1   Financial Assets

A **financial asset** is a legal contract between two parties, the buyer and the seller. The contract works as follows:

i. The seller writes on a piece of paper a description of future promised payments. This piece of paper is the financial asset and whatever is written codifies the terms of the legal contract.

ii. The description can be as simple or as complex as desired. For example:

   - *"pay one dollar a day until the end of this year"*,

   - *"pay one dollar a day until the end of this year if, and only if, the stock market went up the previous day"*,

   - *"on the day Greece defaults on its debt, pay one dollar, and pay nothing otherwise"*.

iii. The buyer and the seller agree on a price P.

iv. The buyer gives the seller P dollars and the seller gives the piece of paper (the financial asset) to the buyer.

v. When a payment comes due, the seller makes the payment to whomever happens to own the piece of paper at the time of the payment, be it the original buyer or a subsequent owner.

vi. If the seller does not make a payment as promised, the financial asset is said to be **in default**. Any violation of the promises, however small, triggers default. For example, default is triggered if payments are:

   • late by a single day, or

   • short by a single dollar.

   In case of default, the owner of the financial asset can take the seller to court to recover the value of the violated promises.

A **financial liability** is a contractual obligation to deliver the payments associated with a

financial asset. In the situation considered above, the seller has a financial liability corresponding to the legal obligation to make the payments promised by the financial asset it created.

Because financial contracts might specify payments from the seller to the buyer, from the buyer to the seller, or both, it is not always the case that the seller ends up with a liability and the buyer with an asset. Indeed, many financial contracts structure future payments so that no money is exchanged when the contract is signed. In this case, neither buyer nor seller can be said to have an asset or a liability. Instead, we refer to the contractual obligations of the buyer and the seller as the two **legs of the contract**.

The terms and logistics surrounding financial assets can be arbitrarily complex. A single contract can stipulate payments among more than two parties, spell out what court jurisdiction can be used in the event of default, prohibit re-selling the asset to third parties, specify what accounts must be used for payments, and so on.

Financial assets are not limited to dollar-denominated (i.e., cash) payments; they can pay off in foreign currency, gold, or even other financial assets. Therefore, when talking about financial assets, we often use the word **payoffs** rather than **payments** to highlight this generality, though both terms are largely interchangeable. When all payments are in dollars, they are usually referred to as **cash flows**.

> **Takeaway**
> - Financial assets are legal contracts defined by their payoffs.

1.1   Bonds

A bond is a financial asset. Like all other financial assets, it is a piece of paper with promises of future payoffs written on it. When a bond is created and sold for the first time, we say that the bond is **issued**.

What distinguishes bonds from other types of financial assets—what makes a bond a *bond*—is that the amount and timing of the promised payoffs are fixed at issuance. Absent default,

the sizes and dates of the payoffs are thus known with certainty from the moment the bond is issued, and they never change throughout the bond's lifetime.

Zero-coupon bonds

The simplest kind of bond is one that promises a single payment at a specified date. Such a bond is called a **discount bond** or **zero-coupon bond**. Figure 1.1(a) provides an example. The promise is for $1,000, to be paid exactly one year after the bond is issued. The promised amount of $1,000 is called the **principal**, **face value**, or **par value** of the bond. The time left until the bond pays the principal is the **maturity** of the bond. After the bond is issued, the maturity decreases as time goes by. For example, if two months pass after a one-year-maturity bond is issued, the maturity of the bond is 10 months.

Coupon bonds

Figure 1.1(b) shows a different kind of bond, a **coupon bond** (often also called a **bearer bond**). It has the same face value and maturity as the bond in Figure 1.1(a), but includes two additional promises, known as **interest payments**, **coupon payments** or simply **coupons**. Coupons are promised payments that occur at fixed intervals. Coupons can be paid before or at maturity.

In the bond of Figure 1.1(b), the first coupon is paid six months after issuance, and the second one year after issuance, concurrent with the principal. Coupons are expressed as a percentage of face value; the ratio of coupon payments to the face value is the **coupon rate**. The coupon rate is always **annualized** or **per annum**. For the bond in Figure 1.1(b), the coupon rate is 2% to be paid semiannually (two times a year, every six months). Because the 2% rate is annualized, each semi-annual payment corresponds to only 1% of face value. With a face value of $1,000, each coupon payment is $10. Together, the payments of this bond are as follows:

- a coupon of $10 six months after issuance,

- a coupon of $10 plus the $1,000 principal (i.e., $1,010 total) one year after issuance.

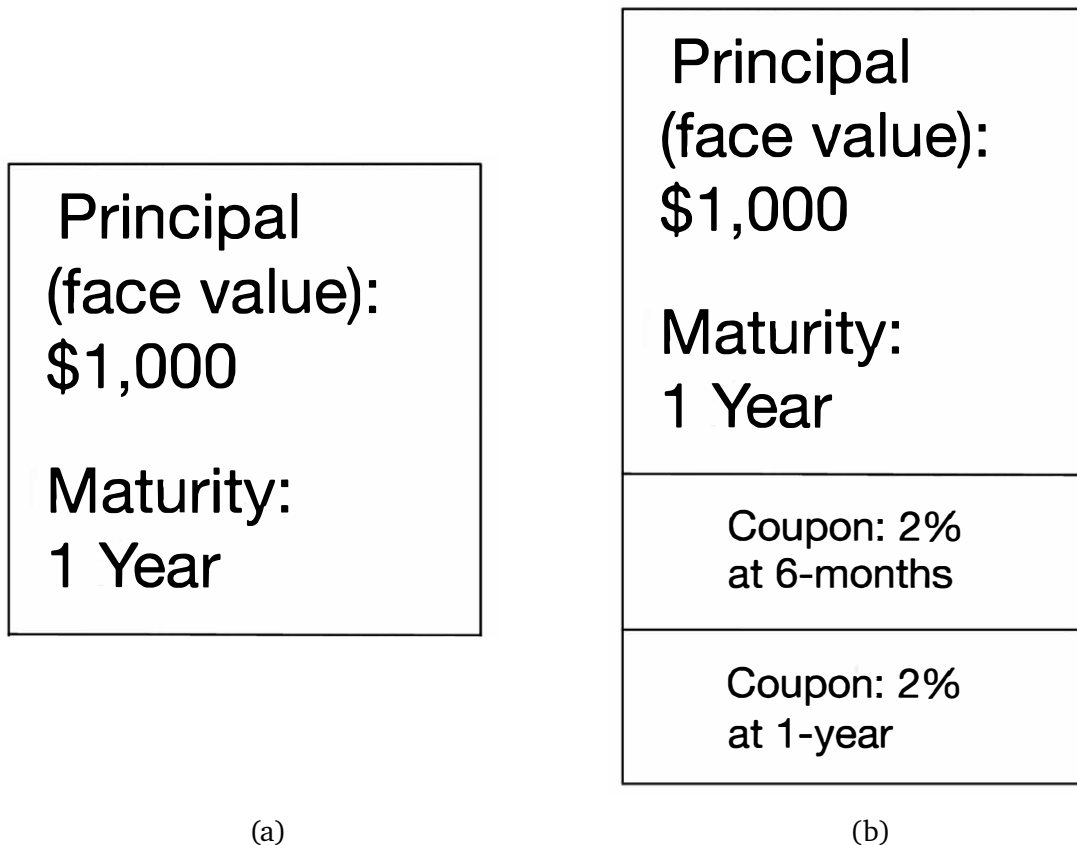|	
Principal (face value): $1,000 **Maturity: 1 Year**	**Principal (face value): $1,000** **Maturity: 1 Year**
	Coupon: 2% at 6-months
	Coupon: 2% at 1-year
(a)	(b)

Figure 1.1: Panel (a) shows a one-year-maturity zero coupon bond with a principal of $1,000. This bond has a single fixed payment of $1,000 that occurs one year after the bond is issued.

Panel (b) shows a one-year-maturity coupon bond with a principal of $1,000 and a 2% coupon rate to be paid semiannually. This bond has two payoffs of fixed size at two fixed dates. The first payment occurs six months after the bond is issued and equals $10 (an annualized coupon rate of 2% is 1% over six months, and 1% of $1,000 is $10). The second payment occurs one year after the bond is issued and equals $1,010 (the principal of $1,000 plus the second coupon of $10).

> **Takeaway**
>
> - Bonds are financial assets with fixed payments.
> - Zero-coupon bonds only pay at maturity.
> - Coupon bonds also have intermediate payments.

Bond Prices

The date and amount of a bond's payment are written on the bond and do not change when the bond changes hands. The price of the bond—the amount that the buyer pays the seller to become the owner of the bond—is *not* written on the bond.

Instead, the price is determined by supply and demand. The price can be different each time the bond is traded. Supply and demand can take different forms depending on how markets are organized. For example, there can be a single seller and a single buyer that negotiate over the price, many traders who buy and sell at a price that adjusts continuously to clear the market, or a single seller and many buyers with the price determined by an auction[1]

Bond Yields

The **interest rate** of a zero-coupon bond is the bond's rate of return until maturity. Denote the price of the bond at time t by B_t. Then the bond's interest rate at time t, denoted by R_t, is

$$R_t = \frac{\$1,000 - B_t}{B_t}. \tag{1.1}$$

The **yield to maturity** on a zero-coupon bond is the same as its interest rate; we use both terms interchangeably. Yield to maturity is often shortened to **yield**.[2]

Equation (1.1) can be solved for the bond's price B_t to get

$$B_t = \frac{\$1,000}{1 + R_t}. \tag{1.2}$$

Equations (1.1) and (1.2) allow us to convert between the bond's price B_t and yield R_t: prices and yields convey the same information. A higher price is associated with a lower yield, and a lower price with a higher yield. When we talk about bond yields, we are

---

[1]U.S. government bonds, for example, are typically sold at issuance through an auction. You can participate in these auctions yourself and buy U.S. government bonds directly from the U.S. Treasury at Treasury Direct.

[2]A bond's **current yield** is the ratio of the coupon payment to the current price of the bond. The current yield is a different concept from yield to maturity. If you see the word yield by itself, it can mean current yield or yield to maturity depending on the context.

therefore just talking about the bond's price.

Bond yields are always expressed in annualized terms. To annualize a yield, we divide the raw (non-annualized) interest rate R_t by the maturity of the bond, with maturity expressed in years. Denote the maturity of the bond at time t expressed in years by m_t. Then the annualized yield is[3]

$$\text{Annualized } R_t = \frac{R_t}{m_t}.$$

For coupon bonds, the **yield to maturity** is the bond's return if held to maturity, assuming all coupon and principal payments are made as scheduled.

Takeaway

- Bond prices and yields convey the same information.
- An increase in the price of a bond is equivalent to a decrease in the yield of the bond (and vice-versa).

Risk-free bonds

Bonds that never default are called **risk-free** or **riskless**. Of course, no bond is truly default-free. However, U.S. government bonds are generally considered very close to default-free, so treating them as riskless is a reasonable approximation in many economic applications.

The **risk-free rate** is the yield of a riskless zero-coupon bond.

The Yield Curve

On any given day, bonds of many different maturities are traded. Imagine that at time t we collect the risk-free rates of bonds with different maturities. A plot of maturities on the

---

[3]This definition assumes interest compounds continuously. An alternative choice is to compound period by period, in which case the annualized yield $R_t^{\text{annualized}}$ is defined by

$$(1 + R_t^{\text{annualized}})^{m_t} = (1 + R_t).$$

Annualized yields using continuous and period-by-period compounding are approximately equal when $R_t^{\text{annualized}}$ is not too big (say, 10%-15% or less). We use continuous compounding because calculations are easier.

horizontal axis against the associated annualized risk-free rates on the vertical axis is called the **yield curve** or the **term structure of interest rates**.

Figure 1.2 shows the yield curve derived from U.S. government bonds for three different days. Note that the different maturities on the horizontal axis are not equally spaced. For example, the distance between 1-month and 2-month is the same as the distance between 20-year and 30-year. The yield curve was upward sloping in December of 2018 (panel (a)), downward sloping in January of 2024 (panel 1.2(b)) and U-shaped in November of 2024 (panel 1.2(c)).

> **Takeaway**
>
> - Bonds that never default are called riskless.
> - The yield curve shows the interest rates of riskless bonds for different maturities.

Price Risk

Let R_{mt} be the annualized yield at time t for a zero-coupon bond with maturity m. At time t, R_{mt} is known. After all, knowing R_{mt} is the same as knowing the bond's price and, if we can buy the bond, then its price must be known!

In contrast, the future yield $R_{m,t+1}$ is *not* known at t; it is first known at time $t+1$. However, at time t we can form some expectation—a best guess—regarding what $R_{m,t+1}$ will be. We denote this **expected yield** or **expected interest rate** by $R^e_{m,t+1}$. The expected yield $R^e_{m,t+1}$ *is* known at t.

Investing $1,000 in a riskless two-year-maturity zero coupon bond at time t has payoffs of $0 at $t+1$ and

$$\$1000 \times (1 + 2R_{2t}) \tag{1.3}$$

at $t+2$.

Investing $1,000 in a riskless *one*-year-maturity zero coupon bond at time t has a payoff equal to

$$\text{payoff}_{t+1} = \$1000 \times (1 + R_{1t})$$

at $t+1$. Reinvesting payoff$_{t+1}$ at $t+1$ on new riskless one-year-maturity zero coupon bond (that matures at time $t+2$) results in a payoff equal to

$$
\begin{aligned}
\text{payoff}_{t+2} &= \text{payoff}_{t+1} \times (1 + R_{1,t+1}) \\
&= \$1000 \times (1 + R_{1t}) \times (1 + R_{1,t+1})
\end{aligned}
\tag{1.4}
$$

at $t+2$. The *expected* payoff at $t+2$ is the same as the actual payoff in Equation (1.4) but replacing the actual or **realized yield** $R_{1,t+1}$ by the expected yield $R_{1,t+1}^e$.

Reinvesting the principal payoff of a bond into a new bond of the same maturity is called **rolling over** the bond. Equation (1.4) gives the payoff of rolling over a one-year-maturity bond for two years.
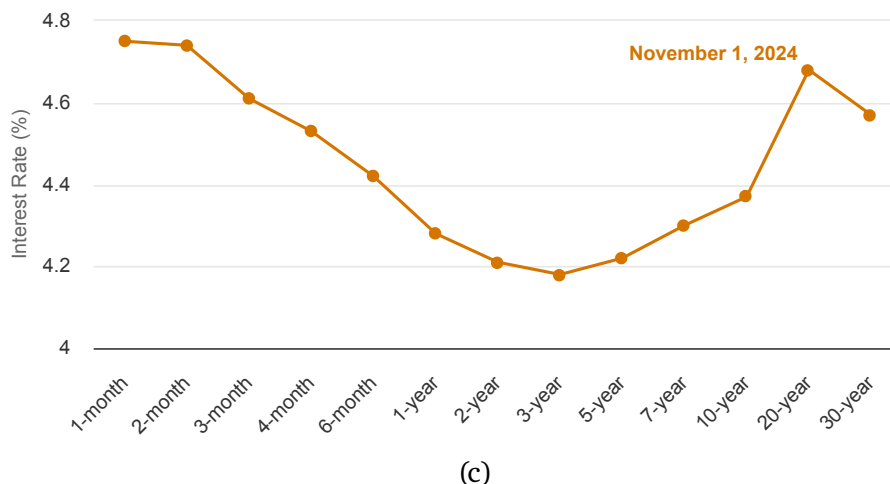
(a)

(b)

(c)
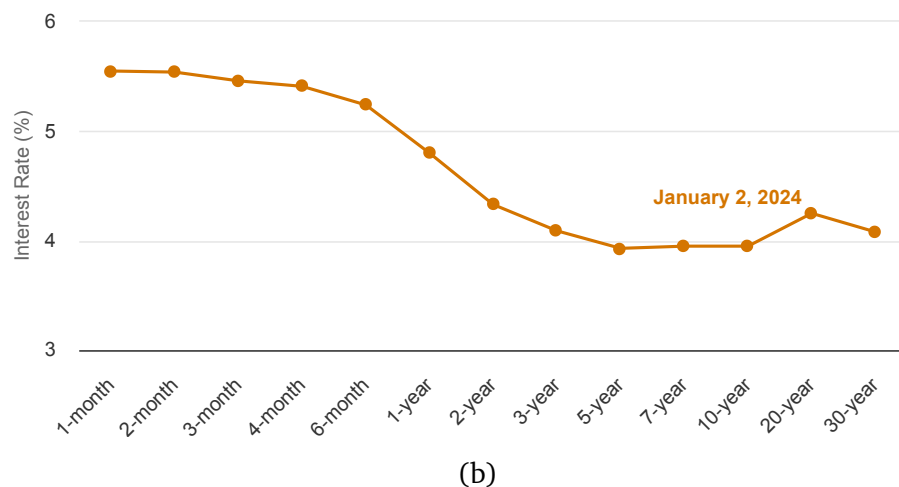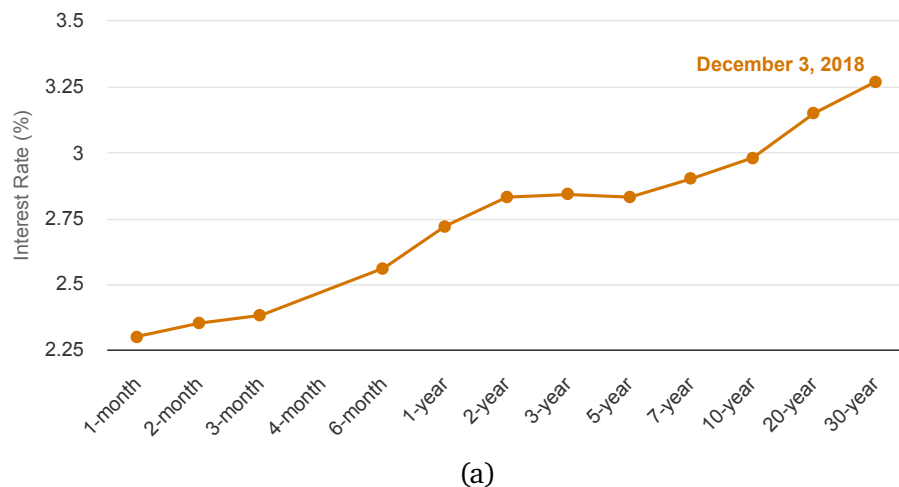
Figure 1.2: The yield curve is a plot of annualized risk-free rates as a function of maturity. The yield curves in this figure are derived from U.S. government bonds.

Panel (a) shows that the yield curve in December of 2018 was upward sloping. Panel (b) shows that the yield curve in January of 2024 was downward sloping. Panel (c) shows that the yield curve in November of 2024 was U-shaped. .

Buying the two-year bond at time t entails no risk: the payoff in Equation (1.3) is known at t. In contrast, rolling over a one-year bond for two years has a risky payoff because the future yield $R_{1,t+1}$ is not known at t. This kind of risk is called **price risk**. It is different from default risk, which is the risk that bond payments are not honored. Confusingly, risk-free bonds can have price risk.[4]

> **Takeaway**
>
> - There are two kinds of risks for bonds: default risk and price risk.
> - Default risk is the risk that payments are not honored.
> - Price risk is the risk that bond yields change in the future.

Bond Risk Premia

Equilibrium in Bond Markets Determines Risk Premia   Investors do not like risk. If buying the two-year bond and rolling over the one-year bond twice had the same expected

---

[4]Economics: Why make it easy when we can make it harder? Don't get me started about *heteroskedasticity*.

payoffs, investors would always prefer to buy the two-year bond. No one would want to hold the existing supply of one-year-maturity bonds, preventing the market for one-year bonds from being in equilibrium.

For the bond market to be in equilibrium, rolling over the one-year bond twice must have a higher expected payoff than buying the two-year bond. The difference in expected payoffs between the two options is a **risk premium**. The risk premium is the compensation for taking on the price risk associated with rolling over the one-year bond. In the context of the yield curve, the risk premium is also referred to as the **term premium**.

Mathematically, equilibrium in the bond market requires that

$$\$1,000 \times (1 + 2R_{2t}) = \$1,000 \times (1 + R_{1t})(1 + R_{1,t+1}^e) + x_2. \tag{1.5}$$

The left-hand side of Equation (1.5) is the payoff from investing in the two-year bond, taken from Equation (1.3). The right-hand side is the expected payoff from rolling over the one-year bond twice (Equation (1.4) with $R_{m,t+1}$ replaced by $R_{m,t+1}^e$), plus the risk premium x_2.

Equation (1.5) can be simplified by ignoring a small cross-term. The product on the right-hand side can be expanded as:

$$(1 + R_{1t})(1 + R_{1,t+1}^e) = 1 + R_{1t} + R_{1,t+1}^e + R_{1t}R_{1,t+1}^e.$$

If R_{1t} and $R_{1,t+1}^e$ are not too big (say, 10% or less), then the term $R_{1t}R_{1,t+1}^e$ is much smaller than the other terms. After canceling the \$1,000 from both sides, Equation (1.5) can thus be approximated by ignoring the small term $R_{1t}R_{1,t+1}^e$, which results in

$$1 + 2R_{2t} = 1 + R_{1t} + R_{1,t+1}^e + x_2,$$

or

$$R_{2t} = \frac{1}{2}(R_{1t} + R_{1,t+1}^e + x_2). \tag{1.6}$$

In words, Equation (1.6) says that the two-year yield is the average of the future path of one-year yields, plus a risk premium.

Comparing an m-year bond to rolling over one-year-maturity bonds for m periods gives the general formula:

$$R_{mt} = \frac{1}{m}(R_{1t} + R^e_{1,t+1} + ... + R^e_{1,t+m-1} + x_m). \tag{1.7}$$

Once again, the m-year yield is the average of the future expected one-year yields, plus a risk premium.

> **Takeaway**
>
> - Equilibrium requires that the yield of a long-maturity bond equals the average of future expected one-year yields, plus a risk premium.

Interpreting the Slope of the Yield Curve   When the yield curve is upward sloping, as in Figure 1.2(a), longer-maturity bonds have higher yields:

$$R_{1t} < R_{2t} < ... < R_{mt} < R_{m+1,t} < ... .$$

Using Equation (1.6), we can rewrite $R_{1t} < R_{2t}$ as:

$$R_{1t} < \frac{1}{2}(R_{1t} + R^e_{1,t+1} + x_2).$$

Rearranging gives:

$$R_{1t} < R^e_{1,t+1} + x_2.$$

Since the risk premium is positive, the last equation implies that

$$R_{1t} < R^e_{1,t+1}$$

Thus, $R_{1t} < R_{2t}$ implies $R_{1t} < R^e_{1,t+1}$.

The same reasoning applies more generally: an upward-sloping yield curve implies that short-term yields are expected to increase over time. Conversely, a downward-sloping yield curve implies that short-term yields are expected to decrease over time.

If we think of short-term yields as being determined mostly by monetary policy decisions, an upward-sloping yield curve forecasts tighter monetary policy in the future. Since tighter monetary policy is usually associated with booms (good economic times), an upward-sloping

yield curve can often be interpreted as a signal of optimism about future economic performance. Conversely, a downward sloping yield curve tends to forecast lower short-term yields, looser monetary policy, and weaker economic performance.

Although the path of short-term yields is a key determinant of longer-term yields, most of the fluctuations in the yield curve are driven by changes in risk premia.

There are two primary factors affecting bond risk premia. First, when the economic environment is more uncertain, future bond prices tend to be more volatile—or simply harder to predict. In this case, the price risk is higher, which drives up risk premia. Second, when bond investors become more risk averse, they will require a higher risk premium even if the price risk itself remains unchanged. There are many factors that can increase investors' risk aversion—financial instability, negative economic news, and a falling stock market are some of them.

> **Takeaway**
>
> - An upward-sloping yield curve indicates that short-term interest rates are expected to rise.
> - Most changes in the yield curve are driven by fluctuations in risk premia (rather than by the path of short-term interest rates).

Nominal and Real Interest Rates

The interest rates and yields we have considered thus far are all **nominal** because the bond payments are denominated in dollars.

The **real interest rate**, also called the **real yield**, is defined as the nominal interest rate minus expected inflation:

$$r_{mt} = R_{mt} - \pi^e_{mt}, \tag{1.8}$$

where r_{mt} is the real interest rate (or real yield), R_{mt} is the nominal interest rate (or nominal yield), and π^e_{mt} is the inflation rate expected to prevail between time t and time $t + m$.

The real yield is the yield on a **real bond**, which has payments specified not in terms of

dollars but in terms of the representative basket of goods (and services) of the economy. Investing an amount equal to one basket of goods in zero-coupon real bonds with maturity m at time t has a promised payoff of $(1 + r_{mt})$ baskets of goods at $t + m$.

Combining the definition of the real yield in Equation (1.8) with Equation (1.7) gives:

$$
\begin{aligned}
R_{mt} &= \frac{1}{m} \left[(r_{1t} + \pi_{1t}^e) + (r_{1,t+1}^e + \pi_{1,t+1}^e) + \dots + (r_{1,t+m-1}^e + \pi_{1,t+m-1}^e) + x_m \right] \\
&= \frac{1}{m} \left[(r_{1t} + r_{1,t+1}^e + \dots + r_{1,t+m-1}^e) + (\pi_{1t}^e + \pi_{1,t+1}^e + \dots + \pi_{1,t+m-1}^e) + x_m \right].
\end{aligned}
$$

This last equation expresses the nominal m-year yield as the average of the expected one-year *real* yields, plus the average expected inflation, plus the risk premium. It is a useful decomposition of long-term nominal yields into three parts: one from real yields, another from inflation, and a third from risk premia.

1.2   Stocks

Stocks are financial assets. Like all other financial assets, they are defined by the future payoffs they promise.

Stocks are **issued**—created and first sold—by corporations, which we refer to as firms for short. A stock promises its holder payoffs equal to a fixed fraction of the lifetime profits of the firm. The size of the fraction is determined by the total number of stocks issued. For example, if a firm has issued 100 stocks, each stock promises to pay out 1% of the firm's lifetime profits. The payments that stock owners receive are called **dividends**.

Legally, each stock represents the ownership of a fraction of the firm. Because stocks represent shares of ownership, they are also called **shares** and the people who own them are **shareholders**.

The promise to pay a share of *lifetime* profits does not mean that all profits must be paid out to shareholders immediately after profits are made. Indeed, even though all profits will ultimately be paid as dividends, stocks make no promises about when dividends will be paid or how much will be paid each time. Dividend decisions are made by each firm's board of directors, who evaluate whether reinvesting profits or distributing them as dividends will

generate greater value for shareholders.

Start-ups and fast-growing firms don't usually pay dividends. Many large, established companies pay dividends every quarter, typically a fixed percentage of the profits earned since the last dividend. Google, founded in 1998, did not pay dividends (through its parent company, Alphabet) until 2024.

1.3 Money

<u>Functions of Money</u>

When economists define money, they do not associate it with any specific object but rather with the functions it fulfills. In other words, if an object fulfills certain functions, then it is regarded as money. If it does not fulfill these functions, then it is not money.

The first function of money is **medium of exchange**. To understand this function, it helps to think about a **barter economy**. A barter economy is an economy in which no money exists and commodities are exchanged for other commodities. For example, five textbooks might exchange for one desk. Barter economies allow owners of commodities to trade for the commodities that they want, but they face one major problem that is referred to as the **double coincidence of wants problem**. For example, suppose that I have five textbooks and would like to purchase one desk. To make this trade, I need to find someone who has a desk to sell. The problem that arises for me is that this person must also want my textbooks if the trade is to occur. For our wants to exactly coincide in this manner would require a double coincidence: the desk owner wants what I have, and I want what the desk owner has.

If money is introduced into this economy, then the problem is solved. Why? Money by its nature is universally regarded as valuable. Even if the desk owner does not want my textbooks, the desk owner will be happy to accept my money because it can be used to purchase something else that the desk owner wants, such as a painting, from someone else. That is, money serves as a medium of exchange. It facilitates exchange by making possible the exchange of the desk for the painting, even though this exchange does not occur directly.

With money regarded as universally valuable, now I only need to find someone with the commodity that I wish to buy (assuming I have sufficient money to pay the price), and the problem of double coincidence of wants is solved.

The use of money as a medium of exchange increases efficiency. The time required to find someone with whom to make a trade in a barter economy is much greater than the time required in a monetary economy. Because money cuts down on the time required to find someone with whom to make a trade, that freed-up time can be used for more productive activities.

A second function that economists associate with money is its role as a **store of value**. As a store of value, money makes it possible to transfer purchasing power from the present to the future. To succeed in this role, the object must be highly durable. An object that spoils or corrodes over relatively short periods of time will not maintain its value in exchange. Precious metals are highly durable. Figure 1.3 shows that gold has historically been a good store of value over long periods of time. Milk, on the other hand, spoils after a short time, and so if wealth is held in this form, it will quickly vanish and the owner will lose all claim to future commodities.

The third function that economists associate with money is its role as **unit of account**. According to this function, money provides a standardized unit by which to measure prices. That is, money provides a gauge for measuring value. Just as we measure distance in miles, we measure prices in dollars. With a standardized unit, it becomes possible to make fine distinctions in the values of commodities. Comparisons of value are then easier to make, which aids in decision-making. The divisibility of the object is thus of crucial importance. Historically, precious metals like gold and silver have served as money. Metallic substances can be melted down, weighed, and transformed into standardized units, such as bars and coins.
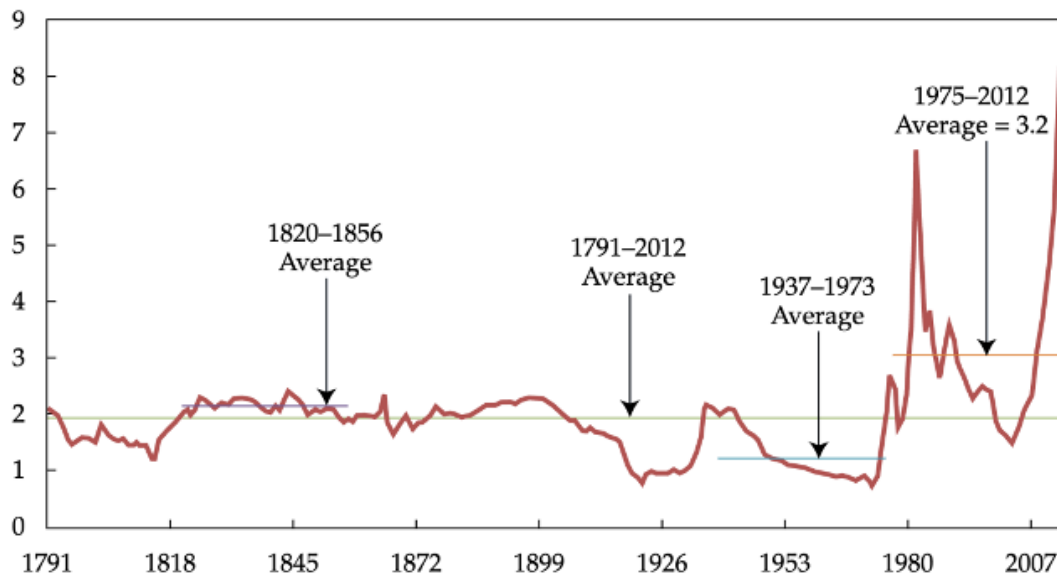
Figure 1.3: **The real price of gold 1791-2012**. The real price of gold has been relatively stable since 1791, making gold a good store of value. The real price is the nominal price (in dollars) adjusted for inflation. *Source*: Erb and Harvey (2013).

Takeaway

Money is defined by its function. Three common functions of money are:

- Medium of exchange
- Store of value
- Unit of account

Different Types of Money: From Mollusk Shells to Bitcoins

Throughout history, many different objects have fulfilled the functions of money. The form of money that was used for the longest period throughout human history is the cowrie, which is a mollusk shell found in the Indian Ocean (see Figure 1.4). For more than 2,000 years, it served as money at various times in China, India, Europe, and Africa. Many other commodities have circulated as money, including stone wheels, gold, silver, copper, salt, and cigarettes. These commodities are **commodity money**: they fulfill one or more of the functions of money while simultaneously being valuable for reasons different than their monetary role. For instance, gold has been highly prized for millennia beyond its monetary

use due to its beauty, durability, and malleability, with uses ranging from jewelry to modern semiconductors. Another example is salt. Historically, salt was valued for its essential role in food preservation and flavoring, which made it a critical commodity for daily life long before it was used as money.

Figure 1.4: The shell of *Cypraea moneta*, commonly known as the Money Cowrie, was was used as money in some parts of the world until the 19th century.

A more recent form of money is **convertible paper money**. For example, during the nineteenth century, commercial banks issued paper notes that represented claims to their gold reserves. The holder of the paper notes could use the notes to pay bills and settle debts, and the paper was "as good as gold." Many governments also started printing paper notes that represented claims to gold starting in the nineteenth century, leading to the **gold standard era**.

Since the 1970s, we now live in a world of **fiat money**, where the value of money depends solely upon the policies of the particular central bank with responsibility for it. The insight that the purchasing power of money can be completely decoupled from the value of any commodity has several deep implications.

First, it implies that the purchasing power of money can be in principle established indepen-

dent of the market price of *any* commodities, and hence independent of the market forces of demand and supply for such commodities.

Second, if the purchasing power is not determined by market forces, it then becomes a proper subject of government policy, an idea first conceived more than a century ago by economist Knut Wicksell.

Third, a policy-determined monetary standard of value allows for the possibility that, under appropriate government policy, there is greater stability in the purchasing power of money, with the potential of increased economic efficiency by, for example, facilitating contracting and market exchange. Fluctuations in the price of gold or other commodities need no longer cause unnecessary—even disruptive—variations in the purchasing power of money. If large gold deposits are suddenly discovered halfway around the world, it makes little sense for a local economy to suffer aggregate repercussions (unless, of course, gold is an important component of its productive structure).

At the same time, the institutional arrangements, goals, responsibilities, and tools of central banks are more challenging and diverse with fiat money than under a commodity standard in which central banks "only" had to maintain convertibility between paper money and the commodity backing it. Indeed, at the beginning of the fiat money era, many nations faced chronic inflation.

Another type of money that has developed with the rise of information technology is **digital currency**. The most widely known digital currency is Bitcoin. Bitcoin is the combination of a **consensus network** and a **cryptocurrency**.

The consensus network is comprised of all Bitcoin users around the world. In order for all network participants to be able to stay compatible with each other and participate in bitcoin transactions, there must be some common rules. When all network participants follow the same rules, then it is a consensus network.

Currency is the physical instantiation of money. For convertible paper and fiat money, currency consists of coins and notes. The currency part of Bitcoin consists of entries in a public ledger called **the blockchain**. The blockchain is decentralized, that is, bits and pieces of it

are stored across the Bitcoin network in a distributed fashion. The purpose of the blockchain is to record all bitcoin transactions ever made; it is a public recorded history of all bitcoin activity. The blockchain is encrypted, making Bitcoin's currency a *crypto*currency. Encryption prevents changes in transactions that have already been confirmed and recorded in the blockchain.

The process of encryption is computationally costly (and hence economically costly). In order to incentivize users to provide the computational resources needed to perform the encryption, new bitcoins are created and awarded to anyone who first completes the encryption of a number of transactions, called a block. The name blockchain denotes the sequential nature of blocks that are built one after the other.

The process of providing computational services to the network in exchange for bitcoin is called **mining**. Bitcoins are created at a decreasing and predictable rate. The number of new bitcoins created each year is automatically halved over time until bitcoin issuance halts completely with a total of 21 million bitcoins in existence. Just like fiat money, bitcoins do not give their owners the legal right to any physical asset.

> **Takeaway**
>
> There are many different types of money, including:
> - Commodity money: a physical commodity (like gold) that is used as money
> - Convertible paper money: a piece of paper that can be exchanged by a commodity
> - Fiat money: issued by a central bank, not backed by any commodity
> - Digital currency: not backed by any commodity, privately issued, electronic payments

References

Blanchard, Olivier. 2024. *Macroeconomics*. 9th ed. New York, NY: Pearson, July. ISBN: 978-0138119010. https://www.pearson.com/en-us/subject-catalog/p/macroeconomics/P200000010516/9780135343340.

Erb, Claude B., and Campbell R. Harvey. 2013. "The Golden Dilemma." *Financial Analysts Journal* 69 (4): 10–42. https://doi.org/10.2469/faj.v69.n4.1. https://www.tandfonline.com/doi/abs/10.2469/faj.v69.n4.1.

Saros, Daniel E. 2019. *Principles of Political Economy: A Pluralistic Approach to Economic Theory.* Routledge. ISBN: 9781138039186.

Woodford, Michael. 2003. *Interest and Prices: Foundations of a Theory of Monetary Policy.* Princeton, NJ: Princeton University Press. ISBN: 9780691010496.