$

Example 1

- Look at the present value factor table
  - Present value factor (PVF) shows the present value of $1 obtained t-period from now with the discount rate r% per period.

Present value interest factor of $1 per period at r% for t periods, PVIF(r,t).

Period	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%
1	0.990	0.980	0.971	0.962	0.952	0.943	0.935	0.926	0.917	0.909	0.901	0.893	0.885	0.877	0.870	0.862	0.855	0.847	0.840	0.833
2	0.980	0.961	0.943	0.925	**0.907**	0.890	0.873	0.857	0.842	0.826	0.812	0.797	0.783	0.769	0.756	0.743	0.731	0.718	0.706	0.694
3	0.971	0.942	0.915	0.889	0.864	0.840	0.816	0.794	0.772	0.751	0.731	0.712	0.693	0.675	0.658	0.641	0.624	0.609	0.593	0.579
4	0.961	0.924	0.888	0.855	0.823	0.792	0.763	0.735	0.708	0.683	0.659	0.636	0.613	0.592	0.572	0.552	0.534	0.516	0.499	0.482
5	0.951	0.906	0.863	0.822	0.784	0.747	0.713	0.681	0.650	0.621	0.593	0.567	0.543	0.519	0.497	0.476	0.456	0.437	0.419	0.402
6	0.942	0.888	0.837	0.790	0.746	0.705	0.666	0.630	0.596	0.564	0.535	0.507	0.480	0.456	0.432	0.410	0.390	0.370	0.352	0.335
7	0.933	0.871	0.813	0.760	0.711	0.665	0.623	0.583	0.547	0.513	0.482	0.452	0.425	0.400	0.376	0.354	0.333	0.314	0.296	0.279
8	0.923	0.853	0.789	0.731	0.677	0.627	0.582	0.540	0.502	0.467	0.434	0.404	0.376	0.351	0.327	0.305	0.285	0.266	0.249	0.233
9	0.914	0.837	0.766	0.703	0.645	0.592	0.544	0.500	0.460	0.424	0.391	0.361	0.333	0.308	0.284	0.263	0.243	0.225	0.209	0.194
10	0.905	0.820	0.744	0.676	0.614	0.558	0.508	0.463	0.422	0.386	0.352	0.322	0.295	0.270	0.247	0.227	0.208	0.191	0.176	0.162
11	0.896	0.804	0.722	0.650	0.585	0.527	0.475	0.429	0.388	0.350	0.317	0.287	0.261	0.237	0.215	0.195	0.178	0.162	0.148	0.135
12	0.887	0.788	0.701	0.625	0.557	0.497	0.444	0.397	0.356	0.319	0.286	0.257	0.231	0.208	0.187	0.168	0.152	0.137	0.124	0.112
13	0.879	0.773	0.681	0.601	0.530	0.469	0.415	0.368	0.326	0.290	0.258	0.229	0.204	0.182	0.163	0.145	0.130	0.116	0.104	0.093
14	0.870	0.758	0.661	0.577	0.505	0.442	0.388	0.340	0.299	0.263	0.232	0.205	0.181	0.160	0.141	0.125	0.111	0.099	0.088	0.078
15	0.861	0.743	0.642	0.555	0.481	0.417	0.362	0.315	0.275	0.239	0.209	0.183	0.160	0.140	0.123	0.108	0.095	0.084	0.074	0.065
16	0.853	0.728	0.623	0.534	0.458	0.394	0.339	0.292	0.252	0.218	0.188	0.163	0.141	0.123	0.107	0.093	0.081	0.071	0.062	0.054
17	0.844	0.714	0.605	0.513	0.436	0.371	0.317	0.270	0.231	0.198	0.170	0.146	0.125	0.108	0.093	0.080	0.069	0.060	0.052	0.045
18	0.836	0.700	0.587	0.494	0.416	0.350	0.296	0.250	0.212	0.180	0.153	0.130	0.111	0.095	0.081	0.069	0.059	0.051	0.044	0.038
19	0.828	0.686	0.570	0.475	0.396	0.331	0.277	0.232	0.194	0.164	0.138	0.116	0.098	0.083	0.070	0.060	0.051	0.043	0.037	0.031
20	0.820	0.673	0.554	0.456	0.377	0.312	0.258	0.215	0.178	0.149	0.124	0.104	0.087	0.073	0.061	0.051	0.043	0.037	0.031	0.026
25	0.780	0.610	0.478	0.375	0.295	0.233	0.184	0.146	0.116	0.092	0.074	0.059	0.047	0.038	0.030	0.024	0.020	0.016	0.013	0.010
30	0.742	0.552	0.412	0.308	0.231	0.174	0.131	0.099	0.075	0.057	0.044	0.033	0.026	0.020	0.015	0.012	0.009	0.007	0.005	0.004
35	0.706	0.500	0.355	0.253	0.181	0.130	0.094	0.068	0.049	0.036	0.026	0.019	0.014	0.010	0.008	0.006	0.004	0.003	0.002	0.002
40	0.672	0.453	0.307	0.208	0.142	0.097	0.067	0.046	0.032	0.022	0.015	0.011	0.008	0.005	0.004	0.003	0.002	0.001	0.001	0.001
50	0.608	0.372	0.228	0.141	0.087	0.054	0.034	0.021	0.013	0.009	0.005	0.003	0.002	0.001	0.001	0.001	0.000	0.000	0.000	0.000

Example 1

- From the table:

$$\mathrm{PVF}(5\%,2) = \frac{1}{(1+0.05)^2} = 0.9070$$

- Present value $= 100 * 0.9070 = 90.70$

Example 2: amortized loan

- A special 10-year amortized loan is assumed to repay $1000 every quarter. If the discount rate is 8% p.a., calculate the fair price of the loan.

Cautions

- T = period before the asset becomes matured!

  $T = n * year \quad ;$

  n = # payment in a year / year = # year

- Discount rate is usually quoted in p.a. percentage. Your discount rate must be adjusted to match with the number payment stream in a year.

  $r_T = \frac{r}{n}$ → **Discount rate p.a.**

Example 2

- Cash flow = 1000 for every quarter.
- 8% → 2% p.q.
- T = 10 * 4 = 40 quarter (period)

$$V_0 = \frac{1000}{1+0.02} + \frac{1000}{(1+0.02)^2} + \cdots + \frac{1000}{(1+0.02)^{40}}$$

$$= 1000\left\{\frac{1}{1+0.02} + \frac{1}{(1+0.02)^2} + \cdots + \frac{1}{(1+0.02)^{40}}\right\}$$

Geometric Series summation

Example 2

- Geometric Series summation

$$S_T = a + a^2 + a^3 + \cdots + a^T$$

$$aS_T = a^2 + a^3 + a^4 + \cdots + a^{T+1}$$

$$(1 - a)S_T = a - a^{T+1}$$

$$S_T = \frac{a - a^{T+1}}{1 - a}$$

$$S_\infty = \lim_{T \to \infty} S_T = \frac{a}{1 - a}; \quad -1 < a < 1$$

Example 2

- Since $a = \frac{1}{1+r}$, we then obtain that

$$S_T = \frac{\left(\frac{1}{1+r}\right) - \left(\frac{1}{1+r}\right)^{T+1}}{1 - \left(\frac{1}{1+r}\right)} = \frac{\mathbf{1 - \left(\frac{1}{1+r}\right)^{T}}}{\boldsymbol{r}}$$

Present value of an annuity factor = PVIFA(r%,T)

Present value interest factor of an (ordinary) annuity of $1 per period at r% for T periods, PVIFA(r,T).

Period	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%
1	0.990	0.980	0.971	0.962	0.952	0.943	0.935	0.926	0.917	0.909	0.901	0.893	0.885	0.877	0.870	0.862	0.855	0.847	0.840	0.833
2	1.970	1.942	1.913	1.886	1.859	1.833	1.808	1.783	1.759	1.736	1.713	1.690	1.668	1.647	1.626	1.605	1.585	1.566	1.547	1.528
3	2.941	2.884	2.829	2.775	2.723	2.673	2.624	2.577	2.531	2.487	2.444	2.402	2.361	2.322	2.283	2.246	2.210	2.174	2.140	2.106
4	3.902	3.808	3.717	3.630	3.546	3.465	3.387	3.312	3.240	3.170	3.102	3.037	2.974	2.914	2.855	2.798	2.743	2.690	2.639	2.589
5	4.853	4.713	4.580	4.452	4.329	4.212	4.100	3.993	3.890	3.791	3.696	3.605	3.517	3.433	3.352	3.274	3.199	3.127	3.058	2.991
6	5.795	5.601	5.417	5.242	5.076	4.917	4.767	4.623	4.486	4.355	4.231	4.111	3.998	3.889	3.784	3.685	3.589	3.498	3.410	3.326
7	6.728	6.472	6.230	6.002	5.786	5.582	5.389	5.206	5.033	4.868	4.712	4.564	4.423	4.288	4.160	4.039	3.922	3.812	3.706	3.605
8	7.652	7.325	7.020	6.733	6.463	6.210	5.971	5.747	5.535	5.335	5.146	4.968	4.799	4.639	4.487	4.344	4.207	4.078	3.954	3.837
9	8.566	8.162	7.786	7.435	7.108	6.802	6.515	6.247	5.995	5.759	5.537	5.328	5.132	4.946	4.772	4.607	4.451	4.303	4.163	4.031
10	9.471	8.983	8.530	8.111	7.722	7.360	7.024	6.710	6.418	6.145	5.889	5.650	5.426	5.216	5.019	4.833	4.659	4.494	4.339	4.192
11	10.368	9.787	9.253	8.760	8.306	7.887	7.499	7.139	6.805	6.495	6.207	5.938	5.687	5.453	5.234	5.029	4.836	4.656	4.486	4.327
12	11.255	10.575	9.954	9.385	8.863	8.384	7.943	7.536	7.161	6.814	6.492	6.194	5.918	5.660	5.421	5.197	4.988	4.793	4.611	4.439
13	12.134	11.348	10.635	9.986	9.394	8.853	8.358	7.904	7.487	7.103	6.750	6.424	6.122	5.842	5.583	5.342	5.118	4.910	4.715	4.533
14	13.004	12.106	11.296	10.563	9.899	9.295	8.745	8.244	7.786	7.367	6.982	6.628	6.302	6.002	5.724	5.468	5.229	5.008	4.802	4.611
15	13.865	12.849	11.938	11.118	10.380	9.712	9.108	8.559	8.061	7.606	7.191	6.811	6.462	6.142	5.847	5.575	5.324	5.092	4.876	4.675
16	14.718	13.578	12.561	11.652	10.838	10.106	9.447	8.851	8.313	7.824	7.379	6.974	6.604	6.265	5.954	5.668	5.405	5.162	4.938	4.730
17	15.562	14.292	13.166	12.166	11.274	10.477	9.763	9.122	8.544	8.022	7.549	7.120	6.729	6.373	6.047	5.749	5.475	5.222	4.990	4.775
18	16.398	14.992	13.754	12.659	11.690	10.828	10.059	9.372	8.756	8.201	7.702	7.250	6.840	6.467	6.128	5.818	5.534	5.273	5.033	4.812
19	17.226	15.678	14.324	13.134	12.085	11.158	10.336	9.604	8.950	8.365	7.839	7.366	6.938	6.550	6.198	5.877	5.584	5.316	5.070	4.843
20	18.046	16.351	14.877	13.590	12.462	11.470	10.594	9.818	9.129	8.514	7.963	7.469	7.025	6.623	6.259	5.929	5.628	5.353	5.101	4.870
25	22.023	19.523	17.413	15.622	14.094	12.783	11.654	10.675	9.823	9.077	8.422	7.843	7.330	6.873	6.464	6.097	5.766	5.467	5.195	4.948
30	25.808	22.396	19.600	17.292	15.372	13.765	12.409	11.258	10.274	9.427	8.694	8.055	7.496	7.003	6.566	6.177	5.829	5.517	5.235	4.979
35	29.409	24.999	21.487	18.665	16.374	14.498	12.948	11.655	10.567	9.644	8.855	8.176	7.586	7.070	6.617	6.215	5.858	5.539	5.251	4.992
40	32.835	**27.355**	23.115	19.793	17.159	15.046	13.332	11.925	10.757	9.779	8.951	8.244	7.634	7.105	6.642	6.233	5.871	5.548	5.258	4.997
50	39.196	31.424	25.730	21.482	18.256	15.762	13.801	12.233	10.962	9.915	9.042	8.304	7.675	7.133	6.661	6.246	5.880	5.554	5.262	4.999

Example 2

- Cash flow = 1000 for every quarter.
- 8% → 2% p.q.
- T = 10 * 4 = 40 quarter (period)

$$V_0 = \frac{1000}{1+0.02} + \frac{1000}{(1+0.02)^2} + \cdots + \frac{1000}{(1+0.02)^{40}}$$

$$= 1000\left\{\frac{1}{1+0.02} + \frac{1}{(1+0.02)^2} + \cdots + \frac{1}{(1+0.02)^{40}}\right\}$$

$$= 1000\left\{\frac{\left(\frac{1}{1+0.02}\right) - \left(\frac{1}{1+0.02}\right)^{40+1}}{1-\left(\frac{1}{1+0.02}\right)}\right\} = 1000 * 27.355 = 27{,}355.$$

Subjective discount rate v.s. market discount rate

$$\text{Fair value/price} = \text{CF} * \frac{1-\left(\frac{1}{1+r}\right)^{T}}{r} = \text{CF} * \text{PVIFA}(\text{r}, \text{T})$$

1. Given subjective discount rate (r) ➔ your fair value, based on your preference.

2. Given the market price where D = S,

➔ Market-consistent discount rate.

➔ yield to maturity = interest rate on bond/fixed income asset

Example 3: Implied discount rate

- If the market value of a semi-annual payment amortized loan is $12,462, calculate the interest rate of this amortized loan when the loan will be matured in 10 years from now.

Example 3 cont

- T = 20
- $12{,}462 = 1000\left\{\frac{1-\left(\frac{1}{1+r}\right)^{20}}{r}\right\}$
- $\left\{\frac{1-\left(\frac{1}{1+r}\right)^{20}}{r}\right\} = 12.462$

Present value interest factor of an (ordinary) annuity of $1 per period at r% for T periods, PVIFA(r,T).

Period	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%
1	0.990	0.980	0.971	0.962	0.952	0.943	0.935	0.926	0.917	0.909	0.901	0.893	0.885	0.877	0.870	0.862	0.855	0.847	0.840	0.833
2	1.970	1.942	1.913	1.886	1.859	1.833	1.808	1.783	1.759	1.736	1.713	1.690	1.668	1.647	1.626	1.605	1.585	1.566	1.547	1.528
3	2.941	2.884	2.829	2.775	2.723	2.673	2.624	2.577	2.531	2.487	2.444	2.402	2.361	2.322	2.283	2.246	2.210	2.174	2.140	2.106
4	3.902	3.808	3.717	3.630	3.546	3.465	3.387	3.312	3.240	3.170	3.102	3.037	2.974	2.914	2.855	2.798	2.743	2.690	2.639	2.589
5	4.853	4.713	4.580	4.452	4.329	4.212	4.100	3.993	3.890	3.791	3.696	3.605	3.517	3.433	3.352	3.274	3.199	3.127	3.058	2.991
6	5.795	5.601	5.417	5.242	5.076	4.917	4.767	4.623	4.486	4.355	4.231	4.111	3.998	3.889	3.784	3.685	3.589	3.498	3.410	3.326
7	6.728	6.472	6.230	6.002	5.786	5.582	5.389	5.206	5.033	4.868	4.712	4.564	4.423	4.288	4.160	4.039	3.922	3.812	3.706	3.605
8	7.652	7.325	7.020	6.733	6.463	6.210	5.971	5.747	5.535	5.335	5.146	4.968	4.799	4.639	4.487	4.344	4.207	4.078	3.954	3.837
9	8.566	8.162	7.786	7.435	7.108	6.802	6.515	6.247	5.995	5.759	5.537	5.328	5.132	4.946	4.772	4.607	4.451	4.303	4.163	4.031
10	9.471	8.983	8.530	8.111	7.722	7.360	7.024	6.710	6.418	6.145	5.889	5.650	5.426	5.216	5.019	4.833	4.659	4.494	4.339	4.192
11	10.368	9.787	9.253	8.760	8.306	7.887	7.499	7.139	6.805	6.495	6.207	5.938	5.687	5.453	5.234	5.029	4.836	4.656	4.486	4.327
12	11.255	10.575	9.954	9.385	8.863	8.384	7.943	7.536	7.161	6.814	6.492	6.194	5.918	5.660	5.421	5.197	4.988	4.793	4.611	4.439
13	12.134	11.348	10.635	9.986	9.394	8.853	8.358	7.904	7.487	7.103	6.750	6.424	6.122	5.842	5.583	5.342	5.118	4.910	4.715	4.533
14	13.004	12.106	11.296	10.563	9.899	9.295	8.745	8.244	7.786	7.367	6.982	6.628	6.302	6.002	5.724	5.468	5.229	5.008	4.802	4.611
15	13.865	12.849	11.938	11.118	10.380	9.712	9.108	8.559	8.061	7.606	7.191	6.811	6.462	6.142	5.847	5.575	5.324	5.092	4.876	4.675
16	14.718	13.578	12.561	11.652	10.838	10.106	9.447	8.851	8.313	7.824	7.379	6.974	6.604	6.265	5.954	5.668	5.405	5.162	4.938	4.730
17	15.562	14.292	13.166	12.166	11.274	10.477	9.763	9.122	8.544	8.022	7.549	7.120	6.729	6.373	6.047	5.749	5.475	5.222	4.990	4.775
18	16.398	14.992	13.754	12.659	11.690	10.828	10.059	9.372	8.756	8.201	7.702	7.250	6.840	6.467	6.128	5.818	5.534	5.273	5.033	4.812
19	17.226	15.678	14.324	13.134	12.085	11.158	10.336	9.604	8.950	8.365	7.839	7.366	6.938	6.550	6.198	5.877	5.584	5.316	5.070	4.843
20	18.046	16.351	14.877	13.590	12.462	11.470	10.594	9.818	9.129	8.514	7.963	7.469	7.025	6.623	6.259	5.929	5.628	5.353	5.101	4.870
25	22.023	19.523	17.413	15.622	14.094	12.783	11.654	10.675	9.823	9.077	8.422	7.843	7.330	6.873	6.464	6.097	5.766	5.467	5.195	4.948
30	25.808	22.396	19.600	17.292	15.372	13.765	12.409	11.258	10.274	9.427	8.694	8.055	7.496	7.003	6.566	6.177	5.829	5.517	5.235	4.979
35	29.409	24.999	21.487	18.665	16.374	14.498	12.948	11.655	10.567	9.644	8.855	8.176	7.586	7.070	6.617	6.215	5.858	5.539	5.251	4.992
40	32.835	**27.355**	23.115	19.793	17.159	15.046	13.332	11.925	10.757	9.779	8.951	8.244	7.634	7.105	6.642	6.233	5.871	5.548	5.258	4.997
50	39.196	31.424	25.730	21.482	18.256	15.762	13.801	12.233	10.962	9.915	9.042	8.304	7.675	7.133	6.661	6.246	5.880	5.554	5.262	4.999

Example 3 cont

- T = 20
- $12{,}462 = 1000\left\{\frac{1-\left(\frac{1}{1+r}\right)^{20}}{r}\right\}$
- $\left\{\frac{1-\left(\frac{1}{1+r}\right)^{20}}{r}\right\} = 12.462$
- r = 5% per semi-annual (= 10% p.a.)

➔ Market discount rate/Yield = 10% p.a.

Example 4: coupon bond

- A 3-year government bond is set to pay the coupon for every six months, with coupon rate of 6% pa. Calculate the fair price if the market rate is 4% pa and the face value of bond is $100.

Example 4: coupon bond

- Periods before it is matured= _____ periods
- Cash flow = _____ per period
- Discount rate = _____

$V_t \quad =$

Example 4

- PVIFA(_____%, _____) = _____
- $PVF(\_\_\_\_\_\%, \_\_\_\_\_) = \_\_\_\_\_$

- Value =

Example 3 cont

- What if c = 2% and 4%?

$$Coupon = 2\ \% \Rightarrow 1\left\{\frac{\left(\frac{1}{1+0.02}\right)-\left(\frac{1}{1+0.02}\right)^{6+1}}{1-\left(\frac{1}{1+0.02}\right)}\right\}+\frac{100}{(1+0.02)^6}=94.48$$

$$Coupon = 4\ \%: \Rightarrow 2\left\{\frac{\left(\frac{1}{1+0.02}\right)-\left(\frac{1}{1+0.02}\right)^{6+1}}{1-\left(\frac{1}{1+0.02}\right)}\right\}+\frac{100}{(1+0.02)^6}=100$$

Observations from the Bond pricing formula

$$P > FV \quad sold\ at\ Premium \quad yield < coupon$$
$$P = FV \quad sold\ at\ PAR \quad yield = coupon$$
$$P < FV \quad sold\ at\ Discount \quad yield > coupon$$

Sum up…

- Bond pricing formula
- In the equilibrium, the formula can be applied to calculate
  - Fair price / Market price
  - Implied "yield to maturity/interest rate"
- Relationship between bond price & FV and Interest rate & Coupon