MSc Business Analytics

Financial Modelling and Analysis

Chapter 1: Introduction to finance.

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Outline

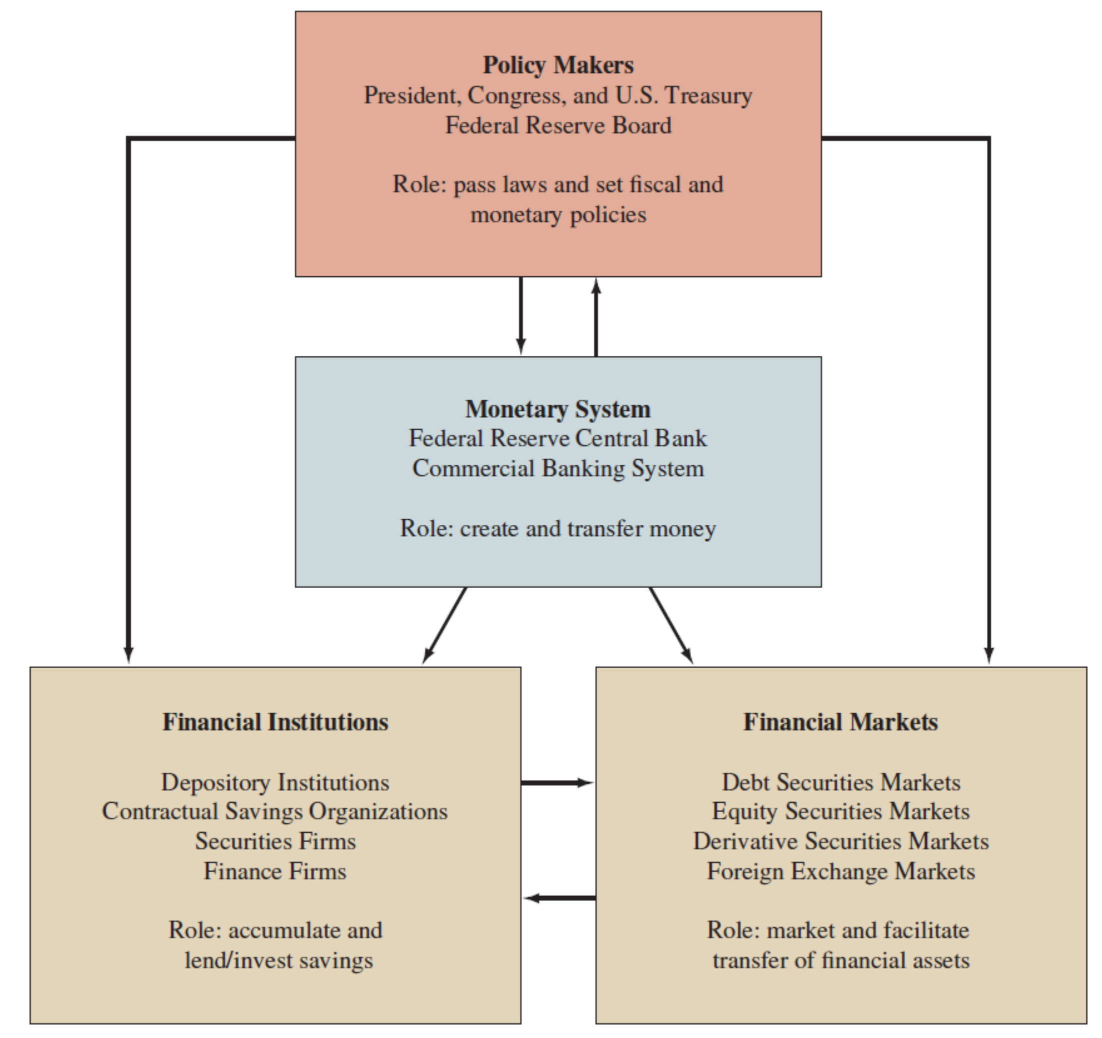
- Introduction to finance.
- Traditional Financial System - its components, financial functions.
- Financial Instruments, markets, and Intermediaries.
- Financial markets vs corporate finance (macro vs micro).
- Data types and sources.
- Return

Six Principles of Finance

- Finance is founded on six important principles.
- **Money has a time value of receiving the same amount in the future.**
  - Money in hand today is worth more than the promise
- **Higher returns are expected for taking on more risk**
  - Risk is the uncertainty about the outcome or payoff of an investment in the future.
- **Diversification of investments can reduce risk.**
  - some risk can be removed or diversified by investing in several different assets or securities.
- **Financial markets are efficient in pricing securities**.
  - A financial market is said to be information efficient if at any point the prices of securities reflect all information available to the public
- **Manager and stockholder objectives may differ.**
  - Owners, or equity investors, want to maximize the returns on their investments but often hire professional managers to run their firms.
  - Managers may seek to emphasize the size of firm sales or assets, have company jets or helicopters available for their travel, and receive company-paid country club memberships.
- **Reputation matters.**
  - An individual’s reputation reflects his or her ethical standards or behavior.

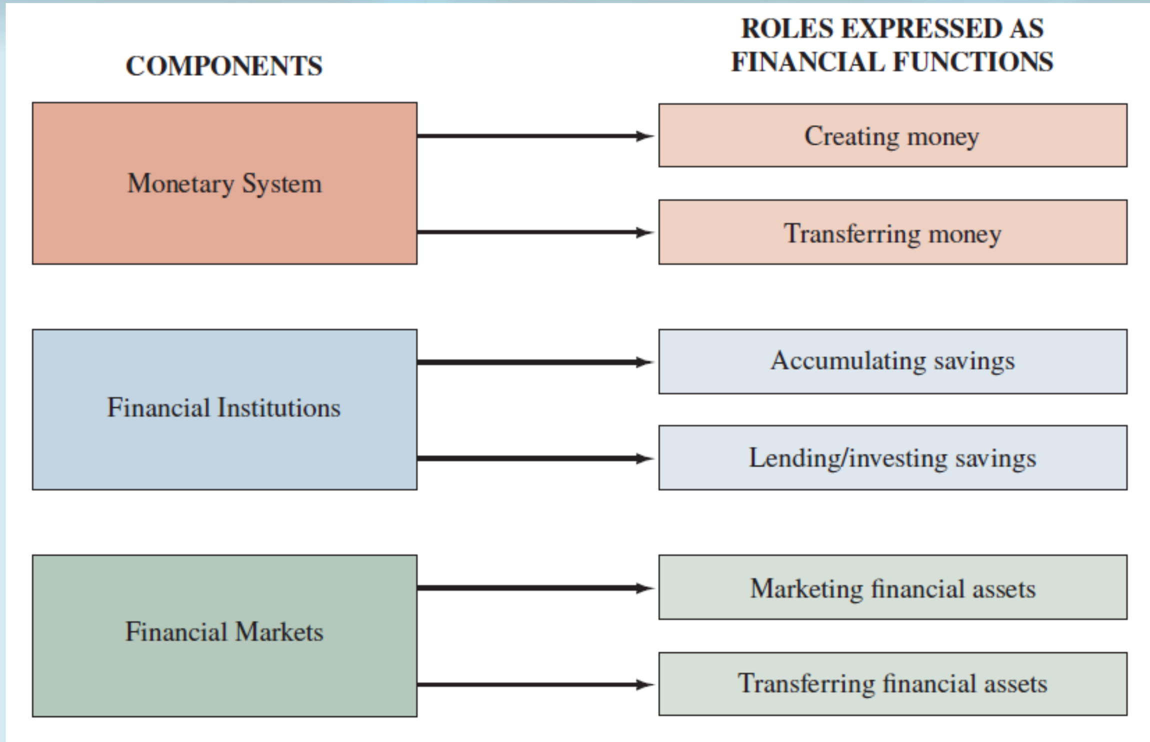
Financial system

- First, an effective financial system must have several sets of *policy makers* who pass laws and make decisions relating to fiscal and monetary policies.
- Second, an effective financial system needs an *efficient monetary system* that is composed of a central bank and a banking system that is able to create and transfer a stable medium of exchange called money.
- Third, an effective financial system also must have *financial institutions, or intermediaries*, that support capital formation either by channeling savings into investment in real assets or by fostering direct financial investments by individuals in financial institutions and businesses.
- Fourth, an effective financial system must also have *financial markets* that facilitate the transfer of financial assets among individuals, institutions, businesses, and governments.



Financial System Components and Financial Functions

- **One of the most significant functions of the monetary system within the financial system is creating money, which serves as a medium of exchange**.
- A sufficient amount of money is essential if economic activity is to take place at an efficient rate.
  - Having too little money constrains economic growth.
  - Having too much money often results in increases in the prices of goods and services.
- Individuals and businesses **hold money for purchases or payments they expect to make in the near future**. One way to hold money is in checkable deposits at depository institutions.
  - A function performed by financial institutions is the accumulation or gathering of individual savings.
  - Most individuals, businesses, and organizations do not want to take the risks involved in having cash on hand
- **Lending and investing:** The money that has been put into these intermediaries may be lent to businesses, farmers, consumers, institutions, and governmental units.
- **Marketing financial assets:** New financial instruments and securities are created and sold in the primary securities market. Brokerage fi rms market and facilitate the transferring of existing, or seasoned, instruments and securities



Financial Markets: Characteristics and Types

- **Money markets** are where debt securities with maturities of one year or less are issued and traded (debt securities are financial assets that entitle their owners to a stream of interest payments).
  - These markets are generally characterized by high liquidity whereby money market securities can be easily sold or traded with little loss of value.
  - These short-lived securities generally have low returns and low risk.
  - Examples: different types bonds, Zero coupon securities (issued at a discount to their face value)
- **Capital markets** are where debt instruments or securities with maturities longer than one year and corporate stocks or equity securities are issued and traded.
  - Capital market securities are generally issued to finance the purchase of homes by individuals, buildings and equipment by businesses, and for provision of infrastructure (roads, bridges, buildings, etc.) by governments.
  - Business firms and governments issue long-term debt securities, called bonds, to finance their assets and operations.
  - Mortgages are issued to finance homes and buildings.
  - Corporations also issue stocks to meet their financing needs.

Financial Markets: Characteristics and Types

- The initial offering, or origination, of debt and equity securities takes place in a **primary**
- **market.**
  - Proceeds from the sale of new securities after issuing costs go to the issuing business or government issuer.
  - The primary market is the only "market" where the security issuer directly benefits (receives funds) from the sale of its securities. Mortgage loans provide financing for the purchase of homes and other real property.
- **Secondary markets** are physical locations or electronic forums where debt (bonds and mortgages) and equity securities are traded.
  - Secondary markets for securities facilitate the transfer of previously issued securities from existing investors to new investors.
  - Security transactions or transfers typically take place on organized security exchanges or in the electronic over-the-counter market.
  - Individuals and other investors can actively buy and sell existing securities in the secondary market.

Financial Markets: Characteristics and Types

- **Debt securities** are obligations to repay borrowed funds. Debt securities markets are markets where money market securities, bonds (corporate, financial institution, and government), and mortgages are originated and traded.
- **Bond markets** are where debt securities with longer-term maturities are originated and traded. Government entities (federal, state, and local), financial institutions, and business fi rms can issue bonds.
- **Mortgage markets** are where loans to purchase real estate (buildings and houses) are originated and traded.
- **Equity securities**, also called **common stocks**, are ownership shares in corporations.
  - Equity securities markets are markets where ownership shares in corporations are initially sold and traded. Corporations can raise funds either through a private placement, which involves issuing new common stocks directly to specific investors, or through a public offering, which involves selling new common stocks to the general public.
  - Financial institutions can also raise equity capital by selling common stocks in their firms.
- **Derivative securities markets**, are markets for financial contracts or instruments that derive their values from underlying debt and equity securities.
  - A familiar form of derivative security is the opportunity to buy or sell a corporation's equity securities for a specified price and within a certain amount of time.
  - Derivative securities may be used to speculate on the future price direction of the underlying financial assets or to reduce price risk associated with holding the underlying financial assets.
- **Foreign exchange markets** (also called FOREX markets) are electronic markets in which banks and institutional traders buy and sell various currencies on behalf of businesses and other clients. In the global economy, consumers may want to purchase goods produced or services provided in other countries. Likewise, an investor residing in one country may wish to hold securities issued in another country.

The role of financial markets

- Financial markets provide the following three major economic functions: **(1) price discovery, (2) liquidity, and (3) reduced transaction costs.**
- *Price discovery* means that the interactions of buyers and sellers in a financial market determine the price of the traded asset.
  - Equivalently, they determine the required return that participants in a financial market demand in order to buy a financial instrument.
  - Financial markets signal how the funds available from those who want to lend or invest funds are allocated among those needing funds.
  - This is because the motive for those seeking funds depends on the required return that investors demand.
- Second, financial markets provide a forum for investors to sell a financial instrument and therefore offer investors *liquidity*.
- *Liquidity* is the presence of buyers and sellers ready to trade.
- *Search costs in turn fall into two categories: explicit costs and implicit costs.*
  - Explicit costs include expenses to advertise one’s intention to sell or purchase a financial instrument.
  - Implicit costs include the value of time spent in locating a counterparty—that is, a buyer for a seller or a seller for a buyer—to the transaction.
  - The presence of some form of organized financial market reduces search costs.

Financial Assets

- **An asset is any resource that we expect to provide future benefits and, hence, has economic value.**
- We can categorize assets into two types: *tangible assets and intangible assets*.
- The value of a *tangible asset* depends on its physical properties.
  - Buildings, aircraft, land, and machinery are examples of tangible assets, which we often refer to as fixed assets.
- An *intangible asset* represents a legal claim to some future economic benefit or benefits.
  - Examples of intangible assets include patents, copyrights, and trademarks.
- The value of an intangible asset bears no relation to the form, physical or otherwise, in which the claims are recorded.
- *Financial assets*, such as stocks and bonds, are also *intangible assets* because the future benefits come in the form of a claim to future cash flows.
- *Another term we use for a financial asset is financial instrument*.

What Is the Difference between Debt and Equity?

- *We can classify a financial instrument by the type of claims that the investor has on the issuer*.
- A financial instrument in which the issuer agrees to pay the investor interest, plus repay the amount borrowed, is a debt instrument or, simply, debt.
  - A debt can be in the form of a note, bond, or loan.
  - The issuer must pay interest payments, which are fixed contractually. In the case of a debt instrument that is required to make payments in U.S. dollars, the amount may be a fixed dollar amount or percentage of the face value of the debt, or it can vary depending upon some benchmark.
  - The investor who lends the funds and expects interest and the repayment of the debt is a creditor of the issuer.
- The key point is that the investor in a debt instrument can realize no more than the contractual amount.
  - *For this reason, we often refer to debt instruments as fixed income instruments*.
  - MICKEY MOUSE DEBT: The Walt Disney Company bonds issued in July 1993, which mature in July 2093, pay interest at a rate of 7.55%. This means that Disney pays the investors who bought the bonds $7.55 per year for every $100 of principal value of debt they own.

What Is the Difference between Debt and Equity?

- **In contrast to a debt obligation, an equity instrument specifies that the issuer pay the investor an amount based on earnings, if any, after the obligations that the issuer is required to make to the company's creditors are paid**.
- Common stock and partnership shares are examples of equity instruments.
- *Common stock is the ownership interest in a corporation, whereas a partnership share is an ownership interest in a partnership*.
- We refer to any distribution of a company's earnings as *dividends*.
- *Preferred stock* is such a hybrid because it looks like debt because investors in this security are only entitled to receive a fixed contractual amount.
- Yet preferred stock is similar to equity because the payment to investors is only made after obligations to the company's creditors are satisfied.

Data: Sources and Types

- In empirical analysis, data come from one of two sources: **experiments** or **nonexperimental** observations of the world
- **Experimental data** come from *experiments designed to evaluate a treatment or policy or to investigate a causal effect*.
- Because real-world experiments with human subjects are difficult to administer and to control, they have flaws relative to ideal randomized controlled experiments.
- Because of financial, practical, and ethical problems, experiments in social science are relatively rare.
- Instead, most economic data are obtained by observing real-world behavior (**observational data**).
- Whether the data are experimental or observational, data sets come in three main types: **cross-sectional data, time series data, and panel data**.
- Depending on the type of data, different approaches/models are to be used.

First thing first: Interest rate

- An interest rate is a price for the use of money for a period of time, just as ground rent is a price for the use of land for a period of time or a wage rate is a price for using a worker’s abilities for a period of time.

- If I pay $7 to borrow $100 for a year, the interest rate for the loan is 7/100 = 0.07, or 7%.

- If you deposit $100 in a savings account that pays 6% compounded annually, at the end of 1 year you have $100(1.06) = $106.

Question: interest rate

- You put € 100 into a savings account for 3 years. The account pays 5% interest during the first year, 3% during the second, and 4% during the third. At the end of each year you add the interest to your account.
- How much do you have in the account at the end of the 3 years?

Question: Solution

- You put € 100 into a savings account for 3 years. The account pays 5% interest during the first year, 3% during the second, and 4% during the third. At the end of each year you add the interest to your account.
- How much do you have in the account at the end of the 3 years?

- At the end of 3 years, you have € 100*(1.05)(1.03)(1.04)* = $112.48.

Future Value

- For example,
  - if r = 0.1 then €100 saved at the start of period 1 becomes € 110 at the start of period 2.

- **The value next period of € 1 saved now is the future value of that euro.**

Future Value

- Given an interest rate $\boldsymbol{r}$ the future value one period from now of € 1 is

$$\boldsymbol{FV = 1 + r}$$

- Given an interest rate $\boldsymbol{r}$ the future value one period from now of €m is

$$\boldsymbol{FV = m(1 + r)}$$

Present Value

- Suppose you can pay now to obtain €1 at the start of next period.

- What is the most you should pay?
  - € 1?

- No.
  - If you kept your € 1 now and saved it then at the start of next period you would have €1+r > €1, so paying €1 now for €1 next period is a bad deal.

Present Value

- Q: How much money would have to be saved now, in the present, to obtain €1 at the start of the next period?

- A: €m saved now becomes €$m(1+r)$ at the start of next period, so we want the value of m for which

$$m(1+r) = 1 \text{ €}$$

That is, **m = 1/(1+r)**, **the present-value of €1 obtained at the start of next period.**

Present Value

- **The present value of €1 available at the start of the next period is**

$$\boldsymbol{PV = \frac{1}{1+r}}$$

And the present value of €m available at the start of the next period is

$$\boldsymbol{PV = \frac{m}{1+r}}$$

Exercise: Present Value

- E.g., if $r = 0.1$ then the most you should pay now for €1 available next period is

- And if $r = 0.2$ then the most you should pay now for €1 available next period is

Exercise: Present Value - solution

- E.g., if r = 0.1 then the most you should pay now for €1 available next period is

$$PV = \frac{1}{1 + 0.1} = 0.91$$

- And if r = 0.2 then the most you should pay now for €1 available next period is

$$PV = \frac{1}{1 + 0.2} = 0.83$$

Exercise : present and future value

- r = 10%
- €100 today is worth how much tomorrow?
- € 100 tomorrow is worth how much today?

Exercise : present and future value

- r = 10%
- €100 today is worth how much tomorrow?
- FV = 100 (1 + 0.1) = 110 €

- € 100 tomorrow is worth how much today?
- PV = 100 / (1 + 0.1) = 90.9 €

FV for several periods

- Suppose you leave the money in the bank for *T* years and the interest rates in decimal form for those years are *r*1, *r*2, . . . , *rT* ; then at the end of the *T* years you have a sum we'll call the future value at time *T* and denote by FV_T.

- This amount is $FV_T = PV(1 + r_1)(1 + r_2) \ldots (1 + r_T)$.

- If the interest rates are the same for all periods, that is, if r_1 = r_2 = . . . = r_T = *r*, then this formula simplifies to $\boldsymbol{FV_T = PV(1 + r)^T}$.

FV for several periods, cont.

- $\boldsymbol{FV_T = PV(1+r)^T}$

- This equation involves four variables. If we know any three, we can use the equation to compute the fourth.

- For example, if we know that *PV* = \$100, *r* = 0.05 and *T* = 3, then we can calculate $FV_3 = 100(1+0.05)^3$ = \$115.76. If the interest rate rose to 10%, we would calculate $FV_3 = 100(1.1)^3$ =\$133.10.

- More generally, the higher the interest rate, the higher the future value, given the present value.

PV for several periods, cont.

- If we know FV_T , *r*, and *T* , we can calculate *PV*:

$$\boldsymbol{PV = FV_T/(1+r)^T.}$$

- **This expression comes in handy when trying to appraise an investment that yields a payoff after *T* years.**
- For example, a bond* that will be worth $10,000 in 5 years but provides no income in the meantime has a present value of $10,000 /$(1+r)^5$. If the rate of interest on *alternative assets* is *r* = 0.06, then the present value is $10,000 / $(1.06)^5$ = $7472.58.
- **The interest rate on *alternative assets*, such as bank deposits, is the opportunity cost of holding the bond; hence that interest rate can be used to calculate the bond's present value.**
- *** A bond is a fixed income instrument that represents a loan made by an investor to a borrower (typically corporate or governmental).**

r and T calculations

- If we know *PV*, FV_T , and *T* , we can calculate *r*:

$$\boldsymbol{r = \left(\frac{FV_T}{PV}\right)^{1/T} - 1}$$

- If we know *PV*, FV_T , and *r*, we can calculate *T* :

$$\boldsymbol{T = \frac{\log\left({FV_T}/{PV}\right)}{\log(1+r)}}$$

Exercise

- How much is $1 million to be delivered 20 years in the future worth today if the interest rate is 20 percent?

Exercise

- How much is $1 million to be delivered 20 years in the future worth today if the interest rate is 20 percent?

- $PV = \frac{FV_T}{(1+r)^T} = \frac{1000000}{(1+0.2)^{20}} = 26084.05$

Exercise

1. If the asset that will be worth $10,000 in 5 years is currently selling for $7000, then investors must believe that the average annual interest rate for the next 5 years will be?

2. if we have $100 to invest at 5% and want to know how long we must wait until our investment is worth $300?

Exercise: Solution

1. If the asset that will be worth \$10,000 in 5 years is currently selling for \$7000, then investors must believe that the average annual interest rate for the next 5 years will be?

$$r = \left(\frac{10000}{7000}\right)^{1/5} - 1 = 0.0739$$

2. if we have \$100 to invest at 5% and want to know how long we must wait until our investment is worth \$300?

$$T = \frac{\log\left({}^{300}/_{100}\right)}{\log(1.05)} = 22.5$$

Net present value

- Suppose that by sinking *C*0 dollars into a project today, a firm will generate income of $\boldsymbol{FV_1}$ one year in the future, $\boldsymbol{FV_2}$ two years in the future, and so on for $\boldsymbol{n}$ years. If the interest rate is $\boldsymbol{r}$, the net present value of the project is

$$NPV = \frac{FV_1}{(1+r)^1} + \frac{FV_2}{(1+r)^2} + \frac{FV_3}{(1+r)^3} + \cdots + \frac{FV_n}{(1+r)^n} - C_0$$

Exercise NPV

- The manager of Automated Products is contemplating the purchase of a new machine that will cost $300,000 and has a useful life of five years. The machine will yield (year-end) cost reductions to Automated Products of $50,000 in year 1, $60,000 in year 2, $75,000 in year 3, and $90,000 in years 4 and 5. What is the present value of the cost savings of the machine if the interest rate is 8 percent? Should the manager purchase the machine?

Exercise NPV: solution

- The manager of Automated Products is contemplating the purchase of a new machine that will cost \$300,000 and has a useful life of five years. The machine will yield (year-end) cost reductions to Automated Products of \$50,000 in year 1, \$60,000 in year 2, \$75,000 in year 3, and \$90,000 in years 4 and 5. What is the present value of the cost savings of the machine if the interest rate is 8 percent? Should the manager purchase the machine?
- By spending \$300,000 today on a new machine, the firm will reduce costs by \$365,000 over five years. By spending \$300,000 today on a new machine, the firm will reduce costs by \$365,000 (\$50,000 + \$60,000 + \$75,000 + \$90,000 + \$90,000) over five years. However, the present value of the cost savings is only

$$\boldsymbol{PV} = \frac{\mathbf{50000}}{(\mathbf{1}+\mathbf{0.08})^{\mathbf{1}}} + \frac{\mathbf{60000}}{(\mathbf{1.08})^{\mathbf{2}}} + \frac{\mathbf{75000}}{(\mathbf{1.08})^{\mathbf{3}}} + \frac{\mathbf{90000}}{(\mathbf{1.08})^{\mathbf{4}}} + \frac{\mathbf{90000}}{(\mathbf{1.08})^{\mathbf{5}}} = \mathbf{\$254\,679}$$

- Consequently, the net present value of the new machine is
- ***NPV=PV-C0=\$254,679-\$300,000=-\$15,321*** Since the net present value of the machine is negative, the manager should not purchase the machine. In other words, the manager could earn more by investing the \$300,000 at 8 percent than by spending the money on the cost-saving technology

Exercise NPV: solution

- The manager of Automated Products is contemplating the purchase of a new machine that will cost $300,000 and has a useful life of five years. The machine will yield (year-end) cost reductions to Automated Products of $50,000 in year 1, $60,000 in year 2, $75,000 in year 3, and $90,000 in years 4 and 5. What is the present value of the cost savings of the machine if the interest rate is 8 percent? Should the manager purchase the machine?
- By spending $300,000 today on a new machine, the firm will reduce costs by $365,000 over five years. By spending $300,000 today on a new machine, the firm will reduce costs by $365,000 ($50,000 + $60,000 + $75,000 + $90,000 + $90,000) over five years. However, the present value of the cost savings is only

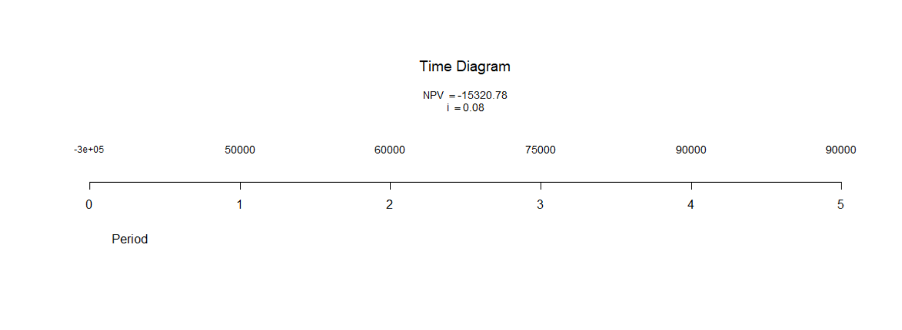
$$PV = \frac{50000}{(1+0.08)^1} + \frac{60000}{(1.08)^2} + \frac{75000}{(1.08)^3} + \frac{90000}{(1.08)^4} + \frac{90000}{(1.08)^5} = \$254\,679$$

- Consequently, the net present value of the new machine is
- ***NPV=PV-C0=$254,679-$300,000=-$15,321*** Since the net present value of the machine is negative, the manager should not purchase the machine. In other words, the manager could earn more by investing the $300,000 at 8 percent than by spending the money on the cost-saving technology

```
library (FinancialMath)

# NPV(cf0,cf,times,i,plot=FALSE)
# cf0 cash flow at period 0
# cf vector of cash flows
# times vector of the times for each cash
flow
# i interest rate per period
# plot tells whether or not to plot the
time diagram of the cash flows

Savings = c(50000, 60000, 75000, 90000,
90000)
i=0.08
cf0 = 300000
times = c(1,2,3,4,5)
NPV(cf0=cf0,
cf=Savings,times=times,i=i,plot=TRUE)
```



Exercise: rate of return of a house

- A house, which you could rent for $10,000 a year and sell for $110,000 a year from now, can be purchased for $100,000. What is the rate of return on this house?

Exercise: rate of return of a house. Solution.

- A house, which you could rent for \$10,000 a year and sell for \$110,000 a year from now, can be purchased for \$100,000. What is the rate of return on this house?

- The rate of return is equal to (10, 000 + 10, 000)/100, 000 = 20%.

Exercise: scarce resource

- Suppose that a scarce resource, facing a constant demand, will be exhausted in 10 years. If an alternative resource will be available at a price of $40 and if the interest rate is 10%, what must the price of the scarce resource be today?

Exercise: scarce resource

- Suppose that a scarce resource, facing a constant demand, will be exhausted in 10 years. If an alternative resource will be available at a price of $40 and if the interest rate is 10%, what must the price of the scarce resource be today?

- The price today must be $40/(1 + .10)^{10} = \$15.42$

DATA TYPES IN FINANCE

Data types in finance

- Data on different entities—workers, consumers, firms, governmental units, and so forth—for a single time period *are called cross-sectional data*
  - *Regressions (uni/multivariate, linear/nonlinear; Logit /Probit; Poisson, Negative Binomial Models (for count data); Censored Regression (tobit model); Truncated Regression, SEM, etc*
- *Time series data* are data for a single entity (person, firm, country) collected at multiple time periods.
  - Stationarity, ARMA class, GARCH class, VAR class, cointegration, spectral analysis, long memory, state-space models etc.
- *Panel data*, also called longitudinal data, are data for multiple entities in which each entity is observed at two or more time periods
- Categorical data (factor data in R),

Key Terms for Data Types

- ***Continuous***
  - Data that can take on any value in an interval.
  - *Synonyms :* interval, float, numeric
- ***Discrete***
  - Data that can only take on integer values, such as counts of the occurrence of an event .
  - *Synonyms :* integer, count
- ***Categorical***
  - Data that can only take on **a specific set of values** (such as a type of TV screen (plasma, LCD, LED, …) or a state name (Alabama,
  - Alaska, …).
  - *Synonyms :* enums, enumerated, factors, nominal, polychotomous
- ***Binary***
  - A special case of categorical with just two categories (0/1, True, False).
  - *Synonyms :* dichotomous, logical, indicator
- ***Ordinal***
  - Categorical data that has an explicit ordering (an example of this is a numerical rating [1, 2, 3, 4, or 5].
  - *Synonyms:* ordered factor

Dependent Variable

- A **dependent variable** is a variable representing the measurements or observations on a independent variable
- **dependent variable** is a variable of interest

Three “Other” Variables

- Important but usually given less attention are
  - **Control variables**
    - Circumstances or factors that (a) might influence a dependent variable, but (b) are not under investigation need to be accommodated in some manner
    - One way is to control them – to treat them as control variables
  - **Random variables**
    - Instead of controlling all circumstances or factors, some might be allowed to vary randomly
    - Such circumstances are random variables
    - More variability is introduced in the measures (that’s bad!), but the results are more generalizable (that’s good!)

Data sources (non-exhaustive)

- **Time-series:** Eurostat, Bloomberg, Thomson EIKON, Yahoo finance
- ORBIS (Account information for 300 million companies worldwide: Balance Sheets, Financial Statements, Forecasts, Profitability Ratios, Detailed Shareholders, M&A...).
- WRDS Platform offering Financial and Economic Data (Including Compustat, CRSP, Bank Regulatory, Blockholders, CBOE (Chicago Board Options Exchange), DMEF (Direct Marketing Educational Foundation), Dow Jones, Fama French Portfolios, FDIC, Federal Reserve Bank Reports, IRI, Penn World Tables, Philadelphia Stock Exchange's and SEC Disclosure of Order Execution.)
- Panel/categorical/surveys:
- Data is Plural tinyletter and associated spreadsheet
- FiveThirtyEight data archive
- Data.gov 186,000+ datasets!
- Social Explorer is a great interface to Census and American Community Survey data (much more user-friendly than the official government sites).
- Data and Story Library (DASL). (This, and more ideas from Robin Lock.)
- Jo Hardin at Pomona College has a nice list of data sources on her website.
- U.S. Bureau of Labor Statistics
- U.S. Census Bureau
- Gapminder, data about the world.
- IRE and NICAR are good resources for the types of data journalists care about. For example, Energy data sources and Chrys Wu's resource page.
- For cryptos: coin.dance, https://coinmetrics.io/community-network-data/ , https://coinmarketcap.com/ etc

RETURN CALCULATION

Return

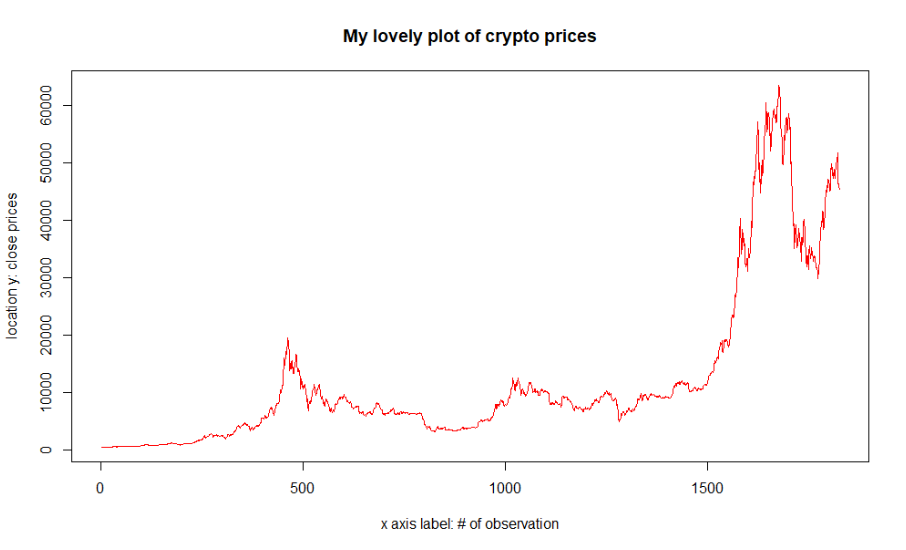
a. We can get a data file called myfile into R, and name it myfile:

```
setwd("~/R/Trinity")
mydata <- read.csv("bitcoinity_data.csv")
```

- we can access the second column with

```
second.column <- mydata[,6]
second.column <- mydata$coinbase

plot (second.column, type = "l",
main="My lovely plot of crypto prices",
xlab= "x axis label: # of observation",
ylab="location y: close prices",
col = "red") # build a graph of the close prices of bitcoin from
coinbase exchange
```



Return the First or Last Parts of an Object

```
> head (mydata) # displays the first 5 rows
                     Time    bit.x bitfinex bitstamp   cex.io coinbase     exmo   gemini    itbit   kraken   others
1 2016-11-15 00:00:00 UTC 708.8853 712.9240 711.2288 714.7271 710.6577 708.3903 712.3298 712.2873 711.8676 722.5570
2 2016-11-16 00:00:00 UTC 720.6633 725.4669 722.9638 726.0132 722.9886 719.6940 723.4332 723.8543 724.2569 763.8430
3 2016-11-17 00:00:00 UTC 742.7016 747.7031 743.2877 747.7235 742.5161 739.0355 744.0655 745.1119 745.6823 743.9310
4 2016-11-18 00:00:00 UTC 740.3813 746.9270 742.4354 749.1732 742.5540 742.4692 743.8376 744.1511 746.4147 744.0098
5 2016-11-19 00:00:00 UTC 747.3360 751.3330 748.1613 754.2156 748.3875 755.6731 749.6770 749.3322 750.8231 752.6049
6 2016-11-20 00:00:00 UTC 740.5769 742.6335 741.1980 745.8030 741.2625 747.7549 740.1922 740.2239 742.8021 742.6191


> tail (mydata) # displays the last 5 rows
                        Time bit.x bitfinex bitstamp   cex.io coinbase     exmo   gemini itbit   kraken others
1933 2022-03-01 00:00:00 UTC    NA 43668.52 43664.61 43656.82 43658.74 45130.35 43663.26    NA 43652.74     NA
1934 2022-03-02 00:00:00 UTC    NA 44096.21 44094.96 44083.48 44075.28 45795.10 44084.89    NA 44089.59     NA
1935 2022-03-03 00:00:00 UTC    NA 43135.32 43112.07 43135.59 43108.78 45062.87 43100.46    NA 43107.48     NA
1936 2022-03-04 00:00:00 UTC 42000 40950.26 40926.07 40955.70 40926.65 43102.10 40914.70    NA 40916.59     NA
1937 2022-03-05 00:00:00 UTC    NA 39183.23 39165.78 39203.55 39163.45 41611.46 39158.07    NA 39159.99     NA
1938 2022-03-06 00:00:00 UTC    NA 39040.75 39017.13 39056.81 39019.45 41829.84 39012.19    NA 39014.91     NA
> View(mydata)
```

Net Return

- Let *Pt* be the price of an asset at time *t*. Assuming no dividends, the *net return* over the holding period from time *t* − 1 to time *t* is

$$R_t = \frac{P_t}{P_{t-1}} - 1 = \frac{P_t - P_{t-1}}{P_{t-1}}$$

- The numerator $\boldsymbol{P_t - P_{t-1}}$ **is the revenue or profit during the holding period**, with a negative profit meaning a loss. **The denominator, $\boldsymbol{P_{t-1}}$, was the initial investment at the start of the holding period. Therefore, the *net return* can be viewed as the relative revenue or profit rate.**
- The revenue from holding an asset is

revenue = initial investment × net return.

- For example, an initial investment of $10,000 and a net return of 6% earns a revenue of $600.
- Because *Pt* ≥ 0, *Rt* ≥ −1 the worst possible return is −1, that is, a 100% loss, and occurs if the asset becomes worthless.

Gross Returns

- **The simple *gross return* is**

$$\frac{P_t}{P_{t-1}} = 1 + R_t$$

- For example, if Pt = 2 and P_{t+1} = 2.1, then 1 + R_{t+1} = 1.05, or 105 %, and R_{t+1} = 0.05, or 5%. **One's final wealth at time *t* is one's initial wealth at time *t*−1 times the gross return**.
- Stated differently, if X_0 is the initial at time t−1, then $X_0(1 + Rt)$ is one's wealth at time t.
- **Returns are scale-free**, meaning that they do not depend on units (dollars, cents, etc.).
- **Returns are *not* unitless. Their unit is time**; they depend on the units of t (hour, day, etc.). In this example, if t is measured in years, then, stated more precisely, the net return is 5% per year.
- The ***gross return over the most recent k periods*** is the product of the k single-period gross returns (from time $t - k$ to time t):

$$1 + R_t(k) = \frac{P_t}{P_{t-1}} = \left(\frac{P_t}{P_{t-1}}\right)\left(\frac{P_t - 1}{P_{t-2}}\right) \dots \left(\frac{P_{t-k+1}}{P_{t-k}}\right) = (1 + R_t) \dots (1 + R_{t-k+1})$$

- The k-period net return is $Rt(k)$.

Log returns

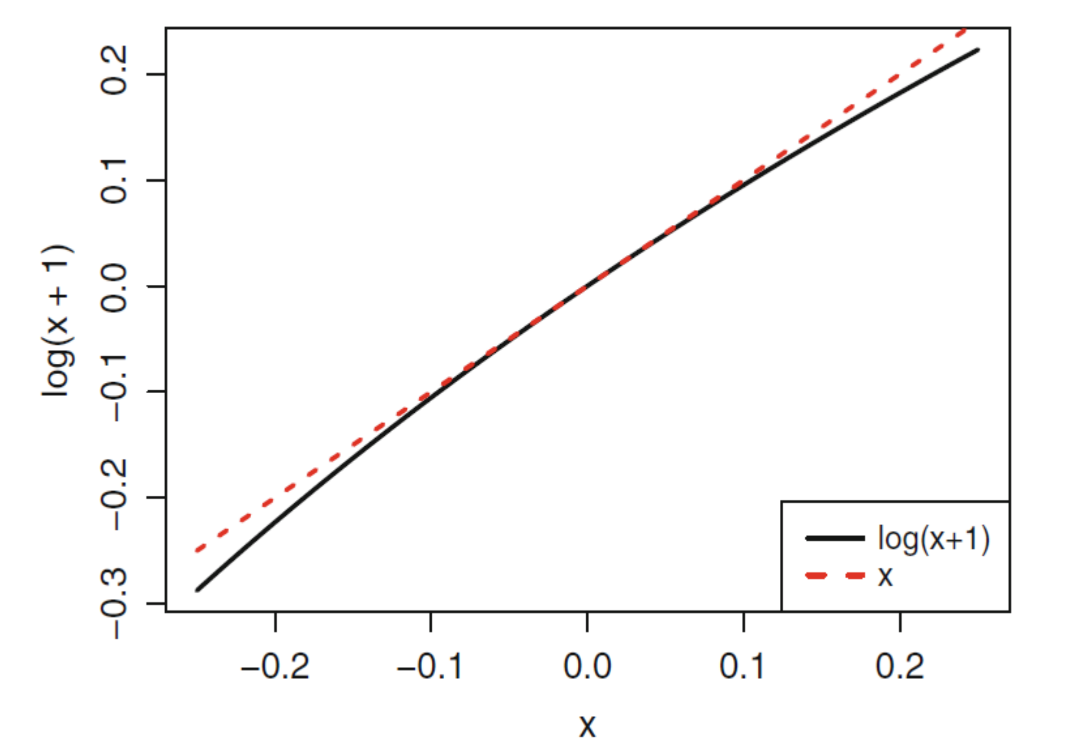
- ***Log returns***, also called ***continuously compounded returns***, are denoted by r_t and defined as

$$r_t = \log(1 + r_t) = \log\left(\frac{P_t}{P_{t-1}}\right) = p_t - p_{t-1}$$

- where $p_t = \log(P_t)$ is called the *log price*.
- **Log returns are approximately equal to returns** because if x is small, then $\log(1+x) \approx x$, as can been seen in Fig., where $\log(1+x)$ is plotted. **Notice in that figure that $\log(1 + x)$ is very close to x if $|x| < 0.1$**, e.g., for returns that are less than 10 %.

Log returns, cont

- For example, a 5% return equals a 4.88% log return since log(1+0.05) =0.0488. Also, a −5% return equals a −5.13% log return since log(1−0.05) =−0.0513. In both cases, ***rt* = log(1+*Rt*) ≈ *Rt***. Also, log(1 + 0.01) = 0.00995 and log(1 − 0.01) = −0.01005, so **log returns of ±1% are very close to the corresponding net returns**.
- **Since returns are smaller in magnitude over shorter periods, we can expect returns and log returns to be similar for daily returns, less similar for yearly returns, and not necessarily similar for longer periods such as 10 years.**
- The return and log return have the same sign. **The magnitude of the log return is smaller (larger) than that of the return if they are both positive (negative).**
- **The difference between a return and a log return is most pronounced when both are very negative. Returns close to the lower bound of −1, that is complete losses, correspond to log return close to −∞.**



Log Returns, cont.

- One **advantage of using log returns is simplicity of multiperiod returns**.
- A *k*-period log return is simply the sum of the single-period log returns, rather than the product as for gross returns. To see this, note that the *k*-period log return is

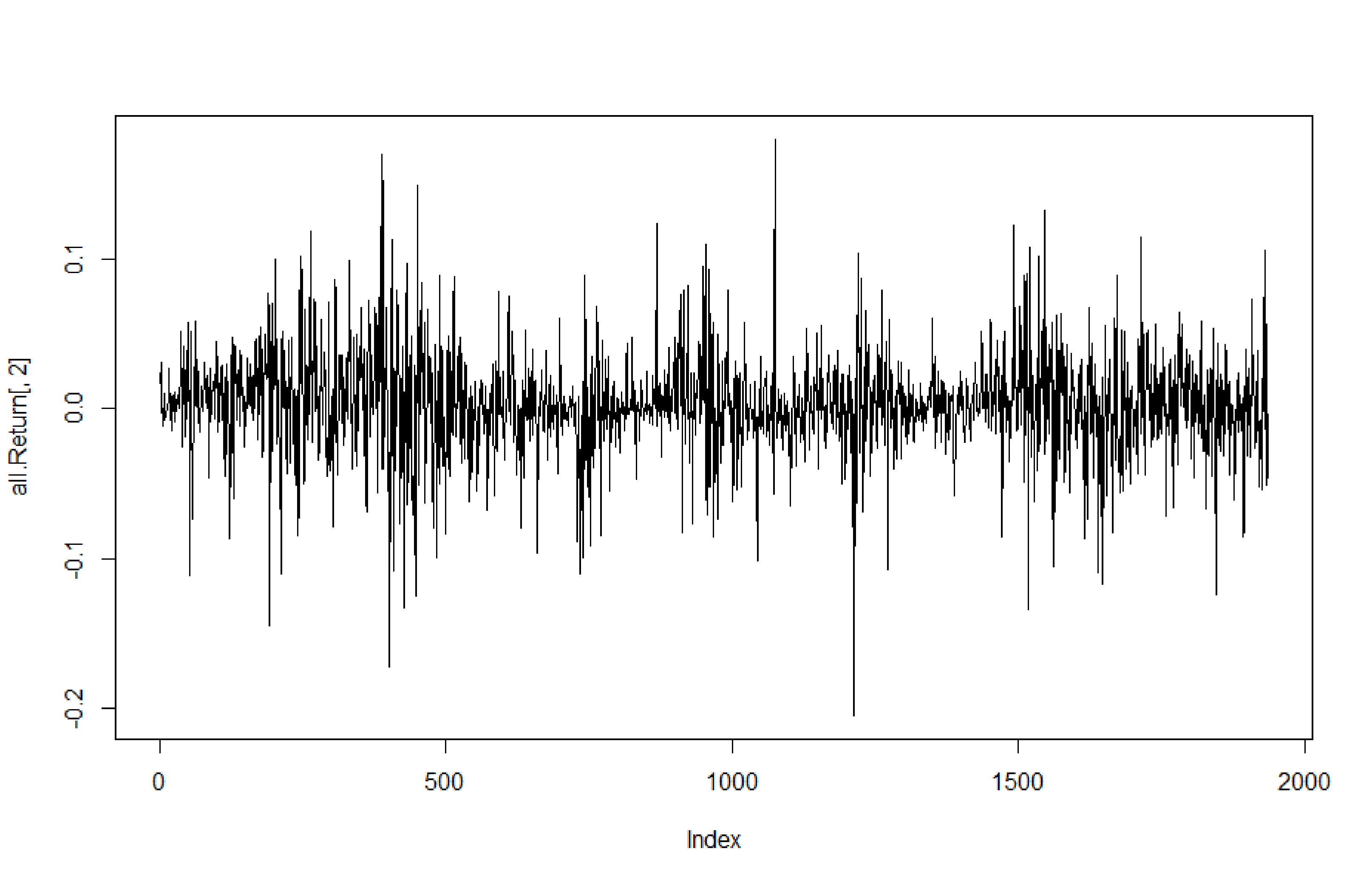
$$r_t(k) = \log\{1 + R_t(k)\} = \log\{(1 + R_t) \cdots (1 + R_{t-k+1})\} = \log(1+R_t) + \cdots + \log(1+R_{t-k+1}) = r_t + r_{t-1} + \cdots + r_{t-k+1}.$$

Exercise 1.1.

- Calculate return Rt = [Pt - Pt-1]/ Pt-1 for all the cryptocurrency exchanges. Plot them. Combine/save all the returns in one dataframe “All.Return”. Save the results into csv file All.Return.csv.
- Calculate correlation between several exchanges (cor.test)

(When you exit R, you can “Save workspace image,” which will create an R workspace file in your working directory. Later, you can restart R and load this workspace image into memory by right-clicking on the R workspace file. When R starts, your working directory will be the folder containing the R workspace that was opened. A useful trick when starting a project in a new folder is to put an empty saved workspace into this folder. Double-clicking on the workspace starts R with the folder as the working directory)

Return



Exercise 1.2. Simulations

- You probably know that hedge funds, an investment fund that trades in rather liquid assets and can apply complex trading, portfolio-construction and risk management techniques to improve performance, i.e., short selling, leverage, derivatives etc., can earn higher profits through the use of leverage (using debt rather than fresh equity). On the other hand, leverage also creates high risk due to debt counterpart).
- Let's imagine that a hedge fund owns 1000000 Euros of stock and used 50000 Euros of its own capital and 950000 Euros in borrowed money for the trading. Thus, it implies, that if the value of the stock falls below 950000 Euros at the end of any trading day, then the hedge fund will sell all the stock and repay the loan. This will wipe out its 50000 Euros of investment. The hedge fund is said to be leveraged 20:1 meaning that its position is 20 times the amount of its own capital invested.
- Suppose that the daily log returns on the stock have a mean of 0.05/year and a standard deviation of 0.23/year. These can be converted to rates per trading day by dividing by 253 and $\sqrt{253}$, respectively.
- **Problem :** *What is the probability that the value of the stock will be below 950000 Euros at the close of at least one of the next 30 trading days?*