20598 – **Finance** (with Big Data)

Week 1: Finance 1-0-1

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Outline

What is an asset ?

Present Value

Time Value of Money

Risk

Compounding

Inflation

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Yesterday I told you...

- The teaching philosophy of this class deviates significantly from most of your earlier coursework
- Key principles that we're trying to implement is to have :
  - less face to face lectures, and more discussions
  - less material to learn by heart, and more space for your own thoughts
  - more space for your own experimentation

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- Key principles that we're trying to implement is to have :
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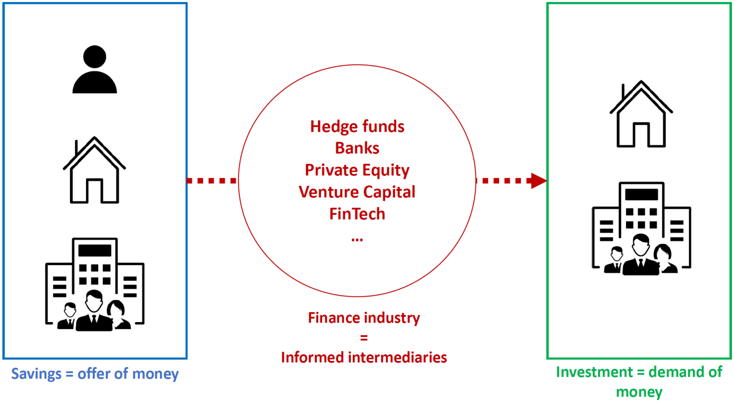
  - more space for your own experimentation
- That does not really apply today: we are going to recap the basics of finance so that everyone is on the same page

Finance = Valuation of Assets



Finance = Valuation of Assets

- Finance primary function is the valuation of business activities
- All business activities reduce to two functions :
  - Grow wealth (create value, i.e, creating assets)
  - Management wealth (acquiring, selling assets)

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- Finance primary function is the valuation of business activities
- All business activities reduce to two functions :
  - Grow wealth (create value, i.e, creating assets)
  - Management wealth (acquiring, selling assets)
- Financially, business decisions start with the valuation of assets :
  - *You can't create and manage what you can't measure*
- Value is an objective measure, often determined by the financial market
- Valuation $\Rightarrow$ central question of finance

What is an Asset ?

- But even before thinking about asset valuation, key question :

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What is an Asset ?

  - Business entity
  - Property, plant and equipment
  - Patents, R&D
  - Stocks, bonds, options, etc.
  - Knowledge, reputation, opportunities

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From a financial perspective, an asset is a **sequence** of cash-flows (CF)

$$\textbf{Asset}_t \equiv \{\mathsf{CF}_t, \mathsf{CF}_{t+1}, \mathsf{CF}_{t+2}, ...\}$$

Examples of Assets as Cash-Flows

- Boeing is evaluating whether to proceed with development of a new airplane. R&D expected to take 3 years and cost: $850 million. Unit cost of production: $33 million. Expected sales: 30 planes every year at an average price of $41 million
- Firms in the S&P 500 are expected to earn, collectively, $66 this year and to pay dividends of $24 per share
- You were just hired by Google. Your initial pay package includes a grant of 50,000 stock options with a strike price of $24.92 and an expiration date of 10 years. Google's stock price has varied between $16.08 and $26.03 during the past two years.

Valuation of Assets

- Sequences of cash-flows are the basic building blocks of finance

How to value an Asset ?

$$\textbf{Value of Asset}_t \equiv \mathbb{V}_t\big(\mathsf{CF}_t, \mathsf{CF}_{t+1}, \mathsf{CF}_{t+2}, \ldots\big)$$

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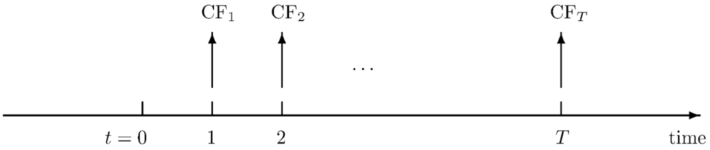

- Always draw a timeline to visualize the timing of cash-flows !
- Key question: what is $\mathbb{V}_t$?

The Present Value Operator

- Key question: what is $\mathbb{V}_t$?
  - What factors are involved in determining the value of any object ?
  - How is value determined ?

The Present Value Operator

- Key question: what is $\mathbb{V}_t$?
  - What factors are involved in determining the value of any object ?
  - How is value determined ?
- Two distinct cases :
  - No uncertainty: we have a complete solution
  - Uncertainty: we have a partial solution
- Value is determined the same way, but we want to understand how

The Present Value Operator

Key insights

- Two important characteristics of a cash-flows: Time and Risk

The Present Value Operator

Key insights

- Two important characteristics of a cash-flows: **Time** and Risk

The Present Value Operator

Time Value of Money

- Which one do you prefer ?

A. 1000$ **today**

B. 1000$ in **1 year**

C. 1000$ in **100 year**

The Present Value Operator

Time Value of Money

- How much would you value these contracts ?

A. 1000$ **today**

Value?

B. 1000$ in **1 year**

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Value?

The Present Value Operator

Time Value of Money

- Insight : cash-flows at different dates are like *different currencies*
- How to manipulate different foreign currencies ?

$$€150 + \$300 = ??$$

The Present Value Operator

Time Value of Money

- Insight : cash-flows at different dates are like *different currencies*
- How to manipulate different foreign currencies ?

$$€150 + \$300 = ??$$

- Cannot add currencies without first converting into common currency
- Exemple : we choose to compute everything in €, with \$1 = €0.95

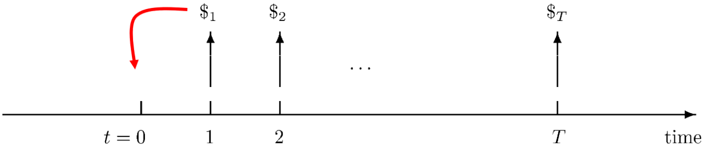
$$€150 + \$300 \times (€0,95/\$) = €435$$

$\Rightarrow$ Same idea for cash-flows at different dates !

The Present Value Operator

Time Value of Money

- Once *exchange rates* are given, adding cash-flows is trivial



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The Present Value Operator

Time Value of Money

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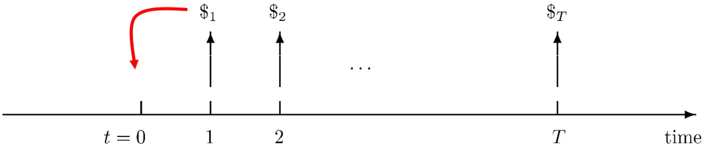

- A reference date should be picked, in general t=0 or today
- Future cash-flows can then be converted to present value :

How to value an Asset ?

$$\textbf{Value of Asset}_{t=0} = \text{CF}_0 + \left(\frac{\$_1}{\$_0}\right) \times \text{CF}_1 + \left(\frac{\$_2}{\$_0}\right) \times \text{CF}_2 + ... + \left(\frac{\$_T}{\$_0}\right) \times \text{CF}_T$$

The Present Value Operator

Time Value of Money : Example

- Suppose we have the following *exchange rates* :

$$\left(\frac{\$_1}{\$_0}\right) = 0.90 \text{ and } \left(\frac{\$_2}{\$_0}\right) = 0.80$$

- Asset : Google wants to launch a project in Machine Learning (=Asset)
  - requires an initial investment of \$10M (at t=0)
  - generates cash-flows of \$5M at t=1 and \$7M at t=2

- What is the present value of this asset ?

The Present Value Operator

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The Present Value Operator

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- Suppose now that Google can pay for the investment two years from now, at the end of the project. What's the new present value ?

The Present Value Operator

Time Value of Money

- Implicit assumptions :
  - cash-flows are known (magnitudes, signs, timing)
  - *exchange rates* are known

The Present Value Operator

Time Value of Money

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- Do these assumptions hold in practice ?

The Present Value Operator

Time Value of Money

- Implicit assumptions :
  - cash-flows are known (magnitudes, signs, timing)
  - *exchange rates* are known
- Do these assumptions hold in practice ?
- Let's focus now on exchange rates

$\Rightarrow$ Where do they come from, how are they determined ?

The Present Value Operator

Time Value of Money

- Why \$1 today should be worth more than \$1 in the future ?
- Opportunity cost of capital : expected return on equivalent investments in financial markets

$\Rightarrow$ With \$1 today, you could invest in a safe asset with interest rate **r**

$$\$1 \text{ in year } 0 = \$1 \times (1 + \mathbf{r}) \text{ in year } 1$$
$$\$1 \text{ in year } 0 = \$1 \times (1 + \mathbf{r})^2 \text{ in year } 2$$
$$\$1 \text{ in year } 0 = \$1 \times (1 + \mathbf{r})^T \text{ in year T}$$

- Equivalence of \$1 today and any single choice above
- **r** is called the risk-free rate, or r_f

The Present Value Operator

Time Value of Money

- Why \$1 today should be worth more than \$1 in the future ?

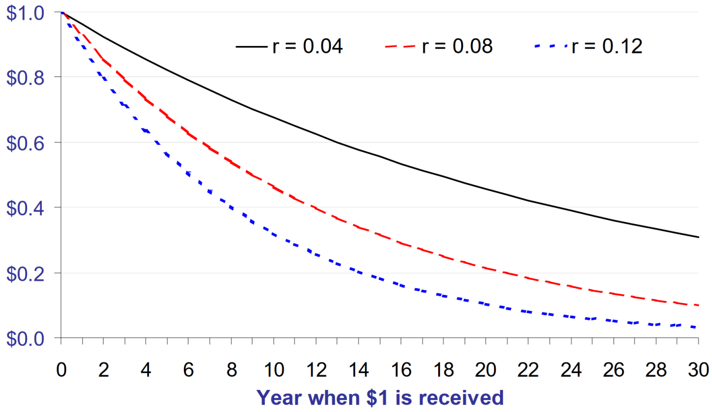
$\Rightarrow$ You can inverse the relationship :

$$\$1/(1+r_f) \text{ in year } 0 = \$1 \text{ in year } 1$$
$$\$1/(1+r_f)^2 \text{ in year } 0 = \$1 \text{ in year } 2$$
$$\$1/(1+r_f)^T \text{ in year } 0 = \$1 \text{ in year T}$$

- These are our *exchange rates* $\left(\frac{\$_t}{\$_0}\right)$ or discount factors

The Present Value Operator

Safe asset



The Present Value Operator

Safe asset

- What determines exchange rates (with no uncertainty) ?
- How evolves the risk-free rate during crisis ? Why ?

The Present Value Operator

Complete solution

- We now have an explicit expression for the value of an asset (with no uncertainty)

How to value an Asset ?

$$\textbf{Value of Asset}_{t=0} = \text{CF}_0 + \frac{1}{(1+r)} \times \text{CF}_1 + \frac{1}{(1+r)^2} \times \text{CF}_2 + ... + \frac{1}{(1+r)^T} \times \text{CF}_T$$

The Present Value Operator

Safe asset

Example 1. (Safe asset) An asset yields cash-flow in one year with a sure value of \$1,000. How much is it worth today ?

- Suppose that assets/cash-flows traded in the financial market with the same timing and risk (i.e., no risk) offer a return of 5% (e.g., one-year US Treasury bonds, yielding a sure annual interest of 5%).

The Present Value Operator

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$$\text{Value of Asset} = \frac{1}{(1+r_f)} \times \text{CF}_1 = \frac{1}{(1+0.05)} \times 1000 = 952$$

- \$952 is the asset's current market value.

The Present Value Operator

Key insights

- Two important characteristics of a cash-flows: Time and **Risk**

The Present Value Operator

Risk

- Two contracts. Which one do you prefer ?

1000$ **probability = 1**

2000$ **probability = 0.5**
0$ **probability = 0.5**

The Present Value Operator

Risk

- How much would you value these contracts ?

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Value?

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Value?

The Present Value Operator

Risk

- Why \$1 with no risk should be worth than (expected) \$1 with risk ?

$\Rightarrow$ Risk-aversion

The Present Value Operator
Risk

- Why \$1 with no risk should be worth than (expected) \$1 with risk ?

$$\Rightarrow \text{Risk-aversion}$$

- Expected utility theory is the leading model of consistent decision making under uncertainty : investors evaluate each gamble not by its expected payoff, but by its expected utility

The Present Value Operator

Expected utility theory

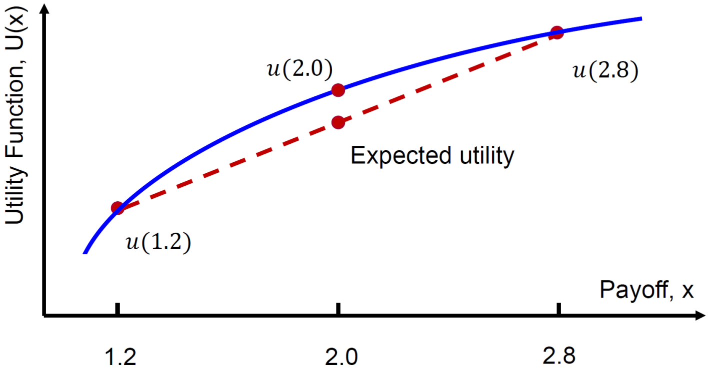
1 MacBook w. **probability = 1**

2 MacBooks w. **probability = 0.5**
Nothing **probability = 0.5**

- Utility function is concave : $U(x) > U(2 \times x) + U(0 \times x)$
- If the utility function is a straight line, you're risk neutral

The Present Value Operator

Expected utility theory



- \$2M with P=1
- \$1.2M with P=0.5 and \$2.8M with P=0.5

The Present Value Operator

Risk

- Risk-adjusted discount factor :

$$\$1 \text{ with risk (today)} = \$1 \times (1 + \mathbf{r}_p) \text{ with no risk (today)}$$

- $\mathbf{r}_p$ is called the risk-premium
- Total risk of a future risky cash-flow writes : R $= r_f + r_p$

The Present Value Operator

Risky asset

Example 2. (Risky asset) An asset yields risky cash-flow in one year with expected value of $1,000. How much is it worth today?

- Suppose that assets/cash-flows traded in the financial market with the same timing and risk offer a return of 10%

The Present Value Operator

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- Suppose that assets/cash-flows traded in the financial market with the same timing and risk offer a return of 10%

$$\text{Value of Asset} = \frac{1}{(1+R)} \times \text{CF}_1 = \frac{1}{(1+0.1)} \times 1000 = 909$$

- \$909 is the asset's current market value.

The Present Value Operator

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- Let's say that the risk free rate is 5%, what is the risk premium ?

The Present Value Operator

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- \$909 is the asset's current market value.
- Let's say that the risk free rate is 5%, what is the risk premium ?

$\rightarrow$ R $= r_f + r_p \rightarrow r_p = 5\%$

The Present Value Operator

Partial solution

- We now have an explicit expression for the value of an asset (with uncertainty)

How to value a risky Asset ?

$$\textbf{Value of Asset}_{t=0} = \mathbb{E}(\mathrm{CF}_0) + \frac{1}{(1+R)} \times \mathbb{E}(\mathrm{CF}_1) + \frac{1}{(1+R)^2} \times \mathbb{E}(\mathrm{CF}_2) + \ldots$$

- with R $= r_f + r_p$
- Why do we call that a partial solution?

Compounding?

Compounding

Yearly vs. **monthly** vs. **daily** interest rates

- Interest May Be Credited/Charged More Often Than Annually
  - Bank account : daily
  - Mortgages and leases : monthly
  - Bonds : semiannually
  - **Effective annual rate** may differ from annual percentage rate

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- Compounding conventions :
  - r is the annual rate, charged over n periods
  - r/n is per-period rate for each period
  - Effective annual rate is :

$$EAR = (1 + r/n)^n - 1$$

Compounding

Yearly vs. **monthly** vs. **daily** interest rates: 10% rate exemple

Month	1 000,0 €	1 000,0 €	1 000,0 €	1 000,0 €
1				1 008,3 €
2				1 016,7 €
3			1 025,0 €	1 025,2 €
4				1 033,8 €
5				1 042,4 €
6		1 050,0 €	1 050,6 €	1 051,1 €
7				1 059,8 €
8				1 068,6 €
9			1 076,9 €	1 077,5 €
10				1 086,5 €
11				1 095,6 €
12	**1 100,0 €**	**1 102,5 €**	**1 103,8 €**	**1 104,7 €**

Compounding

Yearly vs. **monthly** vs. **daily** interest rates

Example : Car loan – Finance charges on the unpaid balance, computed daily, at the rate of 6.75% per year

- If you borrow $10,000, how much would you owe in a year ?

Compounding

Yearly vs. **monthly** vs. **daily** interest rates

Example : Car loan – Finance charges on the unpaid balance, computed daily, at the rate of 6.75% per year

- If you borrow \$10,000, how much would you owe in a year ?
- Daily interest rate = 6.75 / 365 = 0.0185%

  Day 1 : Balance = 10,000.00 × 1.000185 = 10,001.85
  Day 2 : Balance = 10,001.85 × 1.000185 = 10,003.70
  ...
  Day 365 : Balance = 10,696.26 × 1.000185 = 10,698.24

- EAR = 6.982% > 6.750%

Inflation

What is it and why do we care ?

Inflation

What is it and why do we care ?

- Inflation: change in real purchasing power of $1 over time
- Different from time-value of money (how ?)
- For some (all ?) countries, inflation is extremely problematic

Inflation

What is it and why do we care ? → EU

ECONOMY

ECB Raises Interest Rates by Historic 0.75 Point as Europe Stares at Recession

European Central Bank intensifies fight against inflation even as Europe's prospects darken amid economic war with Russia

Inflation

What is it and why do we care ? → Sri Lanka

Inflation

What is it and why do we care? → Argentina

- Read this great NYT article about Argentina

Inflation

What is it and why do we care ?

- What about Italy ?

Inflation

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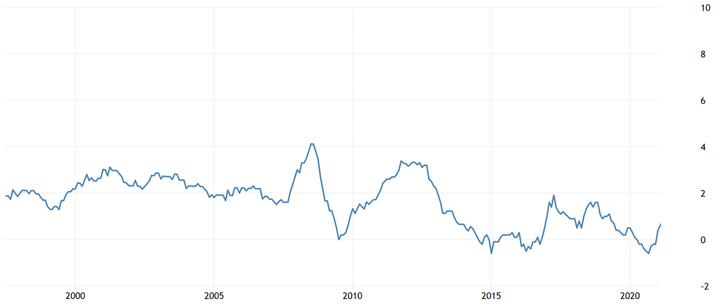

Inflation

What is it and why do we care ?

- What about Italy ?

Inflation

What is it and why do we care ?

Inflation

How to quantify its effects?

- Let's say that W_t is the value of your wealth at t :

$$\text{Wealth } W_t \equiv \text{Price Index } I_t$$
$$\text{Wealth } W_{t+k} \equiv \text{Price Index } I_{t+k}$$

- We can define inflation π as :

$$\text{Increase in Cost of Living} \equiv \frac{I_{t+k}}{I_t} = (1+\pi)^k$$
$$\text{Real Wealth } \tilde{W}_{t+k} \equiv \frac{W_{t+k}}{(1+\pi)^k}$$

Inflation

Applying inflation to cash-flows

Exemple 1 : inflation is 4% per year. You expect to receive \$1.04 in one year, what is the real value of this CF next year ?

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- The inflation adjusted or real value of \$1.04 in a year is :

$$\text{Real CF} = \frac{\text{Nominal CF}}{1 + \text{inflation}}$$

$$= \frac{\$1.04}{1 + 0.04} = \$1.00$$

- Nominal cash flows $\Rightarrow$ expressed in actual-dollar cash flows
- Real cash flows $\Rightarrow$ expressed in constant purchasing power

Inflation

Applying inflation to cash-flows

- Nominal rates of return $\Rightarrow$ prevailing in market rates
- Real rates of return $\Rightarrow$ inflation-adjusted rates

Exemple 3 : \$1.00 invested at a 6% interest rate grows to \$1.06 next year. Now imagine that inflation is 4% per year. What is the real rate of return ?

Inflation

Applying inflation to cash-flows

- Nominal rates of return $\Rightarrow$ prevailing in market rates
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Exemple 3 : \$1.00 invested at a 6% interest rate grows to \$1.06 next year. Now imagine that inflation is 4% per year. What is the real rate of return ?

$\rightarrow$ The real value of the future cash flow is $\frac{1.06}{1.04} = 1.019$. Real rate of return is 1.9% !

Inflation

Applying inflation to cash-flows

- Nominal rates of return $\Rightarrow$ prevailing in market rates
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$\rightarrow$ The real value of the future cash flow is $\frac{1.06}{1.04} = 1.019$. Real rate of return is 1.9% !

$$\mathrm{r}_{real} = \frac{1 + \mathrm{r}_{nominal}}{1 + \text{inflation}}$$

$$= \mathrm{r}_{nominal} - \text{inflation}$$

- But this approximation is correct only when both $\mathrm{r}_{nominal}$ and inflation are very small

Survey

Discussion