WORLDQUANT UNIVERSITY

Financial Markets Module 3

MSc Financial Engineering

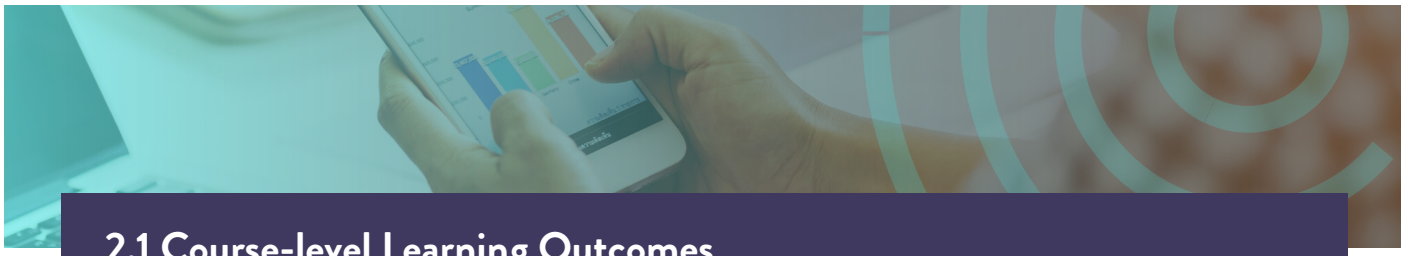
Table of Contents

1. Brief

This document contains the core content for Module 3 of Financial Markets, entitled Interest and Money Markets. It consists of four video lecture scripts, four sets of supplementary notes, and a peer review question.

2. Course Context

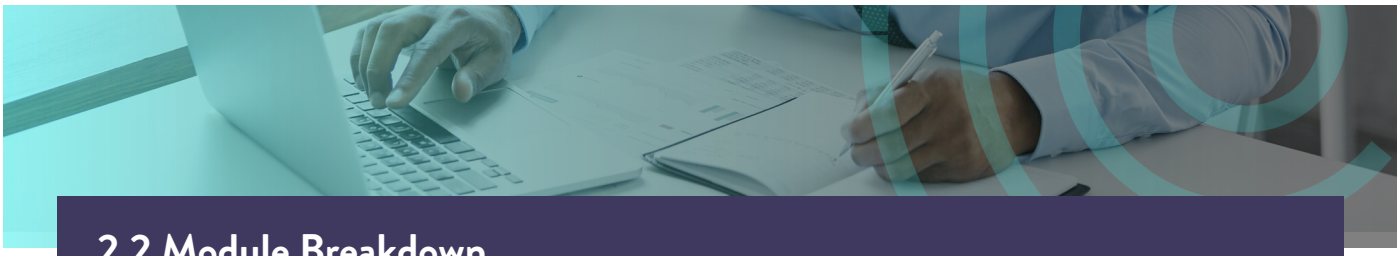
Financial Markets is the first course presented in the WorldQuant University (WQU) Master of Science in Financial Engineering (MScFE) program. The course sets the tone for the wider program, providing the context for the field of financial engineering, while introducing learners to the financial markets, analysis of market events and valuations of financial instruments.



2.1 Course-level Learning Outcomes

Upon completion of the Financial Markets course, you will be able to:

1. Describe the types and components of financial markets.
2. Identify and define the key characteristics of financial instruments.
3. Evaluate the different ways in which financial instruments can address risk.
4. Perform valuations of simple financial instruments (especially bonds and options).
5. Understand the impact of credit risk within financial markets.



2.2 Module Breakdown

The Financial Markets course consists of the following one-week modules:

1. Introduction to Financial Markets
2. Market Regulation
3. Interest and Money Markets
4. Fixed Income and Bond Markets
5. Stock and Equity Markets
6. Futures, Options and Derivatives
7. Market Making and Trading

3. Module 3

Interest and Money Markets

Beginning with a brief introduction to function of money markets, the third module will introduce you to money markets' key components, including the role players within them, and their different financial instruments. Later in the module the focus shifts to the functions these markets serve, pertinent types of risk, and methods for instrument valuation.

3.1 Module-level Learning Outcomes

Upon completion of the Interest and Money Markets module, you will be able to:

1. Understand different money market instruments.
2. Identify and assess risk associated with money market products.
3. Describe factors that affect instrument valuation.
4. Evaluate money market products, according to pricing, interest rates, and discount factors.

3.2 Transcripts and Notes

3.2.1 Transcript: Introduction to Money Markets

In previous modules we have covered the general overarching factors and principles related to financial markets. In this and future modules we will delve deeper into the details of distinct features and aspects related to the different types of financial markets. To begin, we will examine the money markets in detail.

Money markets refer to the specialized part of financial markets that facilitate borrowing and lending in the short term.

If you have ever deposited money in a bank account, you have participated in the money market! This is because whenever money is deposited into your bank account, it is effectively being lent to your bank. For the period that the bank has your money, they have control over it; meaning you cannot use it, and that they can manage these funds as they wish. Regulation, covered in the previous module, could well constrain the bank in some ways (for example, excessively risky uses of depositor money could be prohibited), but control over the money is theirs. Accordingly, when you deposit money at a bank, you give the bank the right to take your money and repay it at a later date (which happens when you withdraw it). When your money is returned (or withdrawn), you may get additional money in the form of an interest payment to compensate you for lending the bank your money.

It is important to note that this 'loan' has a very short term; even though you could leave your deposit with a bank indefinitely, you nonetheless have the right and ability to withdraw it at any time. In fact, the deposit is best thought of an overnight loan (a loan with a term of one day) that is being renewed each day that you chose not to withdraw your money.

In our example where you make bank deposits, it seems clear that anyone with surplus money to deposit can find a bank to accept and manage their money; and obviously most people would prefer a bank that offers a large amount of interest. On the other hand, banks prefer to pay customers the smallest possible amount of interest.

As you may recall from Module 1: Introduction to Financial Markets, we define a market as a centralized place of trade or exchange. Through this trading function, the money market allows the forces of supply and demand to determine interest rates. This type of exchange exemplifies an over-the-counter (OTC) transaction — instead of all the potential lenders and borrowers competing over different interest amounts simultaneously, individual lenders and borrowers (for example, yourself and your bank) deal with one another directly.

Throughout this module we will be exploring the connections between money markets and the classifications introduced in Module 1, for instance the high degree of liquidity in money markets, and the fact that money market transactions are usually very low risk. The short-term nature of lending and borrowing in the money market is instrumental in creating these two features.

So, we have a straightforward and concise definition of money markets — namely, that they are financial markets that facilitate short-term lending and borrowing — and when you deposit money in a bank account is a simple example of a transaction that takes place in these markets. In our notes, this definition and the features of money markets will be explored in greater detail.

3.2.2 Notes: The Money Market

Definition

Similar to financial markets, money markets do not have a universally agreed-upon definition and can be defined in a few different ways. It is therefore a good exercise to consider a few different definitions, paying attention to the themes that are common amongst them, and those that differentiate them. Here are three definitions that can be found from a simple internet search:

1. "…the money market is where companies, governments and banks raise money by getting short-term loans from investors."
2. "The money market is where financial instruments with high liquidity and very short maturities are traded. It is used by participants as a means for borrowing and lending in the short term, with maturities that usually range from overnight to just under a year."
3. "…the money market became a component of the financial markets for assets involved in short-term borrowing, lending, buying and selling with original maturities of one year or less."

The commonalities between these definitions are not hard to see — short-term lending and borrowing is indeed the central theme of money markets. The first definition emphasizes the types of borrowers and lenders that typically participate in the money markets — which we will pay particular attention to in a later section.

Another noteworthy aspect of these definitions, is the idea of buying and selling instruments or assets. It is important to note that money market borrowing, or lending can take place in the form of a financial instrument, which is a contract or agreement of a financial nature. Entering into such a contract gives rise to a certain asset, the asset being the right to trade under the conditions specified in the contract (which are usually cash flows to be determined in some way). Of course, a financial instrument can also give rise to a liability (an asset of negative value) from the perspective of one of the parties to the contract, if it specifies that the party must make payments instead of receiving them.

Buy and selling instruments

Depositing money in the bank is a simple financial agreement that stipulates that the money will be returned upon the client's request to withdraw it and is therefore based on a financial instrument. This creates both an asset for the depositor, and a liability for the bank. As such, depositing money into a bank account can be

viewed as both lending andmpurchasing a simple financial instrument (or thecorresponding asset). Of course, borrowing and lending can take place for terms longer than a year, which cause the underlying loans or instruments to be classified as instruments that belong to the bond (or fixed-income) markets. Comparing the long-term loans in the bond markets to the short-term loans in money markets reveals the rationale behind the term 'money markets' — as the term of the loan becomes shorter, the asset held by the lender increasingly resembles money or cash (that is, highly liquid capital that can spent immediately by its holder). In the very short-term, such as the overnight lending that takes place with bank deposits, the asset is virtually indistinguishable from cash, as the lender can simply withdraw their money if they wish to spend it.

A similar but slightly more formal money-market instrument is a certificate of deposit, where a deposit of money is formally documented in a contract which is issued to the depositor as a certificate. This certificate explicitly states the deposit agreement (the way in which the borrower will return the borrowed amount to the depositor). To buy a certificate of deposit is to give, (or in effect, lend) one's money to a counterparty; the counterparty, who are borrowing the money, are said to have sold a particular financial instrument, namely the certificate of deposit. This certificate of deposit is not strictly tied to the money market, as the instruments conditions may also specify that it can be sold on the secondary market; that is, the lender who has bought the certificate might be allowed to sell it to a third party, who would then obtain the right to receive the repayment from the borrower.

It is not surprising that money markets exist — many parties in the economy have money but do not have to spend it in the short term, and many parties do not have money available but nevertheless require it. As described in Module 1, necessity is the crucial prerequisite to financial markets, regardless of the type of market. Money markets serve the natural, economic requirement of connecting short-term lenders and borrowers, to their mutual benefit.

3.2.3 Transcript: Money Markets – Instruments and Role Players

Aside from a few special cases, a financial instrument involves two parties, and instruments in the money markets are no exception. In these cases, financial instruments are traded between two parties where one party is characterized as the lender, and the other as the borrower. These roles may even apply to cases where the loan specified by the instrument is not completely explicit.

The aforementioned parties can be individuals, businesses or other organizations, such as those introduced in Module 1: Introduction to Financial Markets, when we were examining the categories of prominent financial role players. These include organizations such as governments, central banks, investment banks, insurance companies and the like. In our example of a bank deposit, we saw that transfers to and from your bank account are effectively a financial instrument involving you and your bank as these parties. Equally, banks often lend money to each other, and can also constitute the parties involved in the trade of a money-market instrument.

As with all financial instruments, the two parties will engage in a money-market instrument transaction because they each view the arrangement as beneficial to themselves. In the money-market context, as previously mentioned, the reason that such a mutual benefit is possible, is due to the fact that some parties have money available, while other parties need money (and need it badly enough that they are willing to pay interest to borrow it).

Many financial instruments have been conceived in order to provide this mutual benefit to parties — important examples are the deposits and certificates of deposits discussed in this module. Other examples of important instruments include treasury bills, banker's acceptances, commercial paper and municipal notes, some of which have been mentioned in previous modules. What is common to all these instruments is the basic idea of lending and borrowing; with the differences between them being the details of the parties involved, and the nature of the loan.

For instance, treasury bills, often called T-bills, are financial instruments that enable short-term loans of a national government. In other words, a treasury bill is an agreement between the government (the borrower) and a lender. With treasury bills specifically, the government promises to pay the holder of the treasury bill a certain predetermined amount, known as the par value, at a specified future date, known as the bill's maturity (in money markets, the maturity is within one year of when the bill was issued).

The important take-away from this example is the loan implicit in this arrangement: a treasury bill is bought from the government, which can use the money from this purchase. However, the government must then return the par value to the buyer (the lender). The interest to be paid on the loan is also present, albeit implicitly; the purchase price of the treasury bill (determined by the forces of supply and demand in the money markets) is less than the par value itself. The difference between the purchase price and the par value should therefore be viewed as interest on the loan. In the same way that you can deposit money into the bank and withdraw it later with additional interest, so too can a buyer purchase a treasury bill and wait to receive the larger par value when it matures.

Another important feature of treasury bills to note is that the term 'bill' can refer to the physical (or electronic) document you are issued with when extending the loan, or it can refer to the loan agreement underlying the document. Extending the initial loan seems like buying the bill document, as this document can then prove you are entitled to the asset that is the promised loan repayment (in the modern era of course, there are electronic registries that take over the importance of the physical bill).

Another instrument traded in money markets, termed commercial paper, is very similar to treasury bills; the difference is that the borrower is a not a government, but a private commercial entity, such as a large company. Like governments, large companies can have a need to borrow in the short term, for example to build infrastructure or expand their operations. Therefore, they are similarly willing to pay interest, in the implicit sense we just described, to induce lenders to part with their money.

In our following set of notes, we'll take a look at a more comprehensive list of money-market instruments, along with specific details related to each.

3.2.4 Notes: Money Market – Instruments and Role Players

Here we consider the prominent money market instruments in some more detail:

Deposits

Deposits refer to an amount of money deposited into a bank (in fact, the most basic definition of a bank is an entity that accepts deposits). Typically, deposits can be withdrawn (or called) at any time the depositing party wishes — to emphasize this, they can be known as 'call deposits'.

In certain cases, deposits cannot be withdrawn immediately, but must remain with the bank for a specified period. These deposits are called term or time deposits. Connecting to the concept of liquidity presented in Module 1, call deposits are highly liquid: it is very quick and easy to convert the deposit into usable cash by simply withdrawing the deposit. Term deposits are relatively less liquid, because they cannot be easily and immediately converted to cash (although a bank may allow a term deposit to be withdrawn if a penalty amount is paid). Nonetheless, term deposits are more liquid than many other instruments traded in other financial markets (such as a ten-year loan).

Certificates of deposit

A certificate of deposit is a formalized type of term deposit, where the depositor is issued with a certificate indicating the deposit they have made, the deposit's term and the amount that will be repaid to the depositor upon maturity. One can thus think of depositing money in this way as the purchasing of a certificate of deposit. Often, certificates of deposit can be traded in secondary markets (i.e., can be traded secondarily), in which case they are sometimes called negotiable certificates of deposit.

Negotiable certificates of deposit mean that, in addition to purchasing them from a deposit-accepting bank in the way we have described (a primary purchase), one can also purchase negotiable certificates of deposit from another party who originally purchased them. Equally, a party can also sell their negotiable certificate of deposit. These types of trades involving secondary parties which occur after the original sale, or issue of the certificate, are known as secondary trades. This also means that if a certificate of deposit can be traded secondarily, its liquidity is enhanced: instead of waiting until maturity (when the deposit is returned), the holding party has the option of selling the certificate for immediate cash.

Treasury bills

Treasury bills, which are often termed T-bills, are short-term debt instruments that have been issued by a national government. Sometimes the government in question is unspecified, in which case it is assumed to be that of the United States, given the size of their government treasury and economy. As described in the previous video, treasury bills require the payment of the instrument's par value at its maturity date, the price of which is determined prior to its maturity by market forces in the money market. Thus, this feature also determines the interest associated with the underlying loan. Municipal notes are another type of instrument which is extremely similar to treasury bills; the only significant difference is that the former is issued by a local government instead of one that is national.

Commercial paper

Commercial paper refers to instruments that are also very similar in nature to treasury bills. The primary distinction between the two is that commercial papers are issued by commercial entities as opposed to national governments which issue T-bills. In this context the features of the transaction remain the same, as the commercial entity sells the instrument, which in turn obligates them to pay a specified par value at a specified maturity.

Commercial entities (and governments) can of course issue longer-term debt instruments; that is, issue these types of debt instruments but with a maturity that is in more than a year's time (in other words, they can seek longer term loans). In such cases, the instruments with a long maturity are usually termed bonds, which will be studied in greater detail in our next module. Conversely, short-term debt instruments are commonly termed notes or bills.

Despite their commonalities, there is an important difference between commercial paper issued by private entities, and government-issued treasury bills: governments have a much more robust ability to meet their obligation to pay the promised par value. This is because a commercial entity can go bankrupt at any time and have no money to repay it upon maturity; or it may be dissolved before an issued note has reached maturation. Although it is possible that a government ceases to exist in the short term, it is (usually) highly unlikely; and although governments can encounter financial distress, they always have the option of printing additional money in order to meet their obligations. Municipalities, which issue municipal notes, are typically stable and financially reliable institutions, but not to the extent that national governments are.

As you may recall from the previous module, this type of risk is known as default risk (or credit risk) and will be discussed in more detail in the next section, as it is a critical concept in finance. For now, we will pay attention to the fact that the prices of the instruments will reflect this default risk by virtue of supply and demand. For instance, an investor would typically prefer treasury bills to commercial paper of equal par value and maturity because the former has a larger probability of the par value being paid, and so treasury bills will command a higher price. At this stage, you may be able to recognize the implication: the treasury bill will have a lower interest rate than the corresponding commercial paper. This idea will be outlined and discussed later.

Banker's acceptance

A banker's acceptance is a short-term debt instrument traded in the money market and is a variation of commercial paper. With a banker's acceptance, a commercial entity still issues a note (i.e. they borrow an amount of money) that entitles the holder to a future payment of its par value. However, in the case of a banker's acceptance, even if the issuing entity fails to make its promised payment the guaranteeing bank agrees to make the payment on the issuer's behalf. This guarantee significantly mitigates the default risk of this type of instrument. A party may wish to lend money by purchasing a commercially issued note but may be unsure of the borrower's ability to pay the par value upon maturity. Therefore, the guarantee provided by the bank can enable the loan to be made, as it is typically a larger and more stable entity than the issuer.

Federal funds

Federal funds refer to overnight loans made between two banks, whereby the lending party uses the reserves that they, as a bank, are required to keep at their governing central bank. This often refers to the United States, whose central bank, as you may recall, is named the Federal Reserve. The amount of money that a bank is required to keep at the central bank changes over time and is dependent on the relevant financial regulations and their financial positions (and is thus indirectly affected by factors, such as the political climate, discussed in Module 2). If a bank has a higher reserve amount than the stipulated requirement, they could withdraw it from the central bank or keep it in reserve and lend it to another bank that needs to increase its reserves. In such cases, the money would stay with the central bank under the name of the borrowing bank. The interest rate that banks negotiate for these loans is known as the federal funds rate, which is viewed as an important indicator of the economy's wellbeing. The federal funds rate gives an indication of the general level of interest rates and also suggests how banks perceive the likelihood of other banks defaulting on their loans.

Repurchase agreements

Finally, repurchase agreements — or repos— can be viewed as a money market instruments (although they are not always classified as such). Repurchase agreements involve transactions whereby one party sells an asset that they own to their counterparty, with the agreement to buy it back (i.e. to repurchase it) at a pre-agreed time and price which is usually higher than the initial purchase price. This agreement resembles a loan: the selling party gets immediate access to the money and must repay it to the lending party with interest. Repayment in this context occurs when the borrowing party repurchases their asset, with the interest is the result of the increased repurchase-price. When viewing the arrangement as a loan, the asset that is being repurchased can be thought of as collateral underlying the loan. In effect the lender is allowed to hold onto this asset until the loan is repaid, which mitigates the default risk typically associated with loans, as the borrower forfeits the collateral in the event of default. It important to note that there can be additional complexities around repurchase agreements — such as how income or costs associated with the underlying asset are handled in the agreement; however, such considerations are beyond the scope of our current discussion.

Summary

1. Money market instruments involve a loan between two entities, albeit an implicit loan.
2. The nature of the entities affects the nature of the loan; lending money to the United States government is a very different prospect to lending money to an unknown individual.
3. Money-market instruments are relatively liquid. Even those with longer terms are limited to a year, and secondary tradability enhances this liquidity.
4. Money-market loans are typically unsecured: they usually do not involve collateral, with repurchase agreements being the exception rather than the rule. This means that the lender usually faces default risk (i.e. they stand to lose in the event that the borrower defaults). However, this default risk is relatively minor — we will shortly see how the relatively short-term nature of money-market loans ensures this.

3.2.5 Transcript: Money Market Functions and Risk

The basic function of the money market is to connect parties with available funds (potential lenders) to other parties who need funds (potential borrowers). As you may recall from Module 1, some of the general roles or functions that exist within financial markets are the lenders who are seeking a profitable investment, and the borrowers who are motivated by the need to raise capital. In the corresponding set of notes, we will elaborate further on these basic functions.

For now, let's discuss the level of risk associated with money market instruments and functions.

The low risk of short-term loan instruments

Risk is a very important theme in finance and therefore is prominently featured in this course. However, the nature of money market instruments cause these instruments to exhibit very little risk. Nonetheless, since money market instruments are loan agreements of some kind, they do of course involve risk, primarily default risk. This classification of risk pertains to the possibility that the borrower does not meet their obligation to pay the lender back. In addition to the presence of default risk, there are other types of risk associated with loans, which we will discuss in Module 4, where loans with longer terms are considered. However, the short maturities of money-market instruments minimize the potential for these risks, and also default risk, to have a significant effect. For example, the probability of a company going bankrupt in the next six months is low (especially considering that most companies have existed for many years or even decades and have avoided bankruptcy for that long) — if they issue commercial paper with maturity in six months' time, the associated risk is often very minor.

Risks present in the money markets

Money-market instruments, by their nature, have a large probability of fulfilling their function to provide one party with funds and the counterparty with compensating interest (in addition to the return of their funds). You may also recall that the forces of supply and demand will ensure that the small probability of the funds not being returned is factored into the price of the instrument. Alternatively, the probability of the funds not being returned is applied to the loan in the form of the interest rate — more details on this, and the relationship between prices and interest rates will follow.

However, there is still an important type of risk related to money-market instruments called relative performance risk (which also goes by a few different names), which can be overlooked at first sight. This type relates to the risk that alternative instruments, from alternative markets, could have fulfilled the same functions better. For instance, consider a pension fund that needs to invest their members' monthly pension payments in order to pay out the members' pensions later, which may be several decades after the payment. The pension fund could invest their members' funds in the money market and, as we've discussed, would have an excellent chance of not losing their money and of earning interest on their investment. It may appear as if there is no risk at first glance, until one realizes why riskier investments tend to suit pension fund investments better.

When investing over a very long-term horizon, the short-term variation of something like equity prices is not very problematic, and due to the long-run trend of equity, to increase above the rate of interest is highly desirable as it increases the return over the long-term. Therefore, although investing in a money-market instrument has a low risk in its own right, there are cases where an alternative investment better suits one's investment needs. Similarly, borrowing from the money market (i.e. issuing short-term debt instruments to investors) is low in risk as it will provide the required money in a predictable and reliable way, but should also be compared to alternative routes of raising funds.

Capital markets provide one of these alternative routes, wherein one can issue longer-term debt instruments (in the bond market, studied in Module 4) or issue equity (in the stock market, studied in Module 5). We will see, in these future modules, that these means of raising capital have different characteristics, which may better suit one's needs.

3.2.6 Notes: Functions and Risks of Money Markets

The lender's perspective: Make profit and manage credit risk

The function of the money market is dependent on the perspective we look at it from. From the lender's perspective, the function that the money market serves is to offer the opportunity for a profitable investment to be made. Accordingly, lenders will seek the highest interest rate possible. This function allows lenders to profit, which they would not be able to do if they kept their money in, say, their safe. Also, as we've mentioned previously, this investment is highly liquid. Therefore, if the lender suddenly requires the funds that they have invested in the money markets, it is relatively easy and fast for them to convert their investment into cash (i.e. to liquidate their investment). Another function of money markets we discussed in Module 1 was that of risk management — although this can amount to many different things in different contexts, here we should primarily note that lending in the money market can contribute to an intelligent risk management strategy, because of the reasons discussed in our video lecture; that is the low degree of inherent credit risk related to money-market instruments.

The borrower's perspective: Access funds

Conversely, from the borrower's perspective, the availability of funds from the money market serve a variety of functions, which depends on the context and the particular borrower.
For example, a company might see an opportunity to initiate a new business venture or to purchase a commodity whose price has dropped; in such a case money markets enable the company to finance their commerce and trade without incurring long-term debt. A company under financial strain might not have the funds to pay their employees' salaries, in which case the money markets can give them access to the necessary funds. Governments can also face similar, and sometimes unrelated situations that may necessitate them to access short-term funding.

The market perspective: Stabilize the banking system, finance sector and economy

The money markets also serve some more general functions beyond just serving the role-players. This is because the money market increases the amount of liquid capital within an economy, and in turn increases the stability of the banking system to the benefit of the whole finance sector and economy. This is because banks can borrow via the money markets and use these funds to avoid otherwise problematic liquidity problems.

The money market is also important for central banks, who often use the web of connections from money-market transactions to apply regulations and enact their policies, such as maintaining interest rates at a certain level.

Risk in money markets

In our previous video, we discussed how certain qualities of money-market instruments ensure that they have a high probability of fulfilling their intended functions for both the lender and borrower and are thus relatively low in risk for both parties. Since the maturities of money market loans are over the short term, there is only a small probability that an entity will become unable to meet their promised loan obligations; a problem that may arise when longer-term instruments mature.

While it is possible for an entity's financial standing to deteriorate suddenly, it is typically a gradual and discernible process. As you may recall from previous modules, financial markets tend to be efficient; as any information about an entity's standing becomes available, it is incorporated into market prices for everyone to see. It is important to note that it is also extremely unlikely for an entity to choose to not meet their obligations because they have in fact every incentive to meet their obligations if at all possible. Wherever this is not the case, the market will be reluctant to purchase the entity's instruments in the future, causing the cost of borrowing for the entity to increase drastically, and in extreme cases make borrowing impossible.

While the default risk in money-market instruments is relatively low, as we have already seen supply and demand and market efficiency will causes prices to reflect any default risk that market participants perceive.

For instance, consider a treasury bill that promises to pay the holder 100 units of currency in 3 months' time. The money market will determine the current price of this bill, and if, for example, its market value seems lower than it should be, investors will rush to enter what they view as a good investment opportunity, and demand will drive the price up. Now let's suppose the market settles on a price of 98 for the treasury bill, and therefore you purchase a bill for 98, and after 3 months, the government will repay your 98 units of currency, plus 2 units as interest. This should be seen as compensation for the fact that you (as the investor) had to forgo the use of your money for the 3-month period.

Now, after you've been reimbursed, you consider investing in commercial paper issued by a small company, in particular, one that is not directly comparable to the treasury bill. The commercial paper promises a repayment of 100 units of currency in 3 months' time. As before, the market forces will determine the current price of the instrument, and because there is some probability that the company will run into financial distress in the next while, the price will be less than 98. This is because the note is a less desirable investment than the treasury bill, and therefore its market-going price settles at a lower price of 97. Now you decide to purchase the note for 97 and then, assuming the entity does not default, you will receive your 97 units of currency back in 3 months, along with 3 additional units. These 3 units again should be seen as the usual interest-rate compensation, in addition to compensation for bearing the minor degree of default risk. Therefore, in this second case, you are also compensated for the possibility that the issuing entity does in fact default and will not meet their obligation to repay you the obligatory 100 units.

Conclusions about risk

In conclusion, money-market instruments provide relatively low risk investments, although there can be some degree of default risk dependent on the issuing entity's financial standing. Nonetheless the short-term maturity of money-market instruments make the potential default risk less significant than it could be. Liquidity risk may also be associated with certain instruments traded in money markets, whereby it may be difficult or impossible to convert the instrument to cash immediately. This can be minimized in some cases, but not completely eliminated in all, as one can avoid instruments that are not allowed to be traded secondarily, but not instruments that are tradeable but do not have any interested buyers. However, this is a minor factor relative to instruments from other markets, which have a greater degree of liquidity risk associated with them.

Despite the apparent lack of or, more factually, the minor degree of risk associated with money-market instruments, it is of critical importance to always compare money-market instruments with alternatives from other markets. In other words, one must assess the relative performance risk that can be present, particularly in the context of long-term horizons, because other instruments might be preferable. Despite these alternatives typically being regarded as carrying more risk, they may nevertheless be more suitable to particular contexts.

It is important to recall the idea of risk premiums here, which we discussed in Module 1; riskier investments tend to perform better on average in terms of compensation for investors, who bear the risk of the larger variation of potential outcomes.

Sometimes, this risky variation is not problematic for particular investment contexts; for example, the daily fluctuations of stock prices is not problematic when investing over a thirty-year horizon. In such long-term cases, earning the corresponding risk premium can be attractive as it amounts to more profit, and therefore forgoing it by investing exclusively in money-market instruments might be a sub-optimal strategy. In other words, relative performance risk might be present.

In the next video, we will begin developing a formal framework that will allow us to express the interest rate earned from investing in a particular investment (or, equivalently, the interest rate paid by the issuing entity).

3.2.7 Transcript: Instrument Valuation in Money Markets

We're going to start today's video with an example to demonstrate some of the features related to instrument valuations in money markets. In this example you deposit 100 units of currency for a 3-month period and are promised a return of 102 units. At the same time, your friend deposits 1000 units, also for 3 months, and must therefore receive 1020 units in return.

What we can see here is that there is consistency across deposits, and indeed across all instruments in the money market. The consistency is not in terms of the amount of interest that is earned, as according to our example you have earned 2 units on interest, whereas your friend has earned 20 units. The important consistency between these investments is that both deposits have grown at the same rate: they have both increased by exactly 2 percent. Despite having different starting amounts and returns, the interest rate earned on both investments was equal. The interest rate is simply the return that is promised to a lender of money, and therefore is closely related to a rate of return on an investment.

In practice, there are certain factors that could affect this consistency, for instance fees in some form. In such cases a bank might offer an interest rate of 5% on deposits, but only to accounts with a balance exceeding a certain threshold. In effect, this would mean the bank is charging fees on their small account holders; which is likely because they face the same administrative and logistical costs but raise less funds for them to use.

Nonetheless, this matter of consistency in the rate of return is very clear and natural in the case of a bill or note, where one can vary the number of instruments you purchase. If you invest in double the number of notes, the amount of interest you earn will double, but the rate of increase from your initial investment will be the same. This consistency is a matter of market efficiency. This concept was introduced in Module 1: if two otherwise equivalent instruments are offered at different rates, investors would rush to the invest in the instrument with the larger rate of increase. Supply and demand would then force the two rates to be equal (this mechanism will become clearer in a moment, when we discuss how prices and interest rates are related).

In addition to removing the scale, an interest rate (or a return) makes a correction based on the amount of time for which the underlying loan was made. Although your investment and your friend's each grew by 2 per cent, one should not say that the interest rate is 2 per cent, because this does not take into account the 3-month duration of the deposit; meaning it is only comparable to other investments with a term of three months.

Without correcting for this, the rate of increase would not be comparable to the rate of increase over different investment or loan horizons.

So, an interest rate is just a certain way of expressing the way money increases from the beginning of a loan until the larger amount is paid back. This may be the increase from an initial deposit to the final amount the deposit account. Alternatively, in the context of a bill or note, an interest rate can be the increase from the purchase price to the par value that is paid at maturity. Suppose a bill promises to pay 100 units at maturity; the market will then decide its current price. If this price is low, then there will be a large increase of value between now and maturity, when the value is 100 units (i.e. the interest rate is large), and inversely, if the price is high, the interest rate is low.

Bills and notes are sometimes called discount instruments, because their terms specify the future par value and allow the market to determine a lower price than the current one. The process of going from the par value to the lower current price is known as discounting, which essentially means applying interest backwards in time. For discount instruments, the current price dictates the interest rate (or the rate of discounting) since prices and interest rates are linked. One could also use this link in the other direction: if you knew the interest rate, you could use it to imply the current price. It is often more convenient to work with interest rates, because, as we've mentioned, they correct for the amount invested and for the time horizon, and thus make the interest rate of different instruments easy to compare. In the corresponding set of notes, we will explore the formal details for how this is done.

3.2.8 Notes: Prices, Interest Rates and Discount Factors

To start, let's consider a loan, which can be in the form of a deposit, a bill or any other money-market instrument. For this loan, an initial amount represented by X_0 is lent for a period T. For instance, X_0 could be the purchase price of a bill.

Here, T represents the length of the loan in years (e.g., the amount of time between the purchase of a bill and its maturity). If a loan is 3 months long, we would have T=0.25, as it is a quarter of a year.

Suppose that the promised repayment at time T is denoted X_T. This specification is at the core of the loan agreement, indicating how much is lent, for how long, and the amount repaid at the end. One could view this payment X_T as the repayment of the initial loan X_0 as well as an interest payment of $X_T - X_0$.

It is important to note that some loans have more complicated repayment structures (involving more than one repayment at the end), but these are not important in the money market and are not considered in this module.

Effective interest rate

The simplest interest rate one can define, called an effective interest rate over the period T, is just the rate of increase. The effective interest rate is the increase from the initial loan amount, X_0, to the final amount, X_T, relative to X_0.

$$r_e = \frac{X_T - X_0}{X_0} \tag{1}$$

Dividing by the initial loan amount removes the scale of the investment, so that the growth $X_T - X_0$ is not considered itself but is considered relative to the size of the loan. However, it does not correct for the length of the loan.

Annual effective interest rate

We can calculate another type of interest, called the annual interest rate or the annual effective interest rate, that does make this second correction. The annual effective rate is simply a way to describe how an investment has increased, however it is a more intelligent way than the effective interest rate, because it corrects for both the investment or loan's size, and its duration. This type of interest is calculated according to the formula in Equation (2):

$$r = \left(\frac{X_T}{X_0}\right)^{\frac{1}{T}} - 1 \tag{2}$$

There is important logic behind the definition of this term. The annual interest rate applies over the period of one year, as the name suggests. This means that T=1 (and therefore that $X_T = X_1$), denoting the annual increase you will get on one's money.

$$X_1 = X_0(1 + r) \tag{3}$$

If T=2 (i.e. if the period of investment was two years), the annual interest rate would need to be applied twice. This is to reflect that in the first year, X_0 (the initial investment) grows as per the above equation, but then this amount (including the increase from the first year's interest) increases similarly in the second year.

$$X_2 = X_0(1 + r)(1 + r) = X_0(1 + r)^2 \tag{4}$$

Accordingly, we then get the following expression for a general time period T, meaning that we can assign any value to T to reflect any period we want to consider.

$$X_T = X_0(1 + r)^T \tag{5}$$

We can then rearrange the formula in Equation (5) to get the formula in Equation (2). Note that Equation (2) coincides with equation 1 when T=1; in this special case, the effective interest rate already applied to an annual duration and does not need any further adjustment to apply to one year.

Calculating the annual effective interest rate enables us to compare different money market investments.

To demonstrate this, let's imagine you want to purchase one of two bills:

1. Bill 1 costs 2450 and will reach maturity in 3 months with a par value of 2500.
2. Bill 2 costs 1922 and will reach maturity in 6 months with a par value of 2000.

Upon hearing these prices, you calculate the interest payment using $X_T - X_0$ and see that these bills involve interest payments of 50 and 78, respectively. However, you cannot immediately say how the effective interest rate fares relative to the different periods. This can be done by calculating the annual effective interest rate using the formula in Equation (2):

For bill 1: $r = \left(\frac{2500}{2450}\right)^{\frac{1}{0.25}} - 1 = 0.08416578473$

For bill 2: $r = \left(\frac{2000}{1922}\right)^{\frac{1}{0.5}} - 1 = 0.08281241032$

Here we see that the annual interest rates offered by the two bills are 8,417% and 8,281%, respectively.

If we assume that default is not a material factor for this exercise, we see that the first bill offers a slightly better annual return on investment even though the gross amount of profit is less. The decreased gross amount of profit is more than compensated for by the short period of time that one's money is lent for (which would enable you to re-lend your money after 3 months and continue to earn interest in a further loan).

This points to the inverse relationship between initial prices and interest rates, which is important to note. To demonstrate this, let's consider a fixed repayment value, wherein a bill always pays 100 units in T-years' time, so we can set X_T=100. If we were to apply the formula in Equation (2), we would see that a larger value for X_0 results in a smaller annual interest rate while a smaller X_0 results in a larger rate.

To ensure that you are comfortable with calculating the annual effective interest rate, it is a good idea to consider multiple examples of the two bills and experiment with different initial prices for the bills.

Discount factor

Another way to describe this situation is to say that the future amount X_T is discounted according to the interest rate. The quantity can be called a discount factor, and it is the amount that the future amount needs to be multiplied by in order to get the initial value. The discount factor can be calculated using Equation (6):

$$(1+r)^{-T} \tag{6}$$

Like before, a larger interest rate results in a smaller discount factor, which indicates a greater decrease from the future value. Therefore, we again see the inverse relationship whereby a large interest rate results in a small initial price, and vice versa. Although we will largely ignore default for the remainder of these notes, recall how default risk — if perceived by the market — will reduce the price of a note or bill (via the usual forces of supply and demand); note that this price reduction corresponds to an increase in the interest rate. Remember that interest rates are just a language for expressing how a loan investment increases — the possibility of default is compensated for by a lower price, or, to say this same thing in different language, a higher interest rate. The increase in the interest rate when going from a default-free to a default-risky loan is known as a spread, which we study more specifically in Module 4.

The formula for calculating annual effective rate presented in Equation (2) is just one way — one language — to describe the increase in the loan investment (or, equivalently, the interest charged on the loan). There are other so-called interest-rate (or discounting) conventions.

Annual effective interest rate with periodic compounding

An important convention is the n-compounded annual interest rate, expressed as:

$$r_{(n)} = n\left(\frac{X_T}{X_0}\right)^{\frac{1}{nT}} - n \tag{7}$$

In Equation (3), we considered interest being applied each year, for some total number of years. Interest can instead be applied — or compounded — more often. If it were compounded twice a year, equation 3 would need to be adjusted to:

$$X_1 = X_0(1+\frac{r_{(2)}}{2})(1+\frac{r_{(2)}}{2}) = X_0(1+\frac{r_{(2)}}{2})^2 \tag{8}$$

You may notice that the interest rate is divided by 2 in this equation (i.e. $\frac{r_{(2)}}{2}$) — this new rate is still annual, it is just compounded more often. Instead of applying r once, we cut it in half and apply it twice. The number n is known as a compounding frequency and is sometimes given in qualitative terms.

For example, you may hear something like "12% p.a. compounded monthly", where "p.a." means per annum – confirming we are discussing annual rates; and "compounded monthly" indicates that we can apply Equation (7) if we set $n = 12$.

Note that an increased compounding frequency, all other things equal, will increase the final amount of the loan (for example, 12% p.a. compounded monthly end up charging more interest in total than 12% p.a. compounded semi-annually). This is because increased compounding involves interest being awarded to earlier interest payments. Also note that if n=1, Equation (7) is identical to Equation (2) — in other words, compounding once per year is exactly the same as giving a standard annual interest rate.

Discount rates

Another way to express interest rates are with so-called discount rates. Instead of using a rate to increase X_0 to make it equal X_T (as in Equation (5)) we can decrease X_T to make it equal X_0 using the following equation:

$$X_0 = X_T(1-d)^T \tag{9}$$

where d is known as the annual discount rate. When we add the idea of a compound period to the equation, we get the following formula for the n-compounded annual discount rate:

$$d_{(n)} = n - n(\frac{X_0}{X_T})^{\frac{1}{nT}} \tag{10}$$

Would you be able to describe the logic behind this formula in full, in other words, can you write new versions of Equation (5) and Equation (8) using Equation (9)?

The term annual discount rate (without the specification of a compounding frequency) refers to Equation (9) in which $n = 1$. Therefore, if the compounding is not mentioned, it is assumed to coincide with the annual period of the return.

Discount rates, which shouldn't be confused with discount factors, are quantitatively similar to interest rates. Suppose a deposit of 90 grows to 100 after one year, then the (annual) interest rate is 11,111%, while the (annual) discount rate is 10%. Both numbers are of similar magnitudes, and both describe the quantitative relationship between the principal value and return.

Simple annual interest rate

Yet another way to express loan returns is with a simple annual interest rate, which is calculated using the following equation:

$$r_{(s)} = \frac{1}{T}(\frac{X_T}{X_0} - 1) \tag{11}$$

These rates are called simple, is because we do not use the mathematical idea of compounding interest. Equation (11) is determined according to a straightforward mathematical expression relating X_T and X_0:

$$X_T = X_0(1 + r_{(s)}T) \tag{12}$$

This is simpler than the exponential functions involved in Equations (5) and (9).

Simple annual discount rates

Finally, we can combine simple interest rates and discount rates to define the simple annual discount rate as:

$$d_{(s)} = \frac{1}{T}(1 - \frac{X_0}{X_T}) \tag{13}$$

Certificates of deposit are often traded in terms of simple annual discount rates. This means that instead of giving the current price of the certification (X_0), the bank, broker, or dealer will specify the simple discount rate, which allows you to calculate the price (using the part value of the certification and a re-arrangement of Equation (13)).

Investors often find this more informative, because — returning to an important concept — it adjusts for the size and length of the loan, and thus makes the investment more easily comparable to alternatives.

Conclusion

All of these different types of rates may seem like an overwhelming list of formulae. Instead of attempting to memorize them, one should try to absorb the rationale behind each formula, and the different approaches taken because of their respective rationale.

In fact, there are really two main approach choices: interest-rate versus discount rate, and compound-rate vs simple-rate. If you understand these two choices, and the differences that either choice gives rise to, the formulae become much more manageable.

It is essential to consider and understand how these different types of interest rates can be used. None of what we have discussed can be used to deduce a suitable price for a money-market instrument — we are not valuing instruments in this sense (sometimes called a fundamental valuation).

Instead, what these interest rate conventions allow you to do is take an interest rate and, when we know how to apply it accurately, calculate a suitable price — the price comes from the interest rate, not out of thin air.

This can still be very useful for a host of reasons. The main reason is that — given the efficiency of the market – one can usually find the market-going interest rate. The money market prices all similar instruments so that they have the same interest rates. If interest rates are at 5% (due to some interest-rate convention), you can determine the market-related price of any given bill or note with one of the above formulae. If you are considering depositing your money, you can compare the available interest rate with the market one to determine whether you are getting good deal.

There are two important caveats — both explored in the next module — to this principle of a market-going interest rate. First, interest rates do tend to vary with the term of the underlying loan, so the interest rate used for a 3-month loan is not necessarily suitable to apply to a one-year loan (this idea is known as the term structure of interest rates). For example, the interest rate on a call deposit is different to that on a term deposit. Second, we have discussed how the possible default of a borrower is reected by a higher interest rate, and so it is not necessarily appropriate to apply the same interest rate to instruments issued by different entities. The market interest rate is often understood to refer to instruments without material default risk (such as treasury bills), which we will expand upon in later modules.