



ECONOMICS

CFA® Program Curriculum
2026 • LEVEL II • VOLUME 2

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Glossary**G-1**

How to Use the CFA Program Curriculum

The CFA® Program exams measure your mastery of the core knowledge, skills, and abilities required to succeed as an investment professional. These core competencies are the basis for the Candidate Body of Knowledge (CBOK™). The CBOK consists of four components:

- A broad outline that lists the major CFA Program topic areas (www.cfainstitute.org/programs/cfa/curriculum/cbok/cbok)
- Topic area weights that indicate the relative exam weightings of the top-level topic areas (www.cfainstitute.org/en/programs/cfa/curriculum)
- Learning outcome statements (LOS) that tell you the specific knowledge, skills, and abilities you should gain from each curriculum topic area. You will find these statements at the start of each learning module and lesson.
- We encourage you to review the information about the LOS on our website (www.cfainstitute.org/programs/cfa/curriculum/study-sessions), including the descriptions of LOS “command words” on the candidate resources page at www.cfainstitute.org/-/media/documents/support/programs/cfa-and-cipm-los-command-words.ashx.
- The CFA Program curriculum that candidates receive access to upon exam registration.

Therefore, the key to your success on the CFA exams is studying and understanding the CBOK. You can learn more about the CBOK on our website: www.cfainstitute.org/programs/cfa/curriculum/cbok.

The curriculum, including the practice questions, is the basis for all exam questions. The curriculum is selected/developed specifically to provide candidates with the knowledge, skills, and abilities reflected in the CBOK.

CFA INSTITUTE LEARNING ECOSYSTEM (LES)

Your exam registration fee includes access to the CFA Institute Learning Ecosystem (LES). This digital learning platform provides access to all the curriculum content and practice questions. The LES is organized as a series of learning modules consisting of short online lessons and associated practice questions. This tool is your source for all study materials, including practice questions and mock exams. The LES is the primary method by which CFA Institute delivers your curriculum experience. Here, you will find additional practice questions to test your knowledge, including some interactive questions.

DESIGNING YOUR PERSONAL STUDY PROGRAM

An orderly, systematic approach to exam preparation is critical. You should dedicate a consistent block of time every week to reading and studying. Review the LOS both before and after you study curriculum content to ensure you can demonstrate

the knowledge, skills, and abilities described by the LOS and the assigned learning module. Use the LOS as a self-check to track your progress and highlight areas of weakness for later review.

Successful candidates report an average of more than 300 hours preparing for each exam. Your preparation time will vary based on your prior education and experience, and you will likely spend more time on some topics than on others.

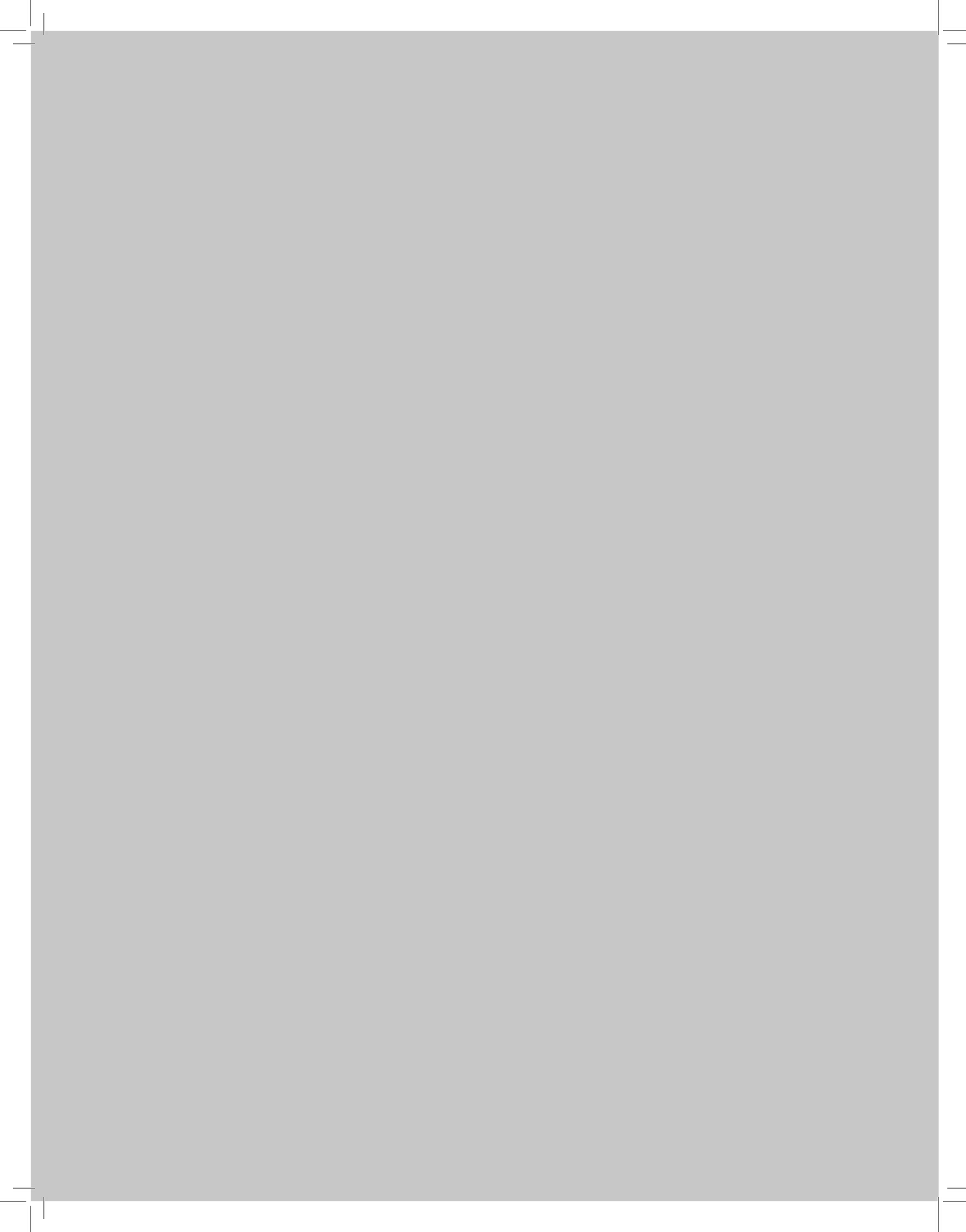
ERRATA

The curriculum development process is rigorous and involves multiple rounds of reviews by content experts. Despite our efforts to produce a curriculum that is free of errors, we must make corrections in some instances. Curriculum errata are periodically updated and posted by exam level and test date on the Curriculum Errata webpage (www.cfainstitute.org/en/programs/submit-errata). If you believe you have found an error in the curriculum, you can submit your concerns through our curriculum errata reporting process found at the bottom of the Curriculum Errata webpage.

OTHER FEEDBACK

Please send any comments or suggestions to info@cfainstitute.org, and we will review your feedback thoughtfully.

Economics



LEARNING MODULE

1

Currency Exchange Rates: Understanding Equilibrium Value

by Michael R. Rosenberg, and William A. Barker, PhD, CFA.

Michael R. Rosenberg (USA). William A. Barker, PhD, CFA (Canada).

LEARNING OUTCOMES

Mastery	<i>The candidate should be able to:</i>
<input type="checkbox"/>	calculate and interpret the bid–offer spread on a spot or forward currency quotation and describe the factors that affect the bid–offer spread
<input type="checkbox"/>	identify a triangular arbitrage opportunity and calculate its profit, given the bid–offer quotations for three currencies
<input type="checkbox"/>	explain spot and forward rates and calculate the forward premium/discount for a given currency
<input type="checkbox"/>	calculate the mark-to-market value of a forward contract
<input type="checkbox"/>	explain international parity conditions (covered and uncovered interest rate parity, forward rate parity, purchasing power parity, and the international Fisher effect)
<input type="checkbox"/>	describe relations among the international parity conditions
<input type="checkbox"/>	evaluate the use of the current spot rate, the forward rate, purchasing power parity, and uncovered interest parity to forecast future spot exchange rates
<input type="checkbox"/>	explain approaches to assessing the long-run fair value of an exchange rate
<input type="checkbox"/>	describe the carry trade and its relation to uncovered interest rate parity and calculate the profit from a carry trade
<input type="checkbox"/>	explain how flows in the balance of payment accounts affect currency exchange rates
<input type="checkbox"/>	explain the potential effects of monetary and fiscal policy on exchange rates
<input type="checkbox"/>	describe objectives of central bank or government intervention and capital controls and describe the effectiveness of intervention and capital controls
<input type="checkbox"/>	describe warning signs of a currency crisis

1**INTRODUCTION**

Exchange rates are well known to follow a random walk, whereby fluctuations from one day to the next are unpredictable. The business of currency forecasting can be a humbling experience. Alan Greenspan, former chair of the US Federal Reserve Board, famously noted that “having endeavored to forecast exchange rates for more than half a century, I have understandably developed significant humility about my ability in this area.”

Hence, our discussion is not about predicting exchange rates but about the tools the reader can use to better understand long-run equilibrium value. This outlook helps guide the market participant’s decisions with respect to risk exposures, as well as whether currency hedges should be implemented and, if so, how they should be managed. After discussing the basics of exchange rate transactions, we present the main theories for currency determination—starting with the international parity conditions—and then describe other important influences, such as current account balances, capital flows, and monetary and fiscal policy.

Although these fundamentals-based models usually perform poorly in predicting future exchange rates in the short run, they are crucial for understanding long-term currency value. Thus, we proceed as follows:

- We review the basic concepts of the foreign exchange market covered in the CFA Program Level I curriculum and expand this previous coverage to incorporate more material on bid–offer spreads.
- We then begin to examine determinants of exchange rates, starting with longer-term interrelationships among exchange rates, interest rates, and inflation rates embodied in the international parity conditions. These parity conditions form the key building blocks for many long-run exchange rate models.
- We also examine the foreign exchange (FX) carry trade, a trading strategy that exploits deviations from uncovered interest rate parity and discuss the relationship between a country’s exchange rate and its balance of payments.
- We then examine how monetary and fiscal policies can *indirectly* affect exchange rates by influencing the various factors described in our exchange rate model.
- The subsequent section focuses on *direct* public sector actions in foreign exchange markets, both through capital controls and by foreign exchange market intervention (buying and selling currencies for policy purposes).
- The last section examines historical episodes of currency crisis and some leading indicators that may signal the increased likelihood of a crisis.

2**FOREIGN EXCHANGE MARKET CONCEPTS**

calculate and interpret the bid–offer spread on a spot or forward currency quotation and describe the factors that affect the bid–offer spread

We begin with a brief review of some of the basic conventions of the FX market that were covered in the CFA Program Level I curriculum. In this section, we cover (1) the basics of exchange rate notation and pricing, (2) arbitrage pricing constraints on spot rate foreign exchange quotes, and (3) forward rates and covered interest rate parity.

An exchange rate is the price of the *base* currency expressed in terms of the *price* currency. For example, a USD/EUR rate of 1.1650 means the euro, the base currency, costs 1.1650 US dollars (an appendix defines the three-letter currency codes). The exact notation used to represent exchange rates can vary widely between sources, and occasionally the same exchange rate notation will be used by different sources to mean completely different things. *The reader should be aware that the notation used here may not be the same as that encountered elsewhere.* To avoid confusion, we will identify exchange rates using the convention of “P/B,” referring to the price of the base currency, “B,” expressed in terms of the price currency, “P.”

NOTATION CONVENTIONS

Notation is generally not standardized in global foreign exchange markets, and there are several common ways of expressing the same currency pair (e.g., JPY/USD, USD:JPY, \$/¥). What is common in FX markets, however, is the concept of a “base” and a “price” currency when setting exchange rates. We will sometimes switch to discussing a “domestic” and a “foreign” currency, quoted as foreign/domestic (f/d). This is only an illustrative device for more easily explaining various theoretical concepts. The candidate should be aware that currency pairs are not described in terms of “foreign” and “domestic” currencies in professional FX markets. This is because what is the “foreign” and what is the “domestic” currency depend on where one is located, which can lead to confusion. For instance, what is “foreign” and what is “domestic” for a Middle Eastern investor trading CHF against GBP with the New York branch of a European bank, with the trade ultimately booked at the bank’s headquarters in Paris?

The spot exchange rate is usually used for settlement on the second business day after the trade date, referred to as *T + 2* settlement (the exception being CAD/USD, for which standard spot settlement is *T + 1*). In foreign exchange markets—as in other financial markets—market participants are presented with a two-sided price in the form of a bid price and an offer price (also called an ask price) quoted by potential counterparties. The bid price is the price, defined in terms of the price currency, at which the counterparty is willing to buy one unit of the base currency. Similarly, the offer price is the price, in terms of the price currency, at which that counterparty is willing to sell one unit of the base currency. For example, given a price request from a client, a dealer might quote a two-sided price on the spot USD/EUR exchange rate of 1.1648/1.1652. This means that the dealer is willing to pay USD 1.1648 to buy one EUR and that the dealer is willing to sell one EUR for USD 1.1652.

There are two points to bear in mind about bid–offer quotes:

1. *The offer price is always higher than the bid price.* The bid–offer spread—the difference between the offer price and the bid price—is the compensation that counterparties seek for providing foreign exchange to other market participants.
2. *The party in the transaction who requests a two-sided price quote has the option (but not the obligation) to deal at either the bid (to sell the base currency) or the offer (to buy the base currency) quoted by the dealer.* If the party chooses to trade at the quoted prices, the party is said to have either “hit the

bid" or "*paid the offer*." If the base currency is being sold, the party is said to have hit the bid. If the base currency is being bought, the party is said to have paid the offer.

We will distinguish here between the bid–offer pricing *a client receives from a dealer* and the pricing *a dealer receives from the interbank market*. Dealers buy and sell foreign exchange among themselves in what is called the interbank market. This global network for exchanging currencies among professional market participants allows dealers to adjust their inventories and risk positions, distribute foreign currencies to end users who need them, and transfer foreign exchange rate risk to market participants who are willing to bear it. The interbank market is typically for dealing sizes of at least 1 million units of the base currency. Of course, the dealing amount can be larger than 1 million units; indeed, interbank market trades generally are measured in terms of multiples of a million units of the base currency. Please note that many non-bank entities can now access the interbank market. They include institutional asset managers and hedge funds.

The bid–offer spread a dealer provides to most clients typically is slightly wider than the bid–offer spread observed in the interbank market. Most currencies, except for the yen, are quoted to four decimal places. The fourth decimal place (0.0001) is referred to as a "pip." The yen is typically quoted to just two decimal places; in yen quotes, the second decimal place (0.01) is referred to as a pip.

For example, if the quote in the interbank USD/EUR spot market is 1.1649/1.1651 (two pips wide), the dealer might quote a client a bid–offer of 1.1648/1.1652 (four pips wide) for a spot USD/EUR transaction. When the dealer buys (sells) the base currency from (to) a client, the dealer is typically expecting to quickly turn around and sell (buy) the base currency in the interbank market. This offsetting transaction allows the dealer to divest the risk exposure assumed by providing a two-sided price to the client and to hopefully make a profit. Continuing our example, suppose the dealer's client hits the dealer's bid and sells EUR to the dealer for USD 1.1648. The dealer is now long EUR (and short USD) and wants to cover this position in the interbank market. To do this, the dealer sells the EUR in the interbank market by hitting the interbank bid. As a result, the dealer *bought* EUR from the client at USD 1.1648 and then *sold* the EUR in the interbank for USD 1.1649. This gives the dealer a profit of USD 0.0001 (one pip) for every EUR transacted. This one pip translates into a profit of USD 100 per EUR million bought from the client. If, instead of hitting his bid, the client paid the offer (1.1652), then the dealer could pay the offer in the interbank market (1.1651), earning a profit of one pip.

The size of the bid–offer spread quoted to dealers' clients in the FX market can vary widely across exchange rates and is not constant over time, even for a single exchange rate. The size of this spread depends primarily on three factors:

- the bid–offer spread in the interbank foreign exchange market for the two currencies involved,
- the size of the transaction, and
- the relationship between the dealer and the client.

We examine each factor in turn.

The size of the bid–offer spread quoted in the interbank market depends on the liquidity in this market. Liquidity is influenced by several factors:

1. *The currency pair involved.* Market participation is greater for some currency pairs than for others. Liquidity in the major currency pairs—for example, USD/EUR, JPY/USD, and USD/GBP—can be quite high. These markets are almost always deep, with multiple bids and offers from market participants around the world. In other currency pairs, particularly some of

the more obscure currency cross rates (e.g., MXN/CHF), market participation is much thinner and consequently the bid–offer spread in the interbank market will be wider.

2. *The time of day.* The interbank FX markets are most liquid when the major FX trading centers are open. Business hours in London and New York—the two largest FX trading centers—overlap from approximately 8:00 a.m. to 11:00 a.m. New York time. The interbank FX market for most currency pairs is typically most liquid during these hours. After London closes, liquidity is thinner through the New York afternoon. The Asian session starts when dealers in Tokyo, Singapore, and Hong Kong SAR open for business, typically by 7:00 p.m. New York time. For most currency pairs, however, the Asian session is not as liquid as the London and New York sessions. Although FX markets are open 24 hours a day on business days, between the time New York closes and the time Asia opens, liquidity in interbank markets can be very thin because Sydney, Australia, tends to be the only active trading center during these hours. For reference, the chart below shows a 24-hour period from midnight (00:00) to midnight (24:00) London time, corresponding standard times in Tokyo and New York, and, shaded in grey, the *approximate* hours of the most liquid trading periods in each market.

Standard Time and Approximate FX Trading Hours in Major Markets: Midnight to Midnight (London Time)							
Tokyo	09:00	13:00	17:00	21:00	01:00 Day+1	05:00 Day+1	09:00 Day+1
London	00:00	04:00	08:00	12:00	16:00	20:00	24:00
New York	19:00 Day-1	23:00 Day-1	03:00	07:00	11:00	15:00	19:00

3. *Market volatility.* As in any financial market, when major market participants have greater uncertainty about the factors influencing market pricing, they will attempt to reduce their risk exposures and/or charge a higher price for taking on risk. In the FX market, this response implies wider bid–offer spreads in both the interbank and broader markets. Geopolitical events (e.g., war, civil strife), market crashes, and major data releases (e.g., US non-farm payrolls) are among the factors that influence spreads and liquidity.

The size of the transaction can also affect the bid–offer spread shown by a dealer to clients. Typically, the larger the transaction, the further away from the current spot exchange rate the dealing price will be. Hence, a client who asks a dealer for a two-sided spot CAD/USD price on, for example, USD 50 million will be shown a wider bid–offer spread than a client who asks for a price on USD 1 million. The wider spread reflects the greater difficulty the dealer faces in offsetting the foreign exchange risk of the position in the interbank FX market. Smaller dealing sizes can also affect the bid–offer quote shown to clients. “Retail” quotes are typically for dealing sizes smaller than 1 million units of the base currency and can range all the way down to foreign exchange transactions conducted by individuals. The bid–offer spreads for these retail transactions can be very large compared with those in the interbank market.

The relationship between the dealer and the client can also affect the size of the bid–offer spread shown by the dealer. For many clients, the spot foreign exchange business is only one business service among many that a dealer provides to that client. For example, the dealer firm might also transact in bond and/or equity securities with the same client. In a competitive business environment, in order to win the client’s business for these other services, the dealer might provide a tighter (i.e., smaller)

bid–offer spot exchange rate quote. The dealer might also give tighter bid–offer quotes in order to win repeat FX business. A client's credit risk can also be a factor. A client with a poor credit profile may be quoted a wider bid–offer spread than one with good credit. Given the short settlement cycle for spot FX transactions (typically two business days), however, credit risk is not the most important factor in determining the client's bid–offer spread on spot exchange rates.

3

ARBITRAGE CONSTRAINTS ON SPOT EXCHANGE RATE QUOTES



identify a triangular arbitrage opportunity and calculate its profit, given the bid–offer quotations for three currencies

The bid–offer quotes a dealer shows in the interbank FX market must respect two arbitrage constraints; otherwise the dealer creates riskless arbitrage opportunities for other interbank market participants. We will confine our attention to the interbank FX market because arbitrage presumes the ability to deal simultaneously with different market participants and in different markets, the ability to access “wholesale” bid–offer quotes, and the market sophistication to spot arbitrage opportunities.

First, the bid shown by a dealer in the interbank market cannot be higher than the current interbank offer, and the offer shown by a dealer cannot be lower than the current interbank bid. If the bid–offer quotes shown by a dealer are inconsistent with the then-current interbank market quotes, other market participants will buy from the cheaper source and sell to the more expensive source. This arbitrage will eventually bring the two prices back into line. For example, suppose that the current spot USD/EUR price in the interbank market is 1.1649/1.1651. If a dealer showed a misaligned price quote of 1.1652/1.1654, then other market participants would pay the offer in the interbank market, *buying* EUR at a price of USD 1.1651, and then *sell* the EUR to the dealer by hitting the dealer's bid at USD 1.1652—thereby making a riskless profit of one pip on the trade. This arbitrage would continue as long as the dealer's bid–offer quote violated the arbitrage constraint.

Second, the cross-rate bids (offers) posted by a dealer must be lower (higher) than the implied cross-rate offers (bids) available in the interbank market. A currency dealer located in a given country typically provides exchange rate quotations between that country's currency and various foreign currencies. If a particular currency pair is not explicitly quoted, it can be inferred from the quotes for each currency in terms of the exchange rate with a third nation's currency. For example, given exchange rate quotes for the currency pairs A/B and C/B, we can back out the implied cross rate of A/C. This implied A/C cross rate must be consistent with the A/B and C/B rates. This again reflects the basic principle of arbitrage: If identical financial products are priced differently, then market participants will buy the cheaper one and sell the more expensive one until the price difference is eliminated. In the context of FX cross rates, there are two ways to trade currency A against currency C: (1) using the cross rate A/C or (2) using the A/B and C/B rates. Because, in the end, both methods involve selling (buying) currency C in order to buy (sell) currency A, the exchange rates for these two approaches must be consistent. If the exchange rates are not consistent, the arbitrageur will buy currency C from a dealer if it is undervalued (relative to the cross rate) and sell currency A. If currency C is overvalued by a dealer (relative to the cross rate), it will be sold and currency A will be bought.

To illustrate this **triangular arbitrage** among three currencies, suppose that the interbank market bid–offer in USD/EUR is 1.1649/1.1651 and that the bid–offer in JPY/USD is 105.39/105.41. We need to use these two interbank bid–offer quotes to calculate the market-implied bid–offer quote on the JPY/EUR cross rate.

Begin by considering the transactions required to *sell JPY* and *buy EUR*, going through the JPY/USD and USD/EUR currency pairs. We can view this process intuitively as follows:

$$\begin{array}{lll} \text{Sell JPY} & = & \text{Sell JPY} \\ \text{Buy EUR} & & \text{Buy USD} \end{array} \quad \text{then} \quad \begin{array}{ll} \text{Sell USD} \\ \text{Buy EUR} \end{array}$$

Note that “Buy USD” and “Sell USD” in the expressions on the right-hand side of the equal sign will cancel out to give the JPY/EUR cross rate. In equation form, we can represent this relationship as follows:

$$\left(\frac{\text{JPY}}{\text{EUR}}\right) = \left(\frac{\text{JPY}}{\text{USD}}\right) \left(\frac{\text{USD}}{\text{EUR}}\right).$$

Now, let’s incorporate the bid–offer rates in order to do the JPY/EUR calculation. A rule of thumb is that when we speak of a bid or offer exchange rate, we are referring to the bid or offer for the currency in the denominator (the base currency).

- i. The left-hand side of the above equal sign is “Sell JPY, Buy EUR.” In the JPY/EUR price quote, the EUR is in the denominator (it is the base currency). Because we want to buy the currency in the denominator, we need an exchange rate that is an offer rate. Thus, we will be calculating the *offer* rate for JPY/EUR.
- ii. The first term on the right-hand side of the equal sign is “Sell JPY, Buy USD.” Because we want to buy the currency in the denominator of the quote, we need an exchange rate that is an offer rate. Thus, we need the *offer* rate for JPY/USD.
- iii. The second term on the right-hand side of the equal sign is “Sell USD, Buy EUR.” Because we want to buy the currency in the denominator of the quote, we need an exchange rate that is an offer rate. Thus, we need the *offer* rate for USD/EUR.

Combining all of this conceptually and putting in the relevant offer rates leads to a JPY/EUR offer rate of

$$\left(\frac{\text{JPY}}{\text{EUR}}\right)_{\text{offer}} = \left(\frac{\text{JPY}}{\text{USD}}\right)_{\text{offer}} \left(\frac{\text{USD}}{\text{EUR}}\right)_{\text{offer}} = 105.41 \times 1.1651 = 122.81.$$

Perhaps not surprisingly, calculating the implied JPY/EUR *bid* rate uses the same process as above but with “Buy JPY, Sell EUR” for the left-hand side of the equation, which leads to

$$\left(\frac{\text{JPY}}{\text{EUR}}\right)_{\text{bid}} = \left(\frac{\text{JPY}}{\text{USD}}\right)_{\text{bid}} \left(\frac{\text{USD}}{\text{EUR}}\right)_{\text{bid}} = 105.39 \times 1.1649 = 122.77.$$

As one would expect, the implied cross-rate bid (122.77) is less than the offer (122.81).

This simple formula seems relatively straightforward: To get the implied *bid* cross rate, simply multiply the *bid* rates for the other two currencies. However, depending on the quotes provided, it may be necessary to *invert* one of the quotes in order to complete the calculation.

This is best illustrated with an example. Consider the case of calculating the implied GBP/EUR cross rate if you are given USD/GBP and USD/EUR quotes. Simply using the provided quotes will not generate the desired GBP/EUR cross rate:

$$\frac{\text{GBP}}{\text{EUR}} \neq \left(\frac{\text{USD}}{\text{GBP}}\right) \left(\frac{\text{USD}}{\text{EUR}}\right).$$

Instead, because the USD is in the numerator in both currency pairs, we will have to invert one of the pairs to derive the GBP/EUR cross rate.

The following equation represents the cross-rate relationship we are trying to derive:

$$\frac{\text{GBP}}{\text{EUR}} = \left(\frac{\text{GBP}}{\text{USD}} \right) \left(\frac{\text{USD}}{\text{EUR}} \right).$$

But we don't have the GBP/USD quote. We can, however, invert the USD/GBP quote and use that in our calculation. Let's assume the bid–offer quote provided is for USD/GBP and is 1.2302/1.2304. With this quote, if we want to *buy* GBP (the currency in the denominator), we will buy GBP at the offer and the relevant quote is 1.2304. We can invert this quote to arrive at the needed GBP/USD quote: $1 \div 1.2304 = 0.81274$. Note that, in this example, when we buy the GBP, we are also selling the USD. When we invert the provided USD/GBP offer quote, we obtain 0.81274 GBP/USD. This is the price at which we sell the USD—that is, the GBP/USD *bid*. It may help here to remember our rule of thumb from above: When we speak of a bid or offer exchange rate, we are referring to the bid or offer for the currency in the denominator (the base currency).

Similarly, to get a GBP/USD *offer*, we use the inverse of the USD/GBP *bid* of 1.2302: $1 \div 1.2302 = 0.81288$. (Note that we extended the calculated GBP/USD 0.81274/0.81288 quotes to five decimal places to avoid truncation errors in subsequent calculations.)

We can now finish the calculation of the bid and offer cross rates for GBP/EUR. Using the previously provided 1.1649/1.1651 as the bid–offer in USD/EUR, we calculate the GBP/EUR *bid* rate as follows:

$$\left(\frac{\text{GBP}}{\text{EUR}} \right)_{\text{bid}} = \left(\frac{\text{GBP}}{\text{USD}} \right)_{\text{bid}} \left(\frac{\text{USD}}{\text{EUR}} \right)_{\text{bid}} = 0.81274 \times 1.1649 = 0.9468.$$

Similarly, the implied GBP/EUR *offer* rate is

$$\left(\frac{\text{GBP}}{\text{EUR}} \right)_{\text{offer}} = \left(\frac{\text{GBP}}{\text{USD}} \right)_{\text{offer}} \left(\frac{\text{USD}}{\text{EUR}} \right)_{\text{offer}} = 0.81288 \times 1.1651 = 0.9471.$$

Note that the implied *bid* rate is less than the implied *offer* rate, as it must be to prevent arbitrage.

We conclude this section on arbitrage constraints with some simple observations:

- The arbitrage constraint on implied cross rates is similar to that for spot rates (posted bid rates cannot be higher than the market's offer; posted offer rates cannot be lower than the market's bid). The only difference is that this second arbitrage constraint is applied *across* currency pairs instead of involving a *single* currency pair.
- In reality, any violations of these arbitrage constraints will quickly disappear. Both human traders and automatic trading algorithms are constantly on alert for any pricing inefficiencies and will arbitrage them away almost instantly. If Dealer 1 is buying a currency at a price higher than the price at which Dealer 2 is selling it, the arbitrageur will buy the currency from Dealer 2 and resell it to Dealer 1. As a result of buying and selling pressures, Dealer 2 will raise his offer prices and Dealer 1 will reduce her bid prices to the point where arbitrage profits are no longer available.
- Market participants do not need to calculate cross rates *manually* because electronic dealing machines (which are essentially just specialized computers) will automatically calculate cross bid–offer rates given any two underlying bid–offer rates.

EXAMPLE 1**Bid–Offer Rates**

The following are spot rate quotes in the interbank market:

USD/EUR	1.1649/1.1651
JPY/USD	105.39/105.41
CAD/USD	1.3199/1.3201
SEK/USD	9.6300/9.6302

1. What is the bid–offer on the SEK/EUR cross rate implied by the interbank market?

- A. 0.1209/0.1211
- B. 8.2656/8.2668
- C. 11.2180/11.2201

Solution

C is correct. Using the provided quotes and setting up the equations so that the cancellation of terms results in the SEK/EUR quote,

$$\frac{\text{SEK}}{\text{EUR}} = \frac{\text{SEK}}{\text{USD}} \times \frac{\text{USD}}{\text{EUR}}.$$

Hence, to calculate the SEK/EUR bid (offer) rate, we multiply the SEK/USD and USD/EUR bid (offer) rates to get the following:

Bid:	11.2180 = 9.6300 × 1.1649.
Offer:	11.2201 = 9.6302 × 1.1651.

2. What is the bid–offer on the JPY/CAD cross rate implied by the interbank market?

- A. 78.13/78.17
- B. 79.85/79.85
- C. 79.84/79.86

Solution

C is correct. Using the intuitive equation-based approach,

$$\frac{\text{JPY}}{\text{CAD}} = \frac{\text{JPY}}{\text{USD}} \times \left(\frac{\text{CAD}}{\text{USD}} \right)^{-1} = \frac{\text{JPY}}{\text{USD}} \times \frac{\text{USD}}{\text{CAD}}.$$

This equation shows that we have to invert the CAD/USD quotes to get the USD/CAD bid–offer rates of 0.75752/0.75763. That is, given the CAD/USD quotes of 1.3199/1.3201, we take the inverse of each and interchange bid and offer, so that the USD/CAD quotes are (1/1.3201)/(1/1.3199), or 0.75752/0.75763. Multiplying the JPY/USD and USD/CAD bid–offer rates then leads to the following:

Bid:	79.84 = 105.39 × 0.75752.
Offer:	79.86 = 105.41 × 0.75763.

3. If a dealer quoted a bid–offer rate of 79.81/79.83 in JPY/CAD, then a triangular arbitrage would involve buying:
- A. CAD in the interbank market and selling it to the dealer, for a profit of JPY 0.01 per CAD.
 - B. JPY from the dealer and selling it in the interbank market, for a profit of CAD 0.01 per JPY.
 - C. CAD from the dealer and selling it in the interbank market, for a profit of JPY 0.01 per CAD.

Solution

C is correct. The implied interbank cross rate for JPY/CAD is 79.84/79.86 (the answer to Question 2). Hence, the dealer is offering to sell the CAD (the base currency in the quote) too cheaply, at an offer rate that is below the interbank bid rate (79.83 versus 79.84, respectively). Triangular arbitrage would involve buying CAD from the dealer (paying the dealer's offer) and selling CAD in the interbank market (hitting the interbank bid), for a profit of JPY 0.01 ($79.84 - 79.83$) per CAD transacted.

4. If a dealer quoted a bid–offer of 79.82/79.87 in JPY/CAD, then you could:
- A. not make any arbitrage profits.
 - B. make arbitrage profits buying JPY from the dealer and selling it in the interbank market.
 - C. make arbitrage profits buying CAD from the dealer and selling it in the interbank market.

Solution

A is correct. The arbitrage relationship is not violated: The dealer's bid (offer) is not above (below) the interbank market's offer (bid). The implied interbank cross rate for JPY/CAD is 79.84/79.86 (the solution to Question 2).

5. A market participant is considering the following transactions:

Transaction 1	Buy CAD 100 million against the USD at 15:30 London time.
Transaction 2	Sell CAD 100 million against the KRW at 21:30 London time.
Transaction 3	Sell CAD 10 million against the USD at 15:30 London time.

Given the proposed transactions, what is the *most likely* ranking of the bid–offer spreads, from tightest to widest, under normal market conditions?

- A. Transactions 1, 2, 3
- B. Transactions 2, 1, 3
- C. Transactions 3, 1, 2

Solution

C is correct. The CAD/USD currency pair is most liquid when New York and London are both in their most liquid trading periods at the same time (approximately 8:00 a.m. to 11:00 a.m. New York time, or about 13:00 to 16:00 London time). Transaction 3 is for a smaller amount than Transaction 1. Transaction 2 is for a less liquid currency pair (KRW/CAD is traded less than CAD/USD) and occurs outside of normal dealing hours in all three major centers (London, North America, and Asia); the transaction is also for a large amount.

FORWARD MARKETS

4



explain spot and forward rates and calculate the forward premium/discount for a given currency

Outright forward contracts (often referred to simply as forwards) are agreements to exchange one currency for another on a future date at an exchange rate agreed upon today. Any exchange rate transaction that has a settlement date longer than $T + 2$ is a forward contract.

Forward exchange rates must satisfy an arbitrage relationship that equates the investment return on two alternative but equivalent investments. To simplify the explanation of this arbitrage relationship and to focus on the intuition behind forward rate calculations, we will ignore the bid–offer spread on exchange rates and money market instruments. In addition, we will alter our exchange rate notation from price/base currency (P/B) to “foreign/domestic currency” (f/d), making the assumption that the domestic currency for an investor is the base currency in the exchange rate quotation. Using this (f/d) notation will make it easier to illustrate the choice an investor faces between domestic and foreign investments, as well as the arbitrage relationships that equate the returns on these investments when their risk characteristics are equivalent.

Consider an investor with one unit of domestic currency to invest for one year. The investor faces two alternatives:

- A. One alternative is to invest cash for one year at the domestic risk-free rate (i_d). At the end of the year, the investment would be worth $(1 + i_d)$.
- B. The other alternative is to convert the domestic currency to foreign currency at the spot rate of $S_{f/d}$ and invest for one year at the foreign risk-free rate (i_f). At the end of the period, the investor would have $S_{f/d}(1 + i_f)$ units of foreign currency. These funds then must be converted back to the investor’s domestic currency. If the exchange rate to be used for this end-of-year conversion is set at the start of the period using a one-year forward contract, then the investor will have eliminated the foreign exchange risk associated with converting at an unknown future spot rate. If we let $F_{f/d}$ denote the forward rate, the investor would obtain $(1/F_{f/d})$ units of the domestic currency for each unit of foreign currency sold forward. Hence, in domestic currency, at the end of the year, the investment would be worth $S_{f/d}(1 + i_f)(1/F_{f/d})$.

The two investment alternatives above (A and B) are risk free and therefore must offer the same return. If they did not offer the same return, investors could earn a riskless arbitrage profit by borrowing in one currency, lending in the other, and using the spot and forward exchange markets to eliminate currency risk. Equating the returns on these two investment alternatives—that is, putting investments A and B on opposite sides of the equal sign—leads to the following relationship:

$$(1 + i_d) = S_{f/d}(1 + i_f)\left(\frac{1}{F_{f/d}}\right).$$

To see the intuition behind forward rate calculations, note that the right-hand side of the expression (for investment B) also shows the chronological order of this investment: Convert from domestic to foreign currency at the spot rate ($S_{f/d}$); invest this foreign currency amount at the foreign risk-free interest rate $(1 + i_f)$; and then at maturity, convert the foreign currency investment proceeds back into the domestic currency using the forward rate $(1/F_{f/d})$.

For simplicity, we assumed a one-year horizon in the preceding example. However, the argument holds for any investment horizon. The risk-free assets used in this arbitrage relationship are typically bank deposits quoted using the appropriate Market Reference Rate for each currency involved. The day count convention MRR deposits may be Actual/360 or Actual/365. The notation Actual/360 means that interest is calculated as if there were 360 days in a year. The notation Actual/365 means interest is calculated as if there were 365 days in a year. The main exception to the Actual/360 day count convention is the GBP, for which the convention is Actual/365. For the purposes of our discussion, we will use Actual/360 consistently in order to avoid complication. Incorporating this day count convention into our arbitrage formula leads to

$$\left(1 + i_d \left[\frac{\text{Actual}}{360} \right]\right) = S_{f/d} \left(1 + i_f \left[\frac{\text{Actual}}{360} \right]\right) \left(\frac{1}{F_{f/d}}\right).$$

This equation can be rearranged to isolate the forward rate:

$$F_{f/d} = S_{f/d} \left(\frac{1 + i_f \left[\frac{\text{Actual}}{360} \right]}{1 + i_d \left[\frac{\text{Actual}}{360} \right]} \right). \quad (1)$$

Equation 1 describes **covered interest rate parity**. Our previous work shows that covered interest rate parity is based on an arbitrage relationship among risk-free interest rates and spot and forward exchange rates. Because of this arbitrage relationship between investment alternatives, Equation 1 can also be described as saying that the covered (i.e., currency-hedged) interest rate differential between the two markets is zero.

The covered interest rate parity equation can also be rearranged to give an expression for the forward premium or discount:

$$F_{f/d} - S_{f/d} = S_{f/d} \left(\frac{\left[\frac{\text{Actual}}{360} \right]}{1 + i_d \left[\frac{\text{Actual}}{360} \right]} \right) (i_f - i_d).$$

The domestic currency will trade at a forward premium ($F_{f/d} > S_{f/d}$) if, and only if, the foreign risk-free interest rate exceeds the domestic risk-free interest rate ($i_f > i_d$). Equivalently, in this case, the foreign currency will trade at a lower rate in the forward contract (relative to the spot rate), and we would say that the foreign currency trades at a forward discount. In other words, if it is possible to earn more interest in the foreign market than in the domestic market, then the forward discount for the foreign currency will offset the higher foreign interest rate. Otherwise, covered interest rate parity would not hold and arbitrage opportunities would exist.

When the foreign currency is at a higher rate in the forward contract, relative to the spot rate, we say that the foreign currency trades at a forward premium. In the case of a forward premium for the foreign currency, the foreign risk-free interest rate will be less than the domestic risk-free interest rate. Additionally, as can be seen in the equation above, the premium or discount is proportional to the spot exchange rate ($S_{f/d}$), proportional to the interest rate differential ($i_f - i_d$) between the markets, and approximately proportional to the time to maturity (Actual/360).

Although we have illustrated the covered interest rate parity equation (Equation 1) in terms of foreign and domestic currencies (using the notation f/d), this equation can also be expressed in our more standard exchange rate quoting convention of price and base currencies (P/B):

$$F_{P/B} = S_{P/B} \left(\frac{1 + i_P \left[\frac{\text{Actual}}{360} \right]}{1 + i_B \left[\frac{\text{Actual}}{360} \right]} \right).$$

When dealing in professional FX markets, it may be more useful to think of the covered interest rate parity equation and the calculation of forward rates in this P/B notation rather than in foreign/domestic (*f/d*) notation. Domestic and foreign are relative concepts that depend on where one is located, and because of the potential for confusion, these terms are not used for currency quotes in professional FX markets.

EXAMPLE 2

Calculating the Forward Premium (Discount)

The following table shows the mid-market rate (i.e., the average of the bid and offer) for the current CAD/AUD spot exchange rate as well as for AUD and CAD 270-day MRR (annualized):

Spot (CAD/AUD)	0.9000
270-day MRR (AUD)	1.47%
270-day MRR (CAD)	0.41%

1. The forward premium (discount) for a 270-day forward contract for CAD/AUD would be *closest* to:

- A. -0.0094.
- B. -0.0071.
- C. +0.0071.

Solution

B is correct. The equation to calculate the forward premium (discount) is as follows:

$$F_{P/B} - S_{P/B} = S_{P/B} \left(\frac{\left[\frac{\text{Actual}}{360} \right]}{1 + i_B \left[\frac{\text{Actual}}{360} \right]} \right) (i_P - i_B).$$

Because AUD is the base currency in the CAD/AUD quote, putting in the information from the table gives us

$$F_{P/B} - S_{P/B} = 0.9000 \left(\frac{\left[\frac{270}{360} \right]}{1 + 0.0147 \left[\frac{270}{360} \right]} \right) (0.0041 - 0.0147) = -0.0071.$$

In professional FX markets, forward exchange rates are typically quoted in terms of points—the difference between the forward exchange rate quote and the spot exchange rate quote, scaled so that the points can be directly related to the last decimal place in the spot quote. Thus, the forward rate quote is typically shown as the bid—offer on the spot rate and the number of forward points at each maturity, as shown in Exhibit 1 (“Maturity” is defined in terms of the time between spot settlement—usually T + 2—and the settlement of the forward contract).

Exhibit 1: Sample Spot and Forward Quotes (Bid–Offer)

Maturity	Spot Rate
Spot (USD/EUR)	1.1649/1.1651
Forward Points	
1 month	-5.6/-5.1
3 months	-15.9/-15.3
6 months	-37.0/-36.3
12 months	-94.3/-91.8

Note the following:

- As always, the offer in the bid–offer quote is larger than the bid. In this example, the forward points are negative (i.e., the forward rate for the EUR is at a discount to the spot rate) but the bid is a smaller number (-5.6 versus -5.1 at the one-month maturity).
- The absolute number of forward points is a function of the term of the forward contract: A longer contract term results in a larger number of points.
- Because this is an OTC market, a client is not restricted to dealing *only* at the dates/maturities shown. Dealers typically quote standard forward dates, but forward deals can be arranged for any forward date the client requires. The forward points for these non-standard (referred to as “broken”) forward dates will typically be interpolated on the basis of the points shown for the standard settlement dates.
- The quoted points are already scaled to each maturity—they are not annualized—so there is no need to adjust them.

To convert any of these quoted forward points into a forward rate, divide the number of points by 10,000 (to scale it down to the same four decimal places in the USD/EUR spot quote) and then add the result to the spot exchange rate quote (because the JPY/USD exchange rate is quoted to only two decimal places, forward points for the dollar–yen currency pair are divided by 100). Be careful, however, about which side of the market (bid or offer) is being quoted. For example, suppose a market participant is *selling* the EUR forward against the USD and is given a USD/EUR quote. The EUR is the base currency; thus, the market participant must use the *bid* rates (i.e., hit the bid). Using the data in Exhibit 1, the three-month forward *bid* rate in this case would be based on the spot bid and the forward points bid and hence would be

$$1.1649 + (-15.9/10,000) = 1.16331.$$

The market participant would be selling EUR three months forward at a price of USD 1.16331 per EUR.

5

THE MARK-TO-MARKET VALUE OF A FORWARD CONTRACT



calculate the mark-to-market value of a forward contract

Next, we consider the mark-to-market value of forward contracts. As with other financial instruments, the mark-to-market value of forward contracts reflects the profit (or loss) that would be realized from closing out the position at current market prices. To close out a forward position, we must offset it with an equal and opposite forward position using the spot exchange rate and forward points available in the market when the offsetting position is created. When a forward contract is initiated, the mark-to-market value of the contract is zero, and no cash changes hands. From that moment onward, however, the mark-to-market value of the forward contract will change as the spot exchange rate changes and as interest rates change in either of the two currencies.

Let's look at an example. Suppose that a market participant bought GBP 10 million for delivery against the AUD in six months at an "all-in" forward rate of 1.8100 AUD/GBP. (The all-in forward rate is simply the sum of the spot rate and the scaled forward points.) Three months later, the market participant wants to close out this forward contract. This would require selling GBP 10 million three months forward using the AUD/GBP spot exchange rate and forward points in effect at that time. Before looking at this exchange rate, note that the offsetting forward contract is defined in terms of the original position taken. The original position in this example was "long GBP 10 million," so the offsetting contract is "short GBP 10 million." However, there is ambiguity here: To be long GBP 10 million at 1.8100 AUD/GBP is equivalent to being short AUD 18,100,000 ($10,000,000 \times 1.8100$) at the same forward rate. To avoid this ambiguity, for the purposes of this discussion, we will state what the relevant forward position is for mark-to-market purposes. The net gain or loss from the transaction will be reflected in the alternate currency.

Assume the bid–offer quotes for spot and forward points three months prior to the settlement date are as follows:

Spot rate (AUD/GBP)	1.8210/1.8215
Three-month points	130/140

To sell GBP (the base currency in the AUD/GBP quote), we will be calculating the *bid* side of the market. Hence, the appropriate all-in three-month forward rate to use is

$$1.8210 + 130/10,000 = 1.8340.$$

This means that the market participant originally bought GBP 10 million at an AUD/GBP rate of 1.8100 and subsequently sold that amount at a rate of 1.8340. These GBP amounts will net to zero at the settlement date (GBP 10 million both bought and sold), but the AUD amounts will not, because the forward rate has changed. The AUD cash flow at the settlement date will be

$$(1.8340 - 1.8100) \times 10,000,000 = +\text{AUD } 240,000.$$

This is a cash *inflow* because the market participant was long the GBP with the original forward position and the GBP subsequently appreciated (the AUD/GBP rate increased).

This cash flow will be paid at the settlement day, which is still three months away. To calculate the mark-to-market value of the dealer's position, we must discount this cash flow to the present. The present value of this amount is found by discounting the settlement day cash flow by the three-month discount rate. Because this amount is in AUD, we use the three-month AUD discount rate. Suppose that three-month AUD MRR is 2.40% (annualized). The present value of this future AUD cash flow is then

$$\frac{\text{AUD } 240,000}{1 + 0.024 \left(\frac{90}{360} \right)} = \text{AUD } 238,569.$$

This result is the mark-to-market value of the original long GBP 10 million six-month forward when it is closed out three months prior to settlement.

To summarize, the process for marking to market a forward position is relatively straightforward:

1. Create an offsetting forward position that is equal to the original forward position. (In the example above, the market participant was long GBP 10 million forward, so the offsetting forward contract would be to sell GBP 10 million.)
2. Determine the appropriate all-in forward rate for this new, offsetting forward position. If the base currency of the exchange rate quote is being sold (bought), then use the bid (offer) side of the market.
3. Calculate the cash flow at the settlement day. This amount will be based on the original contract size times the difference between the original forward rate and that calculated in Step 2. If the currency the market participant was originally long (short) subsequently appreciated (depreciated), then there will be a cash *inflow* (*outflow*). (In the above example, the market participant was long the GBP, which subsequently appreciated, leading to a cash inflow at the settlement day.)
4. Calculate the present value of this cash flow at the future settlement date. The currency of the cash flow and the discount rate must match. (In the example above, the cash flow at the settlement date was in AUD, so an AUD MRR was used to calculate the present value.)

The factors that affect the bid–offer spread for forward points are the same as those we discussed for spot bid–offer rates: the interbank market liquidity of the underlying currency pair, the size of the transaction, and the relationship between the client and the dealer. For forward bid–offer spreads, we can also add a fourth factor: the term of the forward contract. Generally, the longer the term of the forward contract, the wider the bid–offer spread. This relationship holds because as the term of the contract increases,

- liquidity in the forward market tends to decline,
- the exposure to counterparty credit risk increases, and
- the interest rate risk of the contract increases (forward rates are based on interest rate differentials, and a longer duration means greater price sensitivity to movements in interest rates).

EXAMPLE 3

Forward Rates and the Mark-to-Market Value of Forward Positions

A dealer is contemplating trade opportunities in the CHF/GBP currency pair. The following are the current spot rates and forward points being quoted for the CHF/GBP currency pair:

Spot rate (CHF/GBP)	1.2939/1.2941
One month	-8.3/-7.9
Two months	-17.4/-16.8
Three months	-25.4/-24.6
Four months	-35.4/-34.2
Five months	-45.9/-44.1
Six months	-56.5/-54.0

1. The current all-in bid rate for delivery of GBP against the CHF in three months is *closest* to:

- A. 1.29136.
- B. 1.29150.
- C. 1.29164.

Solution

A is correct. The current all-in three-month bid rate for GBP (the base currency) is equal to $1.2939 + (-25.4/10,000) = 1.29136$.

2. The all-in rate that the dealer will be quoted today by another dealer to sell the CHF six months forward against the GBP is *closest* to:

- A. 1.28825.
- B. 1.28835.
- C. 1.28870.

Solution

C is correct. The dealer will sell CHF against the GBP, which is equivalent to buying GBP (the base currency) against the CHF. Hence, the *offer* side of the market will be used for forward points. The all-in forward price will be $1.2941 + (-54.0/10,000) = 1.28870$.

3. Some time ago, Laurier Bay Capital, an investment fund based in Los Angeles, hedged a long exposure to the New Zealand dollar by selling NZD 10 million forward against the USD; the all-in forward price was 0.7900 (USD/NZD). Three months prior to the settlement date, Laurier Bay wants to mark this forward position to market. The bid–offer for the USD/NZD spot rate, the three-month forward points, and the three-month MRRs (annualized) are as follows:

Spot rate (USD/NZD)	0.7825/0.7830
Three-month points	-12.1/-10.0
Three-month MRR (NZD)	3.31%
Three-month MRR (USD)	0.31%

The mark-to-market value for Laurier Bay's forward position is *closest* to:

- A. -USD 87,100.
- B. +USD 77,437.
- C. +USD 79,938.

Solution

C is correct. Laurier Bay sold NZD 10 million forward to the settlement date at an all-in forward rate of 0.7900 (USD/NZD). To mark this position to market, the fund would need an offsetting forward transaction involving buying NZD 10 million three months forward to the settlement date. The NZD amounts on the settlement date net to zero. For the offsetting forward contract, because the NZD is the base currency in the USD/NZD quote, buying NZD forward means paying the offer for both the spot rate and the forward points. This scenario leads to an all-in three-month forward rate of $0.7830 - 0.0010 = 0.7820$. On the settlement day, Laurier Bay will receive USD $7,900,000$ (NZD $10,000,000 \times 0.7900$ USD/NZD) from the original forward contract and pay out USD $7,820,000$ (NZD $10,000,000 \times 0.7820$ USD/

NZD) based on the offsetting forward contract. The result is a net cash flow on the settlement day of $10,000,000 \times (0.7900 - 0.7820) = +\text{USD } 80,000$. This is a cash inflow because Laurier Bay sold the NZD forward and the NZD depreciated against the USD. This USD cash inflow will occur in three months. To calculate the mark-to-market value of the original forward position, we need to calculate the present value of this USD cash inflow using the three-month USD discount rate (we use USD MRR for this purpose):

$$\frac{\text{USD } 80,000}{1 + 0.0031\left(\frac{90}{360}\right)} = +\text{USD } 79,938.$$

4. Now, suppose that instead of having a long exposure to the NZD, Laurier Bay Capital had a long forward exposure to the USD, which it hedged by selling USD 10 million forward against the NZD at an all-in forward rate of 0.7900 (USD/NZD). Three months prior to settlement date, it wants to close out this short USD forward position.

Using the above table, the mark-to-market value for Laurier Bay's short USD forward position is *closest* to:

- A. -NZD 141,117.
- B. -NZD 139,959.
- C. -NZD 87,100.

Solution

B is correct. Laurier Bay initially sold USD 10 million forward, and it will have to buy USD 10 million forward to the same settlement date (i.e., in three months' time) in order to close out the initial position. Buying USD using the USD/NZD currency pair is the same as selling the NZD. Because the NZD is the base currency in the USD/NZD quote, selling the NZD means calculating the *bid* rate:

$$0.7825 + (-12.1/10,000) = 0.78129.$$

At settlement, the USD amounts will net to zero (USD 10 million both bought and sold). The NZD amounts will not net to zero, however, because the all-in forward rate changed between the time Laurier Bay initiated the original position and the time it closed out this position. At initiation, Laurier Bay contracted to sell USD 10 million and receive NZD 12,658,228 (i.e., $10,000,000/0.7900$) on the settlement date. To close out the original forward contract, Laurier Bay entered into an offsetting forward contract to receive USD 10 million and pay out NZD 12,799,345 (i.e., $10,000,000/0.78129$) at settlement. The difference between the NZD amounts that Laurier Bay will receive and pay out on the settlement date equals

$$\text{NZD } 12,658,228 - \text{NZD } 12,799,345 = -\text{NZD } 141,117.$$

This is a cash *outflow* for Laurier Bay because the fund was *short* the USD in the original forward position and the USD subsequently *appreciated* (i.e., the NZD subsequently depreciated, because the all-in forward rate in USD/NZD dropped from 0.7900 to 0.78129). This NZD cash outflow occurs in three months' time, and we must calculate its present value using the three-month NZD MRR:

$$\frac{-\text{NZD } 141,117}{1 + 0.0331\left(\frac{90}{360}\right)} = -\text{NZD } 139,959.$$

INTERNATIONAL PARITY CONDITIONS

6

- explain international parity conditions (covered and uncovered interest rate parity, forward rate parity, purchasing power parity, and the international Fisher effect)

Having reviewed the basic tools of the FX market, we now turn our focus to how they are used in practice. At the heart of the trading decision in FX markets lies a view on equilibrium market prices. An understanding of equilibrium pricing will assist the investor in framing decisions regarding risk exposures and how they should be managed.

In this and the following sections, we lay out a framework for developing a view on equilibrium exchange rates. We begin by examining international parity conditions, which describe the inter-relationships that jointly determine *long-run* movements in exchange rates, interest rates, and inflation. These parity conditions are the basic building blocks for describing long-term equilibrium levels for exchange rates. In subsequent sections, we expand beyond the parity conditions by discussing other factors that influence a currency's value.

Always keep in mind that exchange rate movements reflect complex interactions among multiple forces. In trying to untangle this complex web of interactions, we must clearly delineate the following concepts:

1. Long run versus short run: Many of the factors that determine exchange rate movements exert subtle but persistent influences over long periods of time. Although a poor guide for short-term prediction, longer-term equilibrium values act as an anchor for exchange rate movements.
2. Expected versus unexpected changes: In reasonably efficient markets, prices will adjust to reflect market participants' expectations of future developments. When a key factor—say, inflation—is trending gradually in a particular direction, market pricing will eventually come to reflect expectations that this trend will continue. In contrast, large, unexpected movements in a variable (for example, a central bank intervening in the foreign exchange market) can lead to immediate, discrete price adjustments. This concept is closely related to risk. For example, a moderate but steady rate of inflation will not have the same effect on market participants as an inflation rate that is very unpredictable. The latter clearly describes a riskier financial environment. Market pricing will reflect risk premiums—that is, the compensation that traders and investors demand for being exposed to unpredictable outcomes. Whereas expectations of long-run equilibrium values tend to evolve slowly, risk premiums—which are closely related to confidence and reputation—can change quickly in response to unexpected developments.
3. Relative movements: An exchange rate represents the relative price of one currency in terms of another. Hence, for exchange rate determination, the level or variability of key factors in any particular country is typically much less important than the *differences* in these factors across countries. For example, knowing that inflation is increasing in Country A may not give much insight into the direction of the A/B exchange rate without also knowing what is happening with the inflation rate in Country B.

As a final word of caution—and this cannot be emphasized enough—*there is no simple formula, model, or approach that will allow market participants to precisely forecast exchange rates*. Models that work well in one period may fail in others. Models that work for one set of exchange rates may fail to work for others.

Nonetheless, market participants must have a market view to guide their decisions, even if this view requires significant revision as new information becomes available. The following sections provide a framework for understanding FX markets, a guide for thinking through the complex forces driving exchange rates. As with all theory, however, it does not eliminate the need for insightful analysis of actual economic and market conditions.

International Parity Conditions

International parity conditions form the building blocks of most models of exchange rate determination. The key international parity conditions are as follows:

1. covered interest rate parity,
2. uncovered interest rate parity,
3. forward rate parity,
4. purchasing power parity, and
5. the international Fisher effect.

Parity conditions show how expected inflation differentials, interest rate differentials, forward exchange rates, current spot exchange rates, and expected future spot exchange rates would be linked in an ideal world. These conditions typically make simplifying assumptions, such as zero transaction costs, perfect information that is available to all market participants, risk neutrality, and freely adjustable market prices.

Although empirical studies have found that the parity conditions rarely hold in the short term, they do help form a broadly based, long-term view of exchange rates and accompanying risk exposures. The exception to the rule that parity conditions do not hold in the short term is covered interest rate parity, which is the only parity condition that is enforced by arbitrage. We examine this parity condition first.

7

COVERED AND UNCOVERED INTEREST RATE PARITY AND FORWARD RATE PARITY

- explain international parity conditions (covered and uncovered interest rate parity, forward rate parity, purchasing power parity, and the international Fisher effect)
- describe relations among the international parity conditions
- evaluate the use of the current spot rate, the forward rate, purchasing power parity, and uncovered interest parity to forecast future spot exchange rates

We have already discussed covered interest rate parity in our examination of forward exchange rates. Under this parity condition, *an investment in a foreign money market instrument that is completely hedged against exchange rate risk should yield exactly the same return as an otherwise identical domestic money market investment*. Given the spot exchange rate and the domestic and foreign yields, the forward exchange rate must equal the rate that gives these two alternative investment strategies—invest either in a domestic money market instrument or in a fully currency-hedged foreign money market instrument—exactly the same holding period return. If one strategy gave a higher holding period return than the other, then an investor could short-sell

the lower-yielding approach and invest the proceeds in the higher-yielding approach, earning riskless arbitrage profits in the process. In real-world financial markets, such a disparity will be quickly arbitraged away so that no further arbitrage profits are available. Covered interest rate parity is thus said to be a no-arbitrage condition.

For covered interest rate parity to hold exactly, it must be assumed that there are zero transaction costs and that the underlying domestic and foreign money market instruments being compared are identical in terms of liquidity, maturity, and default risk. Where capital is permitted to flow freely, spot and forward exchange markets are liquid, and financial market conditions are relatively stress free, covered interest rate differentials are generally found to be close to zero and covered interest rate parity holds.

Uncovered Interest Rate Parity

According to the **uncovered interest rate parity** condition, the *expected* return on an uncovered (i.e., unhedged) foreign currency investment should equal the return on a comparable domestic currency investment. Uncovered interest rate parity states that *the change in spot rate over the investment horizon should, on average, equal the differential in interest rates between the two countries. That is, the expected appreciation/depreciation of the exchange rate will just offset the yield differential.*

To explain the intuition behind this concept, let's switch, as we did with the examples for covered interest rate parity, from the standard price/base currency notation (P/B) to foreign/domestic currency notation (f/d) in order to emphasize the choice between foreign and domestic investments. As before, we also will assume that for the investor, the base currency is the domestic currency. (In *covered* interest rate parity, we assumed the investor transacted at a forward rate that was locked in at strategy initiation. In *uncovered* interest rate parity, the investor is assumed to transact at a future spot rate that is unknown at the time the strategy is initiated and the investor's currency position in the future is not hedged—that is, uncovered.)

For our example, assume that this investor has a choice between a one-year domestic money market instrument and an unhedged one-year foreign-currency-denominated money market investment. Under the assumption of uncovered interest rate parity, the investor will compare the *known* return on the domestic investment with the *expected* all-in return on the unhedged foreign-currency-denominated investment (which includes the foreign yield as well as any movements in the exchange rate, in $S_{f/d}$ terms). The choice between these two investments will depend on which market offers the higher expected return on an unhedged basis.

For example, assume that the return on the one-year foreign money market instrument is 10% while the return on the one-year domestic money market instrument is 4%. From the investor's perspective, the 4% expected return on the one-year domestic investment in domestic currency terms is known with complete certainty. This is not the case for the uncovered investment in the foreign currency money market instrument. In domestic currency terms, the investment return on an uncovered (or unhedged) foreign-currency-denominated investment is equal to $(1 + i_f)(1 - \% \Delta S_{f/d}) - 1$.

Intuitively, the formula says that the investor's return on a foreign investment is a function of both the foreign interest rate and the change in the spot rate, whereby a depreciation in the foreign currency reduces the investor's return. The percentage change in $S_{f/d}$ enters with a minus sign because an *increase* in $S_{f/d}$ means the foreign currency *declines* in value, thereby reducing the all-in return from the domestic currency perspective of our investor. This all-in return depends on *future* movements in the $S_{f/d}$ rate, which cannot be known until the end of the period. This return can be approximated by $\approx i_f - \% \Delta S_{f/d}$.

Note that this approximate formula holds because the product ($i \times \%ΔS$) is small compared with the interest rate (i) and the percentage change in the exchange rate ($\%ΔS$). For simplicity of exposition, we will use the \cong symbol when we introduce an approximation but will subsequently treat the relationship as an equality (=) unless the distinction is important for the issue being discussed.

Using the previous example, consider three cases:

1. The $S_{f/d}$ rate is expected to remain unchanged.
2. The domestic currency is expected to appreciate by 10%.
3. The domestic currency is expected to appreciate by 6%.

In the first case, the investor would prefer the foreign-currency-denominated money market investment because it offers a 10% (= 10% – 0%) expected return, while the comparable domestic investment offers only 4%. In the second case, the investor would prefer the domestic investment because the expected return on the foreign-currency-denominated investment is 0% (= 10% – 10%). In the third case, uncovered interest rate parity holds because both investments offer a 4% (for the foreign investment, 10% – 6%) expected return. In this case, the risk-neutral investor is assumed to be indifferent between the alternatives.

Note that in the third case, in which uncovered interest rate parity holds, while the *expected* return over the one-year investment horizon is the same for both instruments, that expected return is *just a point on the distribution* of possible total return outcomes. The all-in return on the foreign money market instrument is uncertain because the *future* $S_{f/d}$ rate is uncertain. Hence, when we say that the investor would be indifferent between owning domestic and foreign investments because they both offer the same *expected* return (4%), we are assuming that the investor is *risk neutral* (risk-neutral investors base their decisions solely on the expected return and are indifferent to the investments' risk). Thus, uncovered interest rate parity assumes that there are enough risk-neutral investors to force equality of expected returns.

Using our example's foreign/domestic (f/d) notation, uncovered interest rate parity says the expected change in the spot exchange rate over the investment horizon should be reflected in the interest rate differential:

$$\%ΔS_{f/d}^e = i_f - i_d \quad (2)$$

where ΔS^e indicates the change in the spot rate expected for *future* periods. Note that Equation 2 cannot hold simultaneously for $S_{f/d}$ and $S_{d/f}$ (= $1/S_{f/d}$) because their percentage changes are not of exactly equal magnitude. This reflects our earlier approximation. Using the exact return on the unhedged foreign instrument would alleviate this issue but would produce a less intuitive equation.

In our example, if the yield spread between the foreign and domestic investments is 6% ($i_f - i_d = 6\%$), then this spread implicitly reflects the expectation that the domestic currency will strengthen versus the foreign currency by 6%.

Uncovered interest rate parity assumes that the country with the *higher* interest rate or money market yield will see its currency *depreciate*. The depreciation of the currency offsets the initial higher yield so that the (expected) all-in return on the two investment choices is the same. Hence, if the uncovered interest rate parity condition held consistently in the real world, it would rule out the possibility of earning excess returns from going long a high-yield currency and going short a low-yield currency: The depreciation of the high-yield currency would exactly offset the yield advantage that the high-yield currency offers. Taking this scenario to its logical conclusion, if uncovered interest rate parity held at all times, investors would have no incentive to shift capital from one currency to another because expected returns on otherwise identical money market investments would be equal across markets and risk-neutral investors would be indifferent among them.

Most studies have found that over short- and medium-term periods, the rate of depreciation of the high-yield currency is less than what would be implied by uncovered interest rate parity. In many cases, high-yield currencies have been found to *strengthen*, not weaken. There is, however, evidence that uncovered interest rate parity works better over very long-term horizons.

Such findings have significant implications for foreign exchange investment strategies. If high-yield currencies do not depreciate in line with the path predicted by the uncovered interest rate parity condition, then high-yield currencies should exhibit a tendency to outperform low-yield currencies over time. If so, investors could adopt strategies that overweight high-yield currencies at the expense of low-yield currencies and generate attractive returns in the process. Such approaches are known as FX carry trade strategies. We will discuss them in greater detail later.

Forward Rate Parity

Forward rate parity states that the forward exchange rate will be an unbiased predictor of the future spot exchange rate. It does not state that the forward rate will be a perfect forecast, just an unbiased one; the forward rate may overestimate or underestimate the future spot rate from time to time, but on average, it will equal the future spot rate. Forward rate parity builds upon two other parity conditions, covered interest rate parity and uncovered interest rate parity.

The covered interest rate parity condition describes the relationship among the spot exchange rate, the forward exchange rate, and interest rates. Let's keep using the foreign/domestic exchange rate notation (f/d) to simplify the explanation. The arbitrage condition that underlies covered interest rate parity (illustrated earlier) can be rearranged to give an expression for the forward premium or discount:

$$F_{f/d} - S_{f/d} = S_{f/d} \left(\frac{\left[\frac{\text{Actual}}{360} \right]}{1 + i_d \left[\frac{\text{Actual}}{360} \right]} \right) (i_f - i_d).$$

The domestic currency will trade at a forward premium ($F_{f/d} > S_{f/d}$) if, and only if, the foreign risk-free interest rate exceeds the domestic risk-free interest rate ($i_f > i_d$).

For the sake of simplicity, we assume that the investment horizon is one year, so that

$$F_{f/d} - S_{f/d} = S_{f/d} \left(\frac{i_f - i_d}{1 + i_d} \right).$$

Because the $1 + i_d$ denominator will be close to 1, we can approximate the above equation as follows:

$$F_{f/d} - S_{f/d} \approx S_{f/d} (i_f - i_d).$$

This covered interest rate parity equation can be rearranged to show the forward discount or premium as a percentage of the spot rate:

$$\frac{F_{f/d} - S_{f/d}}{S_{f/d}} \approx i_f - i_d.$$

We have also shown that if uncovered interest rate parity holds, then the expected change in the spot rate is equal to the interest rate differential:

$$\% \Delta S_{f/d}^e = i_f - i_d.$$

We can link the covered interest rate parity and uncovered interest rate parity equations as follows:

$$\frac{F_{f/d} - S_{f/d}}{S_{f/d}} = \% \Delta S_{f/d}^e = i_f - i_d.$$

Thus, the forward premium (discount) on a currency, expressed in percentage terms, equals the expected percentage appreciation (depreciation) of the domestic currency (assuming that the uncovered interest rate parity condition holds).

In theory, then, *the forward exchange rate will be an unbiased forecast of the future spot exchange rate if both covered and uncovered interest rate parity hold:*

$$F_{fd} = S_{fd}^e$$

This condition is often referred to as **forward rate parity**.

We know covered interest rate parity must hold because it is enforced by arbitrage. *The question of whether forward rate parity holds is thus dependent upon whether uncovered interest rate parity holds.*

How might uncovered interest rate parity be enforced? It is not enforced by arbitrage because there is no combination of trades that will lock in a (riskless) profit. It could, however, hold if speculators willing to take risk enter the market. If the forward rate is above (below) speculators' expectations of the future spot rate, then risk-neutral speculators will buy the domestic currency in the spot (forward) market and simultaneously sell it in the forward (spot) market. These transactions would push the forward premium into alignment with the consensus expectation of the future spot rate. If the speculators' expectations are correct, they will make a profit.

Note, however, that spot exchange rates are volatile and determined by a complex web of influences: Interest rate differentials are only one among many factors. So, speculators can also lose. Because speculators are rarely, if ever, truly risk neutral and without an arbitrage relationship to enforce it, uncovered interest rate parity is often violated. *As a result, we can conclude that forward exchange rates are typically poor predictors of future spot exchange rates in the short run.* Over the longer term, uncovered interest rate parity and forward rate parity have more empirical support.

EXAMPLE 4

Covered and Uncovered Interest Rate Parity: Predictors of Future Spot Rates

An Australia-based fixed-income asset manager is deciding how to allocate money between Australia and Japan. Note that the base currency in the exchange rate quote (AUD) is the domestic currency for the asset manager.

JPY/AUD spot rate (mid-market)	71.78
One-year forward points (mid-market)	-139.4
One-year Australian deposit rate	3.00%
One-year Japanese deposit rate	1.00%

- Based on uncovered interest rate parity, over the next year, the expected change in the JPY/AUD rate is *closest* to a(n):

- A. decrease of 6%.
- B. decrease of 2%.
- C. increase of 2%.

Solution

B is correct. The expected depreciation of the Australian dollar (decline in the JPY/AUD rate) is equal to the interest rate differential between Australia and Japan (3% – 1%).

2. The *best* explanation of why this prediction may not be very accurate is that:
- A. covered interest rate parity does hold in this case.
 - B. the forward points indicate that a riskless arbitrage opportunity exists.
 - C. there is no arbitrage condition that forces uncovered interest rate parity to hold.

Solution

C is correct. There is no arbitrage condition that forces uncovered interest rate parity to hold. In contrast, arbitrage virtually always ensures that covered interest rate parity holds. This is the case for our table, where the -139 point discount is calculated from the covered interest rate equation.

3. Using the forward points to forecast the future JPY/AUD spot rate one year ahead assumes that:
- A. investors are risk neutral.
 - B. spot rates follow a random walk.
 - C. it is not necessary for uncovered interest rate parity to hold.

Solution

A is correct. Using forward rates (i.e., adding the forward points to the spot rate) to forecast future spot rates assumes that uncovered interest rate parity and forward rate parity hold. Uncovered interest rate parity assumes that investors are risk neutral. If these conditions hold, then movements in the spot exchange rate, although they *approximate* a random walk, will not actually be a random walk because current interest spreads will determine expected exchange rate movements.

4. Forecasting that the JPY/AUD spot rate one year from now will equal 71.78 assumes that:
- A. investors are risk neutral.
 - B. spot rates follow a random walk.
 - C. it is necessary for uncovered interest rate parity to hold.

Solution

B is correct. Assuming that the current spot exchange rate is the best predictor of future spot rates assumes that exchange rate movements follow a random walk. If uncovered interest rate parity holds, the current exchange rate will not be the best predictor unless the interest rate differential happens to be zero. Risk neutrality is needed to enforce uncovered interest rate parity, but it will not make the current spot exchange rate the best predictor of future spot rates.

5. If the asset manager completely hedged the currency risk associated with a one-year Japanese deposit using a forward rate contract, the one-year all-in holding return, in AUD, would be *closest* to:
- A. 0%.
 - B. 1%.
 - C. 3%.

Solution

C is correct. A fully hedged JPY investment would provide the same return as the AUD investment: 3%. This represents covered interest rate parity, an arbitrage condition.

6. The fixed-income manager collects the following information and uses it, along with the international parity conditions, to estimate investment returns and future exchange rate movements.

	Today's One-Year MRR	Currency Pair	Spot Rate Today
JPY	0.10%	JPY/USD	105.40
USD	0.10%	USD/GBP	1.2303
GBP	3.00%	JPY/GBP	129.67

If covered interest rate parity holds, the all-in one-year investment return to a Japanese investor whose currency exposure to the GBP is fully hedged is *closest* to:

- A. 0.10%.
- B. 0.17%.
- C. 3.00%.

Solution

A is correct. If covered interest rate parity holds (and it very likely does, because this is a pure arbitrage relationship), then the all-in investment return to a Japanese investor in a one-year, fully hedged GBP MRR position would be identical to a one-year JPY MRR position: 0.10%. No calculations are necessary.

7. If uncovered interest rate parity holds, today's expected value for the JPY/GBP currency pair one year from now would be *closest* to:

- A. 126.02.
- B. 129.67.
- C. 130.05.

Solution

A is correct. If uncovered interest rate parity holds, then forward rate parity will hold and the expected spot rate one year forward is equal to the one-year forward exchange rate. This forward rate is calculated in the usual manner, given the spot exchange rates and MRRs:

$$S^e = F = 129.67(1.001/1.03) = 126.02.$$

8. If uncovered interest rate parity holds, between today and one year from now, the expected movement in the JPY/USD currency pair is *closest* to:

- A. -1.60%.
- B. +0.00%.
- C. +1.63%.

Solution

B is correct. Given uncovered interest rate parity, the expected change in a spot exchange rate is equal to the interest rate differential. At the one-year term, there is no difference between USD MRR and JPY MRR.

PURCHASING POWER PARITY

8

- explain international parity conditions (covered and uncovered interest rate parity, forward rate parity, purchasing power parity, and the international Fisher effect)
- describe relations among the international parity conditions
- evaluate the use of the current spot rate, the forward rate, purchasing power parity, and uncovered interest parity to forecast future spot exchange rates

So far, we have looked at the relationship between exchange rates and interest rate differentials. Now, we turn to examining the relationship between exchange rates and inflation differentials. The basis for this relationship is known as **purchasing power parity (PPP)**.

Various versions of PPP exist. The foundation for all of the versions is the law of one price. According to the **law of one price**, identical goods should trade at the same price across countries when valued in terms of a common currency. To simplify the explanation, as we did with our examples for covered and uncovered interest rate parity, let's continue to use the foreign/domestic currency quote convention (*f/d*) and the case where the base currency in the P/B notation is the domestic currency for the investor in the *f/d* notation.

The law of one price asserts that the foreign price of good *x*, P_f^x , should equal the exchange rate-adjusted price of the identical good in the domestic country, P_d^x :

$$P_f^x = S_{f/d} \times P_d^x$$

For example, for a euro-based consumer, if the price of good *x* in the euro area is EUR 100 and the nominal exchange rate stands at 1.15 USD/EUR, then the price of good *x* in the United States should equal USD 115.

The **absolute version of PPP** simply extends the law of one price to the broad range of goods and services that are consumed in different countries. Expanding our example above to include all goods and services, not just good *x*, the broad price level of the foreign country (P_f) should equal the currency-adjusted broad price level in the domestic country (P_d):

$$P_f = (S_{f/d})(P_d)$$

This equation implicitly assumes that all domestic and foreign goods are tradable and that the domestic and foreign price indexes include the same bundle of goods and services with the same exact weights in each country. Rearranging this equation and solving for the nominal exchange rate ($S_{f/d}$), the absolute version of PPP states that the nominal exchange rate will be determined by the ratio of the foreign and domestic broad price indexes:

$$S_{f/d} = P_f / P_d$$

The absolute version of PPP asserts that the equilibrium exchange rate between two countries is determined entirely by the ratio of their national price levels. However, it is highly unlikely that this relationship actually holds in the real world. The absolute version of PPP assumes that goods arbitrage will equate the prices of all goods and service across countries, but if transaction costs are significant and/or not all goods and services are tradable, then goods arbitrage will be incomplete. Hence, sizable and persistent departures from absolute PPP are likely.

However, if it is assumed that transaction costs and other trade impediments are constant over time, it might be possible to show that *changes* in exchange rates and *changes* in national price levels are related, even if the relationship between exchange rate *levels* and national price *levels* does not hold. According to the **relative version of PPP**, the percentage change in the spot exchange rate ($\%ΔS_{f/d}$) will be completely determined by the difference between the foreign and domestic inflation rates ($π_f - π_d$):

$$\%ΔS_{f/d} \cong π_f - π_d \quad (3)$$

Intuitively, the relative version of PPP implies that the exchange rate changes to offset changes in competitiveness arising from inflation differentials. For example, if the foreign inflation rate is assumed to be 9% while the domestic inflation rate is assumed to be 5%, then the $S_{f/d}$ exchange rate must rise by 4% ($\%ΔS_{f/d} = 9\% - 5\% = 4\%$) in order to maintain the relative competitiveness of the two regions: The currency of the high-inflation country should depreciate relative to the currency of the low-inflation country. If the $S_{f/d}$ exchange rate remained unchanged, the higher foreign inflation rate would erode the competitiveness of foreign companies relative to domestic companies.

Conversion from Absolute Levels to a Rate of Change

We will occasionally need to convert from a relationship expressed in levels of the relevant variables to a relationship among rates of change. If $X = (Y × Z)$, then

$$(1 + \%ΔX) = (1 + \%ΔY)(1 + \%ΔZ)$$

and

$$\%ΔX \approx \%ΔY + \%ΔZ$$

because ($\%ΔY × \%ΔZ$) is “small.” Similarly, it can be shown that if $X = (Y/Z)$, then

$$(1 + \%ΔX) = (1 + \%ΔY)/(1 + \%ΔZ)$$

and

$$\%ΔX \approx \%ΔY - \%ΔZ.$$

Applying this conversion to the equation for absolute PPP gives Equation 3.

Whereas the relative version of PPP focuses on *actual* changes in exchange rates being driven by *actual* differences in national inflation rates, the **ex ante version of PPP** asserts that the *expected* changes in the spot exchange rate are entirely driven by *expected* differences in national inflation rates. *Ex ante* PPP tells us that countries that are expected to run *persistently* high inflation rates should expect to see their currencies depreciate over time, while countries that are expected to run relatively low inflation rates on a sustainable basis should expect to see their currencies appreciate over time. *Ex ante* PPP can be expressed as

$$\%ΔS_{f/d}^e = π_f^e - π_d^e, \quad (4)$$

where it is understood that the use of expectations (the superscript *e*) indicates that we are now focused on *future* periods. That is, $\%ΔS_{f/d}^e$ represents the expected percentage change in the spot exchange rate, while $π_d^e$ and $π_f^e$ represent the expected domestic and foreign inflation rates over the same period.

Studies have found that while *over shorter horizons nominal exchange rate movements may appear random*, *over longer time horizons nominal exchange rates tend to gravitate toward their long-run PPP equilibrium values*.

Exhibit 2 illustrates the success, or lack thereof, of the relative version of PPP at different time horizons: 1 year, 5 years, 10 years, and 15 years for a selection of countries over the period 1990-2020. Each chart plots the inflation differential (vertical axis) against the percentage change in the exchange rate (horizontal axis). If PPP holds, the points should fall along an upward-sloping diagonal line. The first panel of Exhibit 2 indicates no clear relationship between changes in exchange rates and inflation differentials at the one-year time horizon. As the time horizon is lengthened to five years and beyond, however, a strong positive relationship becomes apparent. Hence, *PPP appears to be a valid framework for assessing long-run fair value in the FX markets, even though the path to PPP equilibrium may be slow.*

Exhibit 2: Effect of Relative Inflation Rates on Exchange Rates at Different Time Horizons

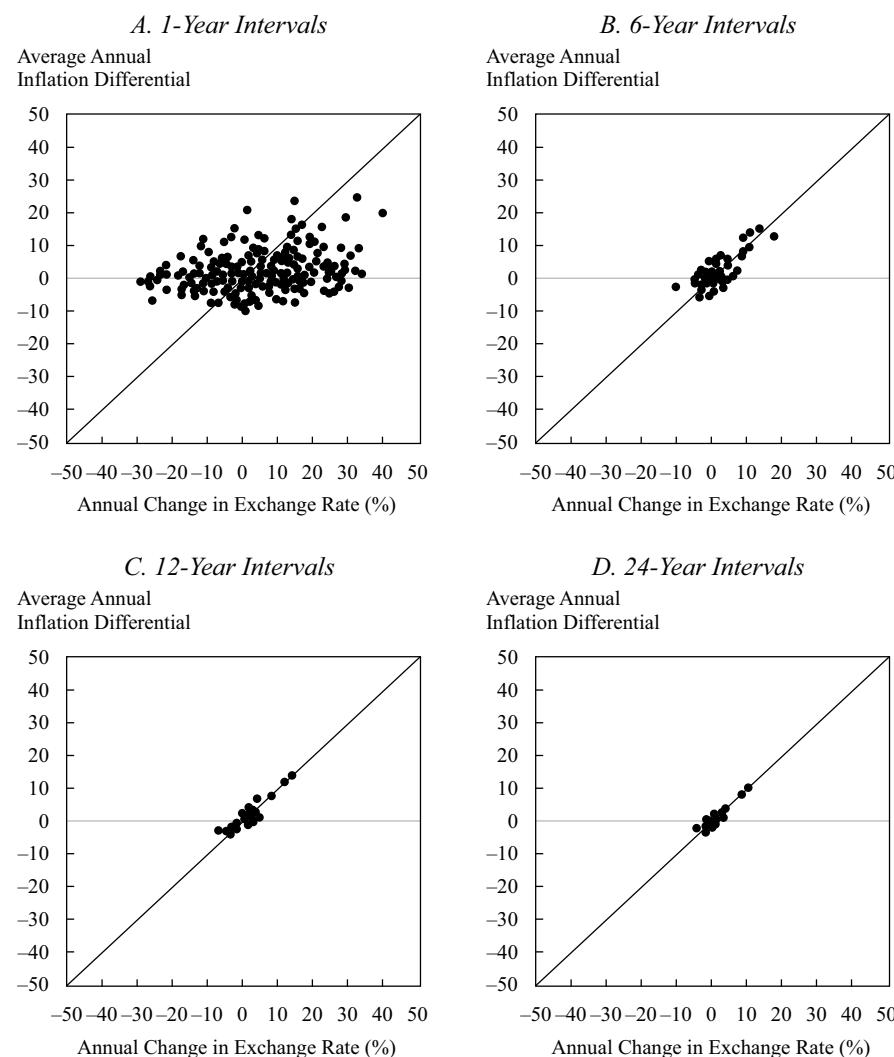
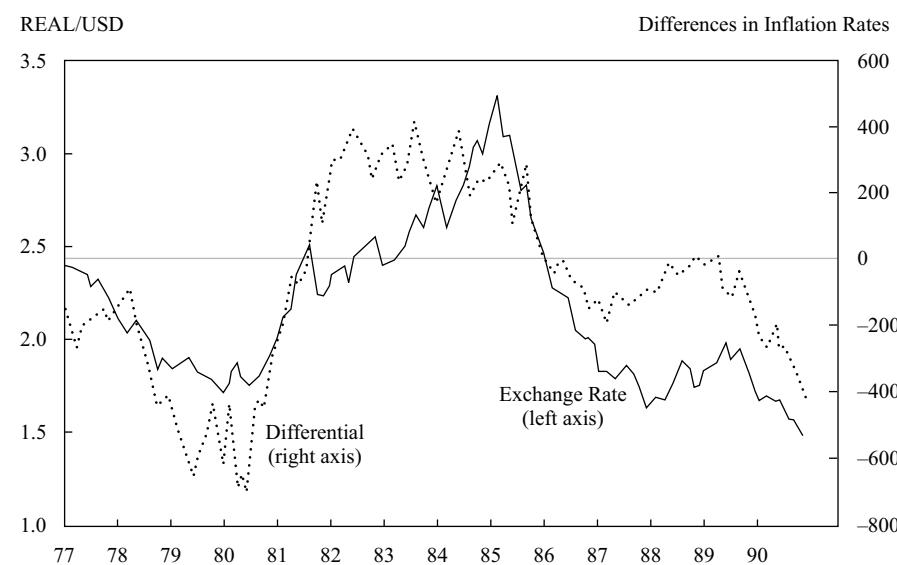


Exhibit 3 illustrates the success of the relative version of PPP even in the short run when differences in inflation rates between countries are large. Note that the Brazilian Real-USD exchange rate changes rapidly in the period 1980-1993, mirroring the very large differences in relative inflation between hyperinflationary Brazil and low inflation rate United States. It also indicates that the majority countries did not have large

inflation differentials with the United States, and so 1-year changes in exchange rates cluster near the origin. This mirrors the upper left panel in Exhibit 2 above, which excludes Brazil from the sample of countries.

Exhibit 3: Effect of Large Differences in Inflation Rates on Exchange Rates over 1-Year Time Horizons



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THE FISHER EFFECT, REAL INTEREST RATE PARITY, AND INTERNATIONAL PARITY CONDITIONS

- explain international parity conditions (covered and uncovered interest rate parity, forward rate parity, purchasing power parity, and the international Fisher effect)
- describe relations among the international parity conditions
- evaluate the use of the current spot rate, the forward rate, purchasing power parity, and uncovered interest parity to forecast future spot exchange rates
- explain approaches to assessing the long-run fair value of an exchange rate

So far, we have examined the relationships between exchange rates and interest rate differentials and between exchange rates and inflation differentials. Now, we will begin to bring these concepts together by examining how exchange rates, interest rates, and inflation rates interact.

According to what economists call the Fisher effect, one can break down the nominal interest rate (i) in a given country into two parts: (1) the real interest rate (r) in that particular country and (2) the expected inflation rate (π^e) in that country:

$$i = r + \pi^e.$$

To relate this concept to exchange rates, we can write the Fisher equation for both the domestic country and a foreign country. If the Fisher effect holds, the nominal interest rates in both countries will equal the sum of their respective real interest rates and expected inflation rates:

$$\begin{aligned} i_d &= r_d + \pi_d^e \\ i_f &= r_f + \pi_f^e. \end{aligned}$$

Let's take a closer look at the macroeconomic forces that drive the trend in nominal yield spreads. Subtracting the top equation from the bottom equation shows that the nominal yield spread between the foreign and domestic countries ($i_f - i_d$) equals the sum of two parts: (1) the foreign–domestic real yield spread ($r_f - r_d$) and (2) the foreign–domestic expected inflation differential ($\pi_f^e - \pi_d^e$):

$$i_f - i_d = (r_f - r_d) + (\pi_f^e - \pi_d^e).$$

We can rearrange this equation to solve for the *real* interest rate differential instead of the *nominal* interest rate differential:

$$(r_f - r_d) = (i_f - i_d) - (\pi_f^e - \pi_d^e).$$

To tie this material to our previous work on exchange rates, recall our expression for uncovered interest rate parity:

$$\% \Delta S_{f/d}^e = i_f - i_d.$$

The nominal interest rate spread ($i_f - i_d$) equals the expected change in the exchange rate ($\% \Delta S_{f/d}^e$).

Recall also the expression for *ex ante* PPP:

$$\% \Delta S_{f/d}^e = \pi_f^e - \pi_d^e.$$

The difference in expected inflation rates equals the expected change in the exchange rate. Combining these two expressions, we derive the following:

$$i_f - i_d = \pi_f^e - \pi_d^e.$$

The nominal interest rate spread is equal to the difference in expected inflation rates. We can therefore conclude that if uncovered interest rate parity and *ex ante* PPP hold,

$$(r_f - r_d) = 0.$$

The real yield spread between the domestic and foreign countries ($r_f - r_d$) will be zero, and the level of real interest rates in the domestic country will be identical to the level of real interest rates in the foreign country.

The proposition that real interest rates will converge to the same level across different markets is known as the **real interest rate parity** condition.

Finally, if real interest rates are equal across markets, then it also follows that the foreign–domestic nominal yield spread is determined solely by the foreign–domestic expected inflation differential:

$$i_f - i_d = \pi_f^e - \pi_d^e.$$

This is known as the **international Fisher effect**. The reader should be aware that some authors refer to uncovered interest rate parity as the “international Fisher effect.” We reserve this term for the relationship between nominal interest rate differentials and expected inflation differentials because the original (domestic) Fisher effect is a relationship between interest rates and expected inflation.

The international Fisher effect and, by extension, real interest rate parity assume that currency risk is the same throughout the world. However, not all currencies carry the same risk. For example, an emerging country may have a high level of indebtedness, which could result in an elevated level of currency risk (i.e., likelihood of currency depreciation). In this case, because the emerging market currency has higher risk, subtracting the expected inflation rate from the nominal interest rate will result in a calculated real interest rate that is higher than in other countries. Economists typically separate the nominal interest rate into the real interest rate, an inflation premium, and a risk premium. The emerging country's investors will require a risk premium for holding the currency, which will be reflected in nominal and real interest rates that are higher than would be expected under the international Fisher effect and real interest rate parity conditions.

EXAMPLE 5

PPP and the International Fisher Effect

An Australia-based fixed-income investment manager is deciding how to allocate her portfolio between Australia and Japan. (As before, the AUD is the domestic currency.) Australia's one-year deposit rate is 3%, considerably higher than Japan's 1% rate, but the Australian dollar is estimated to be roughly 10% overvalued relative to the Japanese yen based on purchasing power parity. Before making her asset allocation, the investment manager considers the implications of interest rate differentials and PPP imbalances.

1. All else equal, which of the following events would restore the Australian dollar to its PPP value?
 - A. The Japanese inflation rate increases by 2%.
 - B. The Australian inflation rate decreases by 10%.
 - C. The JPY/AUD exchange rate declines by 10%.

Solution

C is correct. If the Australian dollar is overvalued by 10% on a PPP basis, with all else held equal, a depreciation of the JPY/AUD rate by 10% would move the Australian dollar back to equilibrium.

2. If real interest rates in Japan and Australia were equal, then under the international Fisher effect, the inflation rate differential between Japan and Australia would be *closest* to:
 - A. 0%.
 - B. 2%.
 - C. 10%.

Solution

B is correct. If the real interest rates were equal, then the difference in nominal yields would be explained by the difference in inflation rates ($3\% - 1\%$).

3. According to the theory and empirical evidence of purchasing power parity, which of the following would *not* be true if PPP holds in the long run?
 - A. An exchange rate's equilibrium path should be determined by the long-term trend in domestic price levels relative to foreign price levels.

- B. Deviations from PPP might occur over short- and medium-term periods, but fundamental forces should eventually work to push exchange rates toward their long-term PPP path.
- C. High-inflation countries should tend to see their currencies appreciate over time.

Solution

C is correct. According to PPP, high-inflation countries should see their currencies depreciate (at least, over the longer term) in order to re-equilibrate real purchasing power between countries.

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- 4. Which of the following would *best* explain the failure of the absolute version of PPP to hold?
 - A. Inflation rates vary across countries.
 - B. Real interest rates are converging across countries.
 - C. Trade barriers exist, and different product mixes are consumed across countries.

Solution

C is correct. The absolute version of PPP assumes that all goods and services are tradable and that the domestic and foreign price indexes include the same bundle of goods and services with the same exact weights in each country.

International Parity Conditions: Tying All the Pieces Together

As noted above, the various parity relationships usually do not hold over short time horizons. However, studies show that over longer time periods, there is a discernible interaction among nominal interest rates, exchange rates, and inflation rates across countries, such that the international parity conditions serve as an anchor for longer-term exchange rate movements. We now summarize the key international parity conditions and describe how they are all linked.

- 1. According to covered interest rate parity, arbitrage ensures that nominal interest rate spreads equal the percentage forward premium (or discount).
- 2. According to uncovered interest rate parity, the expected percentage change of the spot exchange rate should, on average, be reflected in the nominal interest rate spread.
- 3. If both covered and uncovered interest rate parity hold—that is, the nominal yield spread equals both the forward premium (or discount) and the expected percentage change in the spot exchange rate—then the forward exchange rate will be an unbiased predictor of the future spot exchange rate.
- 4. According to the *ex ante* PPP approach to exchange rate determination, the expected change in the spot exchange rate should equal the expected difference between domestic and foreign inflation rates.
- 5. Assuming the Fisher effect holds in all markets—that is, the nominal interest rate in each market equals the real interest rate plus the expected inflation rate—and also assuming that real interest rates are broadly the same across all markets (real interest rate parity), then the nominal yield spread between domestic and foreign markets will equal the domestic–foreign expected inflation differential, which is the international Fisher effect.

6. If *ex ante* PPP and the international Fisher effect hold, then expected inflation differentials should equal both the expected change in the exchange rate and the nominal interest rate differential. This relationship implies that the expected change in the exchange rate equals the nominal interest rate differential, which is uncovered interest rate parity.

In sum, if all the key international parity conditions held at all times, then the expected percentage change in the *spot* exchange rate would equal

- the forward premium or discount (expressed in percentage terms),
- the nominal yield spread between countries, and
- the difference between expected national inflation rates.

In other words, *if all these parity conditions held, it would be impossible for a global investor to earn consistent profits on currency movements.* If forward exchange rates accurately predicted the future path of spot exchange rates, there would be no way to make money in forward exchange speculation. If high-yield currencies fell in value versus low-yield currencies exactly in line with the path implied by nominal interest rate spreads, all markets would offer the same currency-adjusted total returns over time. Investors would have no incentive to shift funds from one market to another based solely on currency considerations.

EXAMPLE 6

The Relationships among the International Parity Conditions

1. Which of the following is a no-arbitrage condition?

- A. Real interest rate parity
- B. Covered interest rate parity
- C. Uncovered interest rate parity

Solution

B is correct. Covered interest rate parity is enforced by equating the investment return on two riskless investments (domestic and currency-hedged foreign).

2. Forward rates are unbiased predictors of future spot rates if two parity conditions hold. Which of the following is *not* one of these conditions?

- A. Real interest rate parity
- B. Covered interest rate parity
- C. Uncovered interest rate parity

Solution

A is correct. Both covered and uncovered interest rate parity must hold for the forward rate to be an unbiased predictor of the future spot rate. Real interest rate parity is not required.

3. The international Fisher effect requires all but which of the following to hold?

- A. *Ex ante* PPP
- B. Absolute PPP

C. Real interest rate parity**Solution**

B is correct. The international Fisher effect is based on real interest rate parity and *ex ante* PPP (not absolute PPP).

4. The forward premium/discount is determined by nominal interest rate differentials because of:

- A.** the Fisher effect.
- B.** covered interest parity.
- C.** real interest rate parity.

Solution

B is correct. The forward premium/discount is determined by covered interest rate arbitrage.

5. If all of the key international parity conditions held at all times, then the expected percentage change in the spot exchange rate would equal all *except* which of the following?

- A.** The real yield spread
- B.** The nominal yield spread
- C.** The expected inflation spread

Solution

A is correct. If all the international parity conditions held, the real yield spread would equal zero, regardless of expected changes in the spot exchange rate.

THE CARRY TRADE**10**

describe the carry trade and its relation to uncovered interest rate parity and calculate the profit from a carry trade

According to uncovered interest rate parity, high-yield currencies are expected to depreciate in value, while low-yield currencies are expected to appreciate in value. If uncovered interest rate parity held at all times, investors would not be able to profit from a strategy that undertook long positions in high-yield currencies and short positions in low-yield currencies. The change in spot rates over the tenor of the forward contracts would cancel out the interest rate differentials locked in at the inception of the position.

Uncovered interest rate parity is one of the most widely tested propositions in international finance. The evidence suggests that uncovered interest rate parity does *not* hold over short and medium time periods. Studies have generally found that *high-yield currencies, on average, have not depreciated and low-yield currencies have not appreciated to the levels predicted by interest rate differentials.*

These findings underscore the potential profitability of a trading strategy known as the **FX carry trade**, which involves taking long positions in high-yield currencies and short positions in low-yield currencies. The latter are often referred to as “funding currencies.” As a simplified example of the carry trade, assume a trader can borrow

Canadian dollars at 1% and earn 9% on an investment in Brazilian reals for one year. To execute the trade to earn 8% from the interest rate differential, the trader will do the following:

1. Borrow Canadian dollars at $t = 0$.
2. Sell the dollars and buy Brazilian reals at the spot rate at $t = 0$.
3. Invest in a real-denominated investment at $t = 0$.
4. Liquidate the Brazilian investment at $t = 1$.
5. Sell the reals and buy dollars at the spot rate at $t = 1$.
6. Pay back the dollar loan.

If the real appreciates, the trader's profits will be greater than 8% because the stronger real will buy more dollars in one year. If the real depreciates, the trader's profits will be less than 8% because the weaker real will buy fewer dollars in the future. If the real falls in value by more than 8%, the trader will experience losses. The carry trader's return consists of the intermarket yield spread, the currency appreciation/depreciation, and the foreign investment appreciation/depreciation. Typically, a carry trade is executed using an investment in highly rated government debt so as to mitigate credit risk. In this simplified example, we use an additive approach to determine the trader's returns (i.e., we ignore the currency gain or loss on the 8% interest rate differential).

Historical evidence shows that carry trade strategies have generated positive returns over extended periods (see for example Dimson, Marsh, McGinnie, Staunton, and Wilmot 2012). One argument for the persistence of the carry trade is that the yields in higher interest rate countries reflect a risk premium due to a more unstable economy, while low-yield currencies represent less risky markets. Although small increases in financial market and/or FX volatility are unlikely to materially affect carry strategy profits, elevated levels of volatility and/or perceived risk in the financial markets can quickly turn these profits into substantial losses. That is, during turbulent periods, the returns on long high-yield currency positions will tend to decline dramatically, while the losses on short low-yield currency positions will tend to rise dramatically.

To understand why, we need to understand the nature of the risk and reward in the carry trade. The reward is the gradual accrual of the interest rate differential—income that is unrelated to exchange rate volatility. The risk arises from the potential for sudden adverse exchange rate movements that result in instantaneous capital losses. During periods of low turbulence, investors may feel relatively confident that exchange rate movements will not jeopardize the gradual accrual of the interest rate differential. Because low-volatility regimes have tended to be the norm and often last for extended periods, investors can become complacent, taking on larger carry trade positions in a search for yield but increasing their risk exposures. When volatility in the currency markets spikes, however, the risk of an adverse exchange rate movement rises sharply relative to the gradual flow of income. As the trade moves toward unprofitability, investors may rush to unwind the carry trade, selling high-yielding currencies and re-purchasing low-yielding currencies. These carry trades are often large-scale trades initiated by trading firms and other opportunistic investors, such as hedge funds. Traders often have stop-loss orders in place that are triggered when price declines reach a certain level. When they all attempt to unwind the trades at once, the selling pressure adds to the losses on the long position currency and the buying pressure on the short position currency drives that currency higher, exacerbating the loss. The “flight to quality” during turbulent times and the leverage inherent in the carry trade further compound the losses. The upshot is that *during periods of low volatility, carry trades tend to generate positive returns, but they are prone to significant crash risk in turbulent times.*

The tendency for carry trades to experience periodic crashes results in a non-normal distribution of returns for both developed and emerging market (EM) carry trades. Relative to a normal distribution, the distributions tend to be more peaked, with fatter tails and negative skewness. The more peaked distribution around the mean implies that carry trades have typically generated a larger number of trades with small gains/losses than would occur with the normal distribution. Although carry trades have generated positive returns on average in the past, the negative skew and fat tails indicate that carry trades have tended to have more frequent and larger losses than would have been experienced had the return distribution been normal.

EXAMPLE 7**Carry Trade Strategies**

A currency fund manager is considering allocating a portion of her FX portfolio to carry trade strategies. The fund's investment committee asks the manager a number of questions about why she has chosen to become involved in FX carry trades and how she will manage the risk of potentially large downside moves associated with the unwinding of carry trades. Which of the following would be her *best* responses to the investment committee's questions?

1. Carry trades can be profitable when:
 - A. covered interest rate parity does not hold.
 - B. uncovered interest rate parity does not hold.
 - C. the international Fisher effect does not hold.
- Solution**

B is correct. The carry trade is based on the supposition that uncovered interest rate parity does not hold.
2. Over time, the return distribution of the fund's FX carry trades is *most* likely to resemble a:
 - A. normal distribution with fat tails.
 - B. distribution with fat tails and a negative skew.
 - C. distribution with thin tails and a positive skew.
- Solution**

B is correct. The "crash risk" of carry trades implies a fat-tailed distribution skewed toward a higher probability of large losses (compared with a normal distribution).
3. The volatility of the fund's returns relative to its equity base is *best* explained by:
 - A. leverage.
 - B. low deposit rates in the funding currency.
 - C. the yield spread between the high- and low-yielding currencies.
- Solution**

A is correct. Carry trades are leveraged trades (borrow in the funding currency, invest in the high-yield currency), and leverage increases the volatility in the investor's return on equity.

4. A Tokyo-based asset manager enters into a carry trade position based on borrowing in yen and investing in one-year Australian MRR.

Today's One-Year MRR	Currency Pair	Spot Rate Today	Spot Rate One Year Later
JPY 0.10%	JPY/USD	105.40	104.60
AUD 1.70%	USD/AUD	0.6810	0.6850

After one year, the all-in return to this trade, measured in JPY terms, would be *closest* to:

- A. +0.03%.
- B. +1.53%.
- C. +1.63%.

Solution

B is correct. To calculate the all-in return for a Japanese investor in a one-year AUD MRR deposit, we must first calculate the current and one-year-later JPY/AUD cross rates. Because USD 1.0000 buys JPY 105.40 today and AUD 1.0000 buys USD 0.6810 today, today's JPY/AUD cross rate is the product of these two numbers: $105.40 \times 0.6810 = 71.78$ (rounded to two decimal places). Similarly, one year later, the observed cross rate is $104.60 \times 0.6850 = 71.65$ (rounded to two decimal places).

Accordingly, measured in yen, the investment return for the unhedged Australian MRR deposit is

$$(1/71.78)(1 + 1.70\%)71.65 - 1 = 0.0152.$$

Against this 1.52% *gross* return, however, the manager must charge the borrowing costs to fund the carry trade investment (one-year JPY MRR was 0.10%). Hence, the *net* return on the carry trade is $1.52\% - 0.10\% = 1.42\%$. We can also calculate the profit using a transactional approach. Assuming an initial position of, for example, 100 yen (JPY 100), the investor will obtain $JPY 100 \times 1/JPY 71.78 = AUD 1.3931$. After one year, the investment will be worth $AUD 1.3931 \times 1.017 = AUD 1.4168$. Converting back to yen in one year results in $AUD 1.4168 \times JPY 71.65/AUD = JPY 101.51$. Paying off the yen loan results in a profit of $JPY 101.51 - (JPY 100 \times 1.001) = JPY 1.41$. This is equivalent to the 1.42% profit calculated previously (slight difference arising due to rounding).

11

THE IMPACT OF BALANCE OF PAYMENTS FLOWS



explain how flows in the balance of payment accounts affect currency exchange rates

As noted earlier, the parity conditions may be appropriate for assessing fair value for currencies over long horizons, but they are of little use as a real-time gauge of value. There have been many attempts to find a better framework for determining a currency's short- or long-run equilibrium value. In this section, we examine the influence of trade and capital flows.

A country's balance of payments consists of its current account as well as its capital and financial account. The official balance of payments accounts make a distinction between the "capital account" and the "financial account" based on the nature of the assets involved. For simplicity, we will use the term "capital account" here to reflect all investment/financing flows. Loosely speaking, the current account reflects flows in the real economy, which refers to that part of the economy engaged in the actual production of goods and services (as opposed to the financial sector). The capital account reflects financial flows. Decisions about trade flows (the current account) and investment/financing flows (the capital account) are typically made by different entities with different perspectives and motivations. Their decisions are brought into alignment by changes in market prices and/or quantities. One of the key prices—perhaps *the* key price—in this process is the exchange rate.

Countries that import more than they export will have a negative current account balance and are said to have current account deficits. Those with more exports than imports will have a current account surplus. A country's current account balance must be matched by an equal and opposite balance in the capital account. Thus, countries with current account deficits must attract funds from abroad in order to pay for the imports (i.e., they must have a capital account surplus).

When discussing the effect of the balance of payments components on a country's exchange rate, one must distinguish between short- and intermediate-term influences on the one hand and longer-term influences on the other. Over the long term, countries that run persistent current account deficits (net borrowers) often see their currencies depreciate because they finance their acquisition of imports through the continued use of debt. Similarly, countries that run persistent current account surpluses (net lenders) often see their currencies appreciate over time.

However, investment/financing decisions are usually the dominant factor in determining exchange rate movements, at least in the short to intermediate term. There are four main reasons for this:

- Prices of real goods and services tend to adjust much more slowly than exchange rates and other asset prices.
- Production of real goods and services takes time, and demand decisions are subject to substantial inertia. In contrast, liquid financial markets allow virtually instantaneous redirection of financial flows.
- Current spending/production decisions reflect only purchases/sales of current production, while investment/financing decisions reflect not only the financing of current expenditures but also the reallocation of existing portfolios.
- *Expected* exchange rate movements can induce very large short-term capital flows. This tends to make the *actual* exchange rate very sensitive to the currency views held by owners/managers of liquid assets.

In this section, we first examine the impact of current account imbalances on exchange rates. Then, we take a closer look at capital flows.

Current Account Imbalances and the Determination of Exchange Rates

Current account trends influence the path of exchange rates over time through several mechanisms:

- The flow supply/demand channel
- The portfolio balance channel
- The debt sustainability channel

We briefly discuss each of these mechanisms next.

The Flow Supply/Demand Channel

The flow supply/demand channel is based on a fairly simple model that focuses on the fact that purchases and sales of internationally traded goods and services require the exchange of domestic and foreign currencies in order to arrange payment for those goods and services. For example, if a country sold more goods and services than it purchased (i.e., the country was running a current account surplus), then the demand for its currency should rise, and vice versa. Such shifts in currency demand should exert upward pressure on the value of the surplus nation's currency and downward pressure on the value of the deficit nation's currency.

Hence, countries with persistent current account surpluses should see their currencies appreciate over time, and countries with persistent current account deficits should see their currencies depreciate over time. A logical question, then, would be whether such trends can go on indefinitely. At some point, domestic currency strength should contribute to deterioration in the trade competitiveness of the surplus nation, while domestic currency weakness should contribute to an improvement in the trade competitiveness of the deficit nation. Thus, the exchange rate responses to these surpluses and deficits should eventually help eliminate—in the medium to long run—the source of the initial imbalances.

The amount by which exchange rates must adjust to restore current accounts to balanced positions depends on a number of factors:

- The initial gap between imports and exports
- The response of import and export prices to changes in the exchange rate
- The response of import and export demand to changes in import and export prices

If a country imports significantly more than it exports, export growth would need to far outstrip import growth in percentage terms in order to narrow the current account deficit. A large initial deficit may require a substantial depreciation of the currency to bring about a meaningful correction of the trade imbalance.

A depreciation of a deficit country's currency should result in an increase in import prices in domestic currency terms and a decrease in export prices in foreign currency terms. However, empirical studies often find limited pass-through effects of exchange rate changes on traded goods prices. For example, many studies have found that for every 1% decline in a currency's value, import prices rise by only 0.5%—and in some cases by even less—because foreign producers tend to lower their profit margins in an effort to preserve market share. In light of the limited pass-through of exchange rate changes into traded goods prices, the exchange rate adjustment required to narrow a trade imbalance may be far larger than would otherwise be the case.

Many studies have found that the response of import and export demand to changes in traded goods prices is often quite sluggish, and as a result, relatively long lags, lasting several years, can occur between (1) the onset of exchange rate changes, (2) the ultimate adjustment in traded goods prices, and (3) the eventual impact of those price changes on import demand, export demand, and the underlying current account imbalance.

The Portfolio Balance Channel

The second mechanism through which current account trends influence exchange rates is the so-called portfolio balance channel. Current account imbalances shift financial wealth from deficit nations to surplus nations. Countries with trade deficits will finance their trade with increased borrowing. This behavior may lead to shifts in global asset preferences, which in turn could influence the path of exchange rates. For example,

nations running large current account surpluses versus the United States might find that their holdings of US dollar–denominated assets exceed the amount they desire to hold in a portfolio context. Actions they might take to reduce their dollar holdings to desired levels could then have a profound negative impact on the dollar's value.

The Debt Sustainability Channel

The third mechanism through which current account imbalances can affect exchange rates is the so-called debt sustainability channel. According to this mechanism, there should be some upper limit on the ability of countries to run persistently large current account deficits. If a country runs a large and persistent current account deficit over time, eventually it will experience an untenable rise in debt owed to foreign investors. If such investors believe that the deficit country's external debt is rising to unsustainable levels, they are likely to reason that a major depreciation of the deficit country's currency will be required at some point to ensure that the current account deficit narrows significantly and that the external debt stabilizes at a level deemed sustainable.

The existence of persistent current account imbalances will tend to alter the market's notion of what exchange rate level represents the true, long-run equilibrium value. For deficit nations, ever-rising net external debt levels as a percentage of GDP should give rise to steady (but not necessarily smooth) downward revisions in market expectations of the currency's long-run equilibrium value. For surplus countries, ever-rising net external asset levels as a percentage of GDP should give rise to steady upward revisions of the currency's long-run equilibrium value. Hence, one would expect currency values to move broadly in line with trends in debt and/or asset accumulation.

PERSISTENT CURRENT ACCOUNT DEFICITS: THE US CURRENT ACCOUNT AND THE US DOLLAR

The historical record indicates that the trend in the US current account has been an important determinant of the long-term swings in the US dollar's value but also that there can be rather long lags between the onset of a deterioration in the current account balance and an eventual decline in the dollar's value. For example, the US current account balance deteriorated sharply in the first half of the 1980s, yet the dollar soared over that period. The reason for the dollar's strength over that period was that high US real interest rates attracted large inflows of capital from abroad, which pushed the dollar higher despite the large US external imbalance. Eventually, however, concerns regarding the sustainability of the ever-widening US current account deficit triggered a major dollar decline in the second half of the 1980s.

History repeated itself in the second half of the 1990s, with the US current account balance once again deteriorating while the dollar soared over the same period. This time, the dollar's strength was driven by strong foreign direct investment, as well as both debt- and equity-related flows into the United States. Beginning in 2001, however, the ever-widening US current account deficit, coupled with a decline in US interest rates, made it more difficult for the United States to attract the foreign private capital needed to finance its current account deficit. The dollar eventually succumbed to the weight of ever-larger trade and current account deficits and began a multi-year slide, starting in 2002–2003. Interestingly, the US dollar has undergone three major downward cycles since the advent of floating exchange rates: 1977–1978, 1985–1987, and 2002–2008. In each of those downward cycles, the dollar's slide was driven in large part by concerns over outsized US current account deficits coupled with relatively low nominal and/or real short-term US interest rates, which made it difficult to attract sufficient foreign capital to the United States to finance those deficits.

EXCHANGE RATE ADJUSTMENT IN SURPLUS NATIONS: JAPAN AND CHINA

Japan and, for a number of years, China represent examples of countries with large current account surpluses and illustrate the pressure that those surpluses can bring to bear on currencies. In the case of Japan, its rising current account surplus has exerted persistent upward pressure on the yen's value versus the dollar over time. Part of this upward pressure simply reflected the increase in demand for yen to pay for Japan's merchandise exports. But some of the upward pressure on the yen might also have stemmed from rising commercial tensions between the United States and Japan.

Protectionist sentiment in the United States rose steadily with the rising bilateral trade deficit that the United States ran with Japan in the postwar period. US policymakers contended that the yen was undervalued and needed to appreciate. With the increasing trade imbalance between the two countries contributing to more heated protectionist rhetoric, Japan felt compelled to tolerate steady upward pressure on the yen. As a result, the yen's value versus the dollar has tended to move in sync with the trend in Japan's current account surplus.

12**CAPITAL FLOWS**

explain how flows in the balance of payment accounts affect currency exchange rates

Greater financial integration of the world's capital markets and greater freedom of capital to flow across national borders have increased the importance of global financial flows in determining exchange rates, interest rates, and broad asset price trends. One can cite many examples in which global financial flows either caused or contributed to extremes in exchange rates, interest rates, or asset prices.

In numerous cases, global capital flows have helped fuel boom-like conditions in emerging market economies for a while before, suddenly and often without adequate warning, those flows reversed. The reversals often caused a major economic downturn, sovereign default, a serious banking crisis, and/or significant currency depreciation. Excessive emerging market capital inflows often plant the seeds of a crisis by contributing to:

1. an unwarranted appreciation of the emerging market currency,
2. a huge buildup in external indebtedness,
3. an asset bubble,
4. a consumption binge that contributes to explosive growth in domestic credit and/or the current account deficit, or
5. an overinvestment in risky projects and questionable activities.

Governments in emerging markets often resist currency appreciation from excessive capital inflows by using capital controls or selling their currency in the FX market. An example of capital controls is the Brazilian government 2016 tax on foreign exchange transactions to control capital flows and raise government revenue. In general, government control of the exchange rate will not be completely effective because even if

a government prohibits investment capital flows, some capital flows will be needed for international trade. In addition, the existence or emergence of black markets for the country's currency will inhibit the ability of the government to fully control the exchange rates for its own currency.

Sometimes, capital flows due to interest rate spreads have little impact on the trend in exchange rates. Consider the case of the Turkish lira. The lira attracted a lot of interest on the part of global fund managers over the 2002–10 period, in large part because of its attractive yields. Turkish–US short-term yield spreads averaged over 1,000 bps during much of this period. As capital flowed into Turkey, the Turkish authorities intervened in the foreign exchange market in an attempt to keep the lira from appreciating. The result was that international investors were not able to reap the anticipated currency gains over this period. While the return from the movement in the spot exchange rate was fairly small, a long Turkish lira/short US dollar carry trade position generated significant long-run returns, mostly from the accumulated yield spread.

One-sided capital flows can persist for long periods. Consider the case of a high-yield, inflation-prone emerging market country that wants to promote price stability and long-term sustainable growth. To achieve price stability, policymakers in the high-yield economy will initiate a tightening in monetary policy by gradually raising the level of domestic interest rates relative to yield levels in the rest of the world. If the tightening in domestic monetary policy is sustained, inflation expectations for the high-yield economy relative to other economies should gradually decline. The combination of sustained wide nominal yield spreads and a steady narrowing in relative inflation expectations should exert upward pressure on the high-yield currency's value, resulting in carry trade profits over long periods.

Policymakers in high-yield markets can also pursue policies which attract foreign investment; such policies might include tighter fiscal policies, liberalization of financial markets, fewer capital flow restrictions, privatization, and/or a better business environment. Such policies should encourage investors to gradually require a lower risk premium to hold the high-yield currency's assets and revise upward their assessment of the long-run equilibrium value of that country's currency.

The historical evidence suggests that the impact of nominal interest rate spreads on the exchange rate tends to be gradual. Monetary policymakers tend to adjust their official lending rates slowly over time—in part because of the uncertainty that policymakers face and in part because the authorities do not want to disrupt the financial markets. This very gradual change in rates implies a very gradual narrowing of the spread between high-yield and low-yield countries. Similarly, the downward trends in inflation expectations and risk premiums in the higher-yield market also tend to unfold gradually. It often takes several years to determine whether structural economic changes will take root and boost the long-run competitiveness of the higher-yield country. Because these fundamental drivers tend to reinforce each other over time, there may be persistence in capital flows and carry trade returns.

Equity Market Trends and Exchange Rates

Increasing equity prices can also attract foreign capital. Although exchange rates and equity market returns sometimes exhibit positive correlation, the relationship between equity market performance and exchange rates is not stable. The long-run correlation between the US equity market and the dollar, for example, is very close to zero, but over short to medium periods, correlations tend to swing from being highly positive to being highly negative, depending on market conditions. For instance, between 1990 and 1995, the US dollar fell while the US equity market was strong and the Japanese yen soared while Japanese stocks were weak. In contrast, between 1995 and early 2000, the US dollar soared in tandem with a rising US equity market while the yen

weakened in tandem with a decline in the Japanese equity market. *Such instability in the correlation between exchange rates and equity markets makes it difficult to form judgments on possible future currency moves based solely on expected equity market performance.*

Since the global financial crisis, there has been a decidedly negative correlation between the US dollar and the US equity market. Market observers attribute this behavior of the US dollar to its role as a safe haven asset. When investors' appetite for risk is high—that is, when the market is in “risk-on” mode—investor demand for risky assets, such as equities, tends to rise, which drives up their prices. At the same time, investor demand for safe haven assets, such as the dollar, tends to decline, which drives their values lower. The opposite has occurred when the market has been in “risk-off” mode.

EXAMPLE 8

Capital Flows and Exchange Rates

Monique Kwan, a currency strategist at a major foreign exchange dealer, is responsible for formulating trading strategies for the currencies of both developed market (DM) and emerging market (EM) countries. She examines two countries—one DM and one EM—and notes that the DM country has what is considered a low-yield safe haven currency while the EM country has a high-yield currency whose value is more exposed to fluctuations in the global economic growth rate. Kwan is trying to form an opinion about movements in the exchange rate for the EM currency.

1. All else equal, the exchange rate for the EM currency will *most likely* depreciate if the:
 - A. long-run equilibrium value of the high-yield currency is revised upward.
 - B. nominal yield spread between the EM and DM countries increases over time.
 - C. expected inflation differential between the EM and DM countries is revised upward.

Solution

C is correct. All else equal, an increase in the expected inflation differential should lead to depreciation of the EM currency.

2. An increase in safe haven demand would *most likely*:
 - A. increase the risk premium demanded by international investors to hold assets denominated in the EM currency.
 - B. raise the return earned on carry trade strategies.
 - C. exert upward pressure on the value of the EM currency.

Solution

A is correct. During times of intense risk aversion, investors will crowd into the safe haven currency. This tendency implies an increased risk premium demanded by investors to hold the EM currency.

3. Kwan notes that the DM country is running a persistent current account deficit with the EM country. To isolate the influence of this chronic imbalance on exchange rates, she focuses only on the bilateral relationship between the EM and DM countries and makes the simplifying assumption

that the external accounts of these two countries are otherwise balanced (i.e., there are no other current account deficits).

Over time and all else equal, the persistent current account deficit with the EM country would *most likely* lead to:

- A. a large buildup of the EM country's assets held by the DM country.
- B. an increase in the trade competitiveness of the EM country.
- C. an upward revision in the long-run equilibrium EM currency value.

Solution

C is correct. Over time, the DM country will see its level of external debt rise as a result of the chronic current account imbalance. Eventually, this trend should lead to a downward revision of the DM currency's long-run equilibrium level (via the debt sustainability channel). This is equivalent to an *increase* in the EM currency's long-run exchange rate. A is incorrect because the DM country's current account deficit is likely to lead to a buildup in DM country assets held by the EM country. B is incorrect because, at some point, the currency strength should contribute to deterioration in the trade competitiveness of the country with the trade surplus (the EM country).

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4. Kwan notes that because of the high yield on the EM country's bonds, international investors have recently been reallocating their portfolios more heavily toward this country's assets. As a result of these capital inflows, the EM country has been experiencing boom-like conditions.

Given the current boom-like conditions in the EM economy, in the *near term*, these capital inflows are *most likely* to lead to:

- A. a decrease in inflation expectations in the EM.
- B. an increase in the risk premium for the EM.
- C. an increase in the EM currency value.

Solution

C is correct. Given the current investor enthusiasm for the EM country's assets and the boom-like conditions in the country, it is most likely that in the near term, the EM currency will appreciate. At the same time, expected inflation in the EM country is also likely increasing and—given the enthusiasm for EM assets—the risk premium is likely decreasing.

-
5. If these capital inflows led to an unwanted appreciation in the real value of its currency, the EM country's government would *most likely*:
- A. impose capital controls.
 - B. decrease taxes on consumption and investment.
 - C. buy its currency in the foreign exchange market.

Solution

A is correct. To reduce unwanted appreciation of its currency, the EM country would be most likely to impose capital controls to counteract the surging capital inflows. Because these inflows are often associated with overinvestment and consumption, the EM government would not be likely to encourage these activities through lower taxes. Nor would the EM country be likely to encourage further currency appreciation by intervening in the market to *buy* its own currency.

6. If government actions were ineffective and the EM country's bubble eventually burst, this would *most likely* be reflected in an increase in:

- A. the risk premium for the EM.
- B. the EM currency value.
- C. the long-run equilibrium EM currency value.

Solution

A is correct. Episodes of surging capital flows into EM countries have often ended badly (with a rapid reversal of these inflows as the bubble bursts). This is most likely to be reflected in an increase in the EM risk premium. It is much less likely that a bursting bubble would be reflected in an increase in either the EM currency value or its long-term equilibrium value.

7. Finally, Kwan turns to examining the link between the value of the DM country's currency and movements in the DM country's main stock market index. One of her research associates tells her that, in general, the correlation between equity market returns and changes in exchange rates has been found to be highly positive over time.

The statement made by the research associate is:

- A. correct.
- B. incorrect, because the correlation is highly negative over time.
- C. incorrect, because the correlation is not stable and tends to converge toward zero in the long run.

Solution

C is correct. Correlations between equity returns and exchange rates are unstable in the short term and tend toward zero in the long run.

13

MONETARY AND FISCAL POLICIES



explain the potential effects of monetary and fiscal policy on exchange rates

As the foregoing discussion indicates, government policies can have a significant impact on exchange rate movements. We now examine the channels through which government monetary and fiscal policies are transmitted.

The Mundell–Fleming Model

The Mundell–Fleming model describes how changes in monetary and fiscal policy within a country affect interest rates and economic activity, which in turn leads to changes in capital flows and trade and ultimately to changes in the exchange rate. The model focuses only on aggregate demand and assumes there is sufficient slack in the economy to allow increases in output without price level increases.

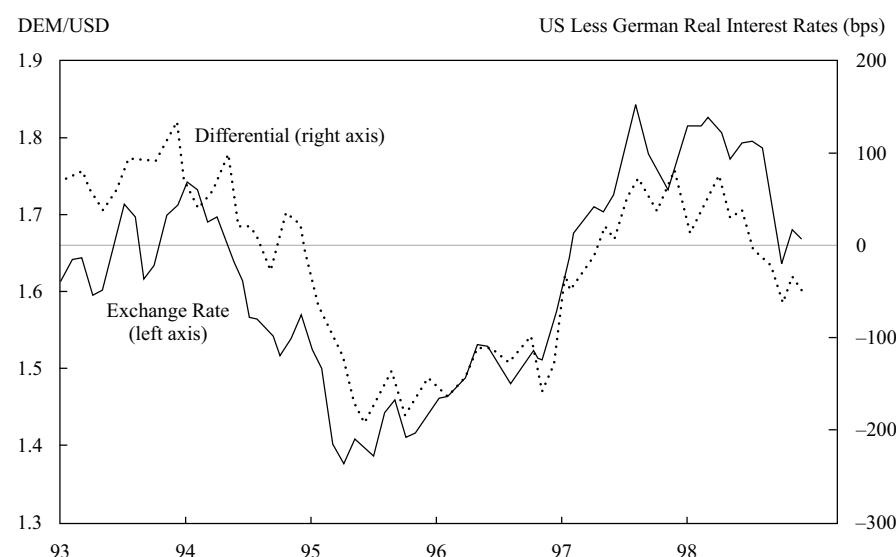
In this model, expansionary monetary policy affects growth, in part, by reducing interest rates and thereby increasing investment and consumption spending. Given flexible exchange rates and expansionary monetary policy, downward pressure on

domestic interest rates will induce capital to flow to higher-yielding markets, putting downward pressure on the domestic currency. The more responsive capital flows are to interest rate differentials, the greater the depreciation of the currency.

Expansionary fiscal policy—either directly through increased spending or indirectly via lower taxes—typically exerts upward pressure on interest rates because larger budget deficits must be financed. With flexible exchange rates and mobile capital, the rising domestic interest rates will attract capital from lower-yielding markets, putting upward pressure on the domestic currency. If capital flows are highly sensitive to interest rate differentials, then the domestic currency will tend to appreciate substantially. If, however, capital flows are immobile and very insensitive to interest rate differentials, the policy-induced increase in aggregate demand will increase imports and worsen the trade balance, creating downward pressure on the currency with no offsetting capital inflows to provide support for the currency.

The specific mix of monetary and fiscal policies in a country can have a profound effect on its exchange rate. Consider first the case of high capital mobility. With floating exchange rates and high capital mobility, a domestic currency will appreciate given a restrictive domestic monetary policy and/or an expansionary fiscal policy that results in higher real interest rates. Similarly, a domestic currency will depreciate given an expansionary domestic monetary policy and/or a restrictive fiscal policy that results in lower real interest rates. In Exhibit 4, we show that the combination of a restrictive monetary policy and an expansionary fiscal policy (higher real rates) is extremely bullish for a currency when capital mobility is high; likewise, the combination of an expansionary monetary policy and a restrictive fiscal policy (lower real rates) is bearish for a currency. The effect on the currency of monetary and fiscal policies that are both expansionary or both restrictive is indeterminate under conditions of high capital mobility.

Exhibit 4: Monetary–Fiscal Policy Mix and the Determination of Exchange Rates under Conditions of High Capital Mobility



Source: Rosenberg (1996, p. 132).

When capital mobility is low, the effects of monetary and fiscal policy on exchange rates will operate primarily through trade flows rather than capital flows. The combination of expansionary monetary *and* fiscal policy will be bearish for a currency.

Earlier we said that expansionary fiscal policy will increase imports and hence the trade deficit, creating downward pressure on the currency. Layering on an expansive monetary policy will further boost spending and imports, worsening the trade balance and exacerbating the downward pressure on the currency.

The combination of restrictive monetary *and* fiscal policy will be bullish for a currency. This policy mix will tend to reduce imports, leading to an improvement in the trade balance.

The impact of expansionary monetary and restrictive fiscal policies (or restrictive monetary and expansionary fiscal policies) on aggregate demand and the trade balance, and hence on the exchange rate, is indeterminate under conditions of low capital mobility. Exhibit 5 summarizes these results.

Exhibit 5: Monetary–Fiscal Policy Mix and the Determination of Exchange Rates under Conditions of Low Capital Mobility

		Expansionary Monetary Policy	Restrictive Monetary Policy
Expansionary Fiscal Policy	Domestic currency depreciates	Indeterminate	
	Indeterminate	Domestic currency appreciates	

Source: Adapted from Rosenberg (1996, p. 133).

Exhibit 4 is more relevant for the G–10 countries because capital mobility tends to be high in developed economies. Exhibit 5 is more relevant for emerging market economies that restrict capital movement.

A classic case in which a dramatic shift in the policy mix caused dramatic changes in exchange rates was that of Germany in 1990–1992. During that period, the German government pursued a highly expansionary fiscal policy to help facilitate German unification. At the same time, the Bundesbank pursued an extraordinarily restrictive monetary policy to combat the inflationary pressures associated with unification. The expansive fiscal/restrictive monetary policy mix drove German interest rates sharply higher, eventually causing the German currency to appreciate.

Monetary Models of Exchange Rate Determination

In the Mundell–Fleming model, monetary policy is transmitted to the exchange rate through its impact on interest rates and output. Changes in the price level and/or the inflation rate play no role. Monetary models of exchange rate determination generally take the opposite perspective: Output is fixed and monetary policy affects exchange rates primarily through the price level and the rate of inflation. In this section, we briefly describe two variations of the monetary approach to exchange rate determination.

The monetary approach asserts that an X percent rise in the domestic money supply will produce an X percent rise in the domestic price level. Assuming that purchasing power parity holds—that is, that changes in exchange rates reflect changes in relative inflation rates—a money supply–induced increase (decrease) in domestic prices relative to foreign prices should lead to a proportional decrease (increase) in the domestic currency's value.

One of the major shortcomings of the pure monetary approach is the assumption that purchasing power parity holds in both the short and long runs. Because purchasing power parity rarely holds in either the short or medium run, the pure monetary model may not provide a realistic explanation of the impact of monetary forces on the exchange rate.

To rectify that problem, Dornbusch (1976) constructed a modified monetary model that assumes prices have limited flexibility in the short run but are fully flexible in the long run. The long-run flexibility of the price level ensures that any increase in the domestic money supply will give rise to a proportional increase in domestic prices and thus contribute to a depreciation of the domestic currency in the long run, which is consistent with the pure monetary model. If the domestic price level is assumed to be inflexible in the short run, however, the model implies that the exchange rate is likely to overshoot its long-run PPP path in the short run. With inflexible domestic prices in the short run, any increase in the nominal money supply results in a decline in the domestic interest rate. Assuming that capital is highly mobile, the decline in domestic interest rates will precipitate a capital outflow, which in the short run will cause the domestic currency to depreciate below its new long-run equilibrium level. In the long run, once domestic nominal interest rates rise, the currency will appreciate and move into line with the path predicted by the conventional monetary approach.

Monetary Policy and Exchange Rates: The Historical Evidence

Historically, changes in monetary policy have had a profound impact on exchange rates. In the case of the US dollar, the Federal Reserve's policy of quantitative easing after the global financial crisis resulted in dollar depreciation from mid-2009 to 2011. The subsequent ending of quantitative easing in 2014, along with the anticipation that the United States would raise interest rates before many other countries, played a key role in driving the dollar higher.

Beginning in 2013, Abenomics—fiscal stimulus, monetary easing, and structural reforms—and the use of quantitative easing in Japan led to a steady decline in interest rates and eventually to negative interest rates in 2016. From 2013 to 2015, the value of the yen changed from roughly JPY 90/USD to JPY 120/USD. Likewise, the use of quantitative easing by the European Central Bank in 2015 led to declines in the value of the euro.

Excessively expansionary monetary policies by central banks in emerging markets have often planted the seeds of speculative attacks on their currencies. In the early 1980s, exchange rate crises in Argentina, Brazil, Chile, and Mexico were all preceded by sharp accelerations in domestic credit expansions. In 2012, Venezuela began a period of triple-digit inflation, followed by a massive currency depreciation and an economic crisis.

EXAMPLE 9**Monetary Policy and Exchange Rates**

Monique Kwan, the currency strategist at a major foreign exchange dealer, is preparing a report on the outlook for several currencies that she follows. She begins by considering the outlook for the currency of a developed market country with high capital mobility across its borders and a flexible exchange rate. This DM country also has low levels of public and private debt.

Given these conditions, Kwan tries to assess the impact of each of the following policy changes.

1. For the DM currency, increasing the degree of monetary easing (reducing interest rates and increasing money supply) will *most likely*:

- A. cause the currency to appreciate.
- B. cause the currency to depreciate.
- C. have an indeterminate effect on the currency.

Solution

B is correct. A decrease in the policy rate would most likely cause capital to re-allocate to higher-yielding markets. This would lead to currency depreciation.

2. The pursuit of an expansionary domestic fiscal policy by the DM country will, in the short run, *most likely*:

- A. cause the domestic currency's value to appreciate.
- B. cause the domestic currency's value to depreciate.
- C. have an indeterminate effect on the domestic currency's value.

Solution

A is correct. An expansionary fiscal policy will lead to higher levels of government debt and interest rates, which will attract international capital flows. (In the long run, however, an excessive buildup in debt may eventually cause downward pressure on the domestic currency.)

3. Next, Kwan turns her attention to an emerging market country that has low levels of public and private debt. Currently, the EM country has a fixed exchange rate but no controls over international capital mobility. However, the country is considering replacing its fixed exchange rate policy with a policy based on capital controls. These proposed controls are meant to reduce international capital mobility by limiting short-term investment flows ("hot money") in and out of its domestic capital markets.

To maintain the exchange rate peg while increasing the degree of monetary easing, the EM country will *most likely* have to:

- A. tighten fiscal policy.
- B. decrease interest rates.
- C. buy its own currency in the FX market.

Solution

C is correct. The looser monetary policy will lead to exchange rate depreciation. To counter this effect and maintain the currency peg, the central bank will have to intervene in the FX market, buying the country's own currency.

A is incorrect because tighter fiscal policy is associated with lower interest rates and is therefore likely to increase rather than mitigate the downward pressure on the domestic currency. Similarly, B is incorrect because a move to lower interest rates would exacerbate the downward pressure on the currency and hence the pressure on the peg.

4. After the EM country replaces its currency peg with capital controls, would its exchange rate be unaffected by a tightening in monetary policy?

- A. Yes.
- B. No, the domestic currency would appreciate.
- C. No, the domestic currency would depreciate.

Solution

B is correct. In general, capital controls will not completely eliminate capital flows but will limit their magnitude and responsiveness to investment incentives such as interest rate differentials. At a minimum, flows directly related to financing international trade will typically be allowed. The exchange rate will still respond to monetary policy. With limited capital mobility, however, monetary policy's main influence is likely to come through the impact on aggregate demand and the trade balance. A tighter domestic monetary policy will most likely lead to higher interest rates and less domestic demand, including less demand for imported goods. With fewer imports and with exports held constant, there will be modest upward pressure on the currency.

5. After the EM country replaces its currency peg with capital controls, the simultaneous pursuit of a tight monetary policy and a highly expansionary fiscal policy by the EM country will *most likely*:

- A. cause the currency to appreciate.
- B. cause the currency to depreciate.
- C. have an indeterminate effect on the currency.

Solution

C is correct because (1) capital mobility is low, so the induced increase in interest rates is likely to exert only weak upward pressure on the currency; (2) the combined impact on aggregate demand is indeterminate; and (3) if aggregate demand increases, the downward pressure on the currency due to a worsening trade balance may or may not fully offset the upward pressure exerted by capital flows.

The Portfolio Balance Approach

In this section, we re-examine the role fiscal policy plays in determining exchange rates. The Mundell–Fleming model is essentially a short-run model of exchange rate determination. It makes no allowance for the long-term effects of budgetary imbalances that typically arise from sustained fiscal policy actions. The portfolio balance approach to exchange rate determination remedies this limitation. In our previous discussion of the portfolio balance channel, we stated that the currencies of countries with trade deficits will decline over time. We expand that discussion here to more closely examine how exchange rates change over the long term.

In the **portfolio balance approach**, global investors are assumed to hold a diversified portfolio of domestic and foreign assets, including bonds. The desired allocation is assumed to vary in response to changes in expected return and risk considerations.

In this framework, a growing government budget deficit leads to a steady increase in the supply of domestic bonds outstanding. These bonds will be willingly held only if investors are compensated in the form of a higher expected return. Such a return could come from (1) higher interest rates and/or a higher risk premium, (2) immediate depreciation of the currency to a level sufficient to generate anticipation of gains from subsequent currency appreciation, or (3) some combination of these two factors. The currency adjustments required in the second mechanism are the core of the portfolio balance approach.

One of the major insights one should draw from the portfolio balance model is that *in the long run, governments that run large budget deficits on a sustained basis could eventually see their currencies decline in value.*

The Mundell–Fleming and portfolio balance models can be combined into a single integrated framework in which expansionary fiscal policy under conditions of high capital mobility may be positive for a currency in the short run but negative in the long run. Exhibit 6 illustrates this concept. A domestic currency may rise in value when the expansionary fiscal policy is first put into place. As deficits mount over time and the government's debt obligations rise, however, market participants will begin to wonder how that debt will be financed. If the volume of debt rises to levels that are believed to be unsustainable, market participants may believe that the central bank will eventually be pressured to "monetize" the debt—that is, to buy the government's debt with newly created money. Such a scenario would clearly lead to a rapid reversal of the initial currency appreciation. Alternatively, the market may believe that the government will eventually have to shift toward significant restraint to implement a more restrictive, sustainable fiscal policy over the longer term.

Exhibit 6: The Short- and Long-Run Response of Exchange Rates to Changes in Fiscal Policy

		Expansionary Monetary Policy	Restrictive Monetary Policy
Expansionary Fiscal Policy	Domestic currency depreciates	Indeterminate	
	Indeterminate	Domestic currency appreciates	
Restrictive Fiscal Policy			

Source: Rosenberg (2003).

EXAMPLE 10

Fiscal Policy and Exchange Rates

Monique Kwan is continuing her analysis of the foreign exchange rate outlook for selected countries. She examines a DM country that has a high degree of capital mobility and a floating-rate currency regime. Kwan notices that although

the current outstanding volume of government debt is low, as a percentage of GDP, it is rising sharply as a result of expansionary fiscal policy. Moreover, projections for the government debt-to-GDP ratio point to further increases well into the future.

Kwan uses the Mundell–Fleming and portfolio balance models to form an opinion about both the short-run and long-run implications for the DM country's exchange rate.

1. Over the short run, Kwan is *most likely* to expect:

- A. appreciation of the DM's currency.
- B. an increase in the DM's asset prices.
- C. a decrease in the DM's risk premium.

Solution

A is correct. The DM country currently has a low debt load (as a percentage of GDP), and in the short run, its expansionary fiscal policy will lead to higher interest rates and higher real rates relative to other countries. This path should lead to currency appreciation. The higher domestic interest rates will (all else equal) depress local asset prices (so B is incorrect), and the rising debt load is likely to increase rather than decrease the risk premium (so C is incorrect).

2. Over the medium term, as the DM country's government debt becomes harder to finance, Kwan would be *most likely* to expect that:

- A. fiscal policy will turn more accommodative.
- B. the mark-to-market value of the debt will increase.
- C. monetary policy will become more accommodative.

Solution

C is correct. As government debt becomes harder to finance, the government will be tempted to monetize the debt through an accommodative monetary policy. A is incorrect because an inability to finance the debt will make it hard for fiscal policy to become more accommodative. B is incorrect because as investors demand a higher risk premium (a higher return) for holding the DM country's debt, the mark-to-market value of the debt will decline (i.e., bond prices will decrease and bond yields will increase).

3. Assuming that the DM country's government debt becomes harder to finance and there is no change in monetary policy, Kwan is *most likely* to expect that over the longer term, there will be a fiscal policy response that will lead to:

- A. currency appreciation as yields rise.
- B. currency depreciation as yields decline.
- C. an indeterminate impact on the currency, depending on which effect prevails.

Solution

B is correct. As the DM country's debt ratio deteriorates, foreign investors will demand a higher rate of return to compensate them for the increased risk. Assuming that the central bank will not accommodate (monetize) the rising government debt, the most likely fiscal response is an eventual move toward fiscal consolidation—reducing the public deficit and debt levels that were causing the debt metrics to deteriorate. This policy adjustment would

involve issuing fewer government bonds. All else equal, bond yields would decrease, leading to a weaker domestic currency over the longer term. A is incorrect because currency appreciation is not likely to accompany rising yields when the government is having difficulty financing its deficit. There would be a rising risk premium (a deteriorating investor appetite) for holding DM assets, and hence a currency appreciation would be unlikely despite high DM yields. To avoid paying these high yields on its debt, the DM government would eventually have to take measures to reduce its deficit spending. This approach would eventually help reduce investor risk aversion and DM yields. C is incorrect because given the deterioration in the DM's debt metrics, a depreciation of its exchange rate is likely to be an important part of the restoration of financial market equilibrium.

14

EXCHANGE RATE MANAGEMENT: INTERVENTION AND CONTROLS



describe objectives of central bank or government intervention and capital controls and describe the effectiveness of intervention and capital controls

Capital flows can be both a blessing and a curse. Capital inflows can be a blessing when they increase domestic investment, thereby increasing a country's economic growth and asset values. Currency appreciation often follows, which increases returns to global investors. Capital inflows can be a curse, however, if they fuel boom-like conditions, asset price bubbles, and overvaluation of a country's currency. If capital inflows then reverse, the result may be a major economic downturn, a significant decline in asset prices, and a large depreciation of the currency. Capital inflows often are driven by a combination of "pull" and "push" factors. Pull factors represent a favorable set of developments that encourage foreign capital inflows. These factors may stem from both the public and private sectors. Examples of better economic management by a government include

- a decrease in inflation and inflation volatility,
- more-flexible exchange rate regimes,
- improved fiscal positions,
- privatization of state-owned entities,
- liberalization of financial markets, and
- lifting of foreign exchange regulations and controls.

Ideally, these changes will facilitate strong economic growth in the private sector, which will attract further foreign investment. A healthy export sector will generate improvement in the current account balance and an increase in FX reserves, which can be used by the government as a buffer against future speculative attacks. The returns from the currency and assets should increase, increasing the foreign investor's return.

Push factors driving foreign capital inflows are not determined by the domestic policies but arise from the primary sources of internationally mobile capital, notably the investor base in industrial countries. For example, the pursuit of low interest rate policies in industrial countries since the 2008 financial crisis has encouraged global investors to seek higher returns abroad.

Another important push factor is the long-run trend in asset allocation by industrial country investors. For example, many fund managers have traditionally had underweight exposures to emerging market assets, but with the weight of emerging market equities in broad global equity market indexes on the rise (as of 2019 the EM share of world GDP at current prices is over 40%, up from 17% in the 1960s, according to the IMF), capital flows to EM countries, in the form of increased allocations to EM equities, are likely to rise.

Private capital inflows to emerging markets go through significant changes over time. For example, they rose steadily between 2003 and 2007, posting nearly a six-fold increase over the period. Both push and pull factors contributed to that surge in capital flows. Net private capital flows to emerging markets tumbled in 2008 and 2009 as heightened risk aversion during the global financial crisis prompted investors to unwind some of their EM exposures in favor of US assets. In 2010, capital flows to emerging markets rose as many EM economies weathered the global financial crisis better than many industrial economies. In addition, the pursuit of ultra-low interest rate policies in the United States, the euro area, and Japan encouraged global investors to invest in higher-yielding EM assets.

However beneficial foreign capital is, policymakers must guard against excessive capital inflows that could quickly be reversed. Capital flow surges planted the seeds of three major currency crises in the 1990s—the European Exchange Rate Mechanism (ERM) crisis in 1992–1993, the Mexican peso crisis in late 1994, and the Asian currency and financial crisis in 1997–1998. Each crisis episode was preceded by a surge in capital inflows and a buildup of huge, highly leveraged speculative positions by local as well as international investors in currencies that eventually came under heavy speculative attack. In the run-up to the ERM crisis, investors—believing that European yield convergence would occur as European monetary union approached—took on highly leveraged long positions in the higher-yielding European currencies financed by short positions in the lower-yielding European currencies. Likewise, in the run-up to the Mexican peso crisis, investors and banks were highly leveraged and made extensive use of derivative products in taking on speculative long Mexican peso/short US dollar positions. And in the run-up to the Asian financial crisis, Asian companies and banks were highly leveraged as they took on a huge volume of short-term dollar- and yen-denominated debt to fund local activities. In each case, the sudden unwinding of those leveraged long speculative positions triggered the attacks on the currencies.

Governments resist excessive inflows and currency bubbles by using capital controls and direct intervention (selling their currency) in the foreign exchange market. Capital controls can take many forms. In the Asian financial crisis, many countries, such as Malaysia, prevented their banks from offering currency transactions in which their currency was sold. As mentioned earlier, Brazil has used a tax to limit currency transactions. In 2006, Thailand required a one-year, non-interest-bearing deposit of 30% of an investment's value to reduce new foreign inflows, which had been appreciating the Thai baht. Vietnam has limited the foreign ownership of local financial institutions. In 2015, Ukraine was removed from the MSCI Frontier Markets equity index after its central bank prevented foreign investors from repatriating funds from the sale of Ukrainian stocks. By 2016, Venezuela had instituted capital controls in the form of four different exchange rates, whereby the rate for selling Venezuelan bolivars for US dollars depended on what the dollars were used for. As a result, many Venezuelans used the black market to obtain dollars. Venezuela's capital controls were subsequently loosened in 2018 and 2019.

At one time, capital controls were frowned on as a policy tool for curbing undesired surges in capital inflows. It was generally felt that such controls tended to generate distortions in global trade and finance and that, in all likelihood, market participants would eventually find ways to circumvent the controls. Furthermore, many thought that capital controls imposed by one country could deflect capital flows to other

countries, which could complicate monetary and exchange rate policies in those economies. Despite such concerns, the IMF has said that the benefits associated with capital controls may exceed the associated costs. Given the painful lessons that EM policymakers have learned from previous episodes of capital flow surges, some believe that under certain circumstances, capital controls may be needed to prevent exchange rates from overshooting, asset bubbles from forming, and future financial conditions from deteriorating.

Although a case can be made for government intervention and capital controls to limit the potential damage associated with unrestricted inflows of overseas capital, the key issue for policymakers is whether intervention and capital controls will actually work in terms of (1) preventing currencies from appreciating too strongly, (2) reducing the aggregate volume of capital inflows, and (3) enabling monetary authorities to pursue independent monetary policies without having to worry about whether changes in policy rates might attract too much capital from overseas. As an example of the last issue, if a central bank increases interest rates to slow inflation, then capital controls might prevent foreign capital inflows from subsequently depressing interest rates.

Evidence on the effectiveness of direct government intervention suggests that, in the case of industrial countries, the volume of intervention is often quite small relative to the average daily turnover of G–10 currencies in the foreign exchange market. Hence, most studies have concluded that the effect of intervention in developed market economies is limited. For most developed market countries, the ratio of official FX reserves held by the respective central banks to the average daily turnover of foreign exchange trading in that currency is negligible. Most industrial countries hold insufficient reserves to significantly affect the supply of and demand for their currency. Note that if a central bank is intervening in an effort to weaken, rather than strengthen, its own currency, it could (at least in principle) create and sell an unlimited amount of its currency and accumulate a correspondingly large quantity of FX reserves. However, persistent intervention in the FX market can undermine the efficacy of domestic monetary policy.

The evidence on the effectiveness of government intervention in emerging market currencies is more mixed. Intervention appears to contribute to lower EM exchange rate volatility, but no statistically significant relationship has emerged between the level of EM exchange rates and intervention. Some studies have found, however, that EM policymakers might have greater success in controlling exchange rates than their industrial country counterparts because the ratio of EM central bank FX reserve holdings to average daily FX turnover in their domestic currencies is actually quite sizable. With considerably greater firepower in their reserve arsenals, emerging market central banks appear to be in a stronger position than their developed market counterparts to influence the level and path of their exchange rates. What's more, with emerging market central banks' FX reserve holdings expanding at a near-record clip in the past decade, the effectiveness of intervention may be greater now than in the past.

15

WARNING SIGNS OF A CURRENCY CRISIS



describe warning signs of a currency crisis

If capital inflows come to a sudden stop, the result may be a financial crisis, in which the economy contracts, asset values plummet, and the currency sharply depreciates. History is filled with examples of currencies that have come under heavy selling pressure within short windows of time. For example, between August 2008 and February

2009, 23 currencies dropped by 25% or more against the US dollar. These included the developed market currencies of Australia, Sweden, and the United Kingdom, which dropped by 35% or more, and the emerging market currencies of Brazil, Russia, and South Korea, which fell by more than 50%.

Currency crises often occur suddenly, with many investors caught by surprise. Once a wave of selling begins, investors and borrowers must immediately reposition their portfolios to avoid excessive capital losses. For example, assume a carry trader had gone long the Brazilian real and borrowed US dollars. Upon an initial depreciation of the real, the trader would be inclined to exit the trade by selling reals and buying dollars. Or consider a Brazilian public or private borrower that had financed in US dollars. The borrower would also be selling reals to buy dollars in order to cover future repayment of the dollar debt. Either of these actions will intensify selling pressure on the depreciated currency. It is this massive liquidation of vulnerable positions, often reinforced by speculative offshore selling, that is largely responsible for the excessive exchange rate movements that occur during currency crises.

Because most crisis episodes have not been adequately anticipated, a great deal of effort has been spent developing early warning systems. One of the problems in developing an early warning system is that views on the underlying causes of currency crises differ greatly. One school of thought contends that currency crises tend to be precipitated by deteriorating economic fundamentals, while a second school contends that currency crises can occur out of the blue, with little evidence of deteriorating fundamentals preceding them.

If, according to the first school of thought, deteriorating economic fundamentals often precede crises and if those economic fundamentals tend to deteriorate steadily and predictably, then it should be possible to construct an early warning system to anticipate when a currency might be vulnerable.

The second school of thought argues that, although evidence of deteriorating economic fundamentals might explain a relatively large number of currency collapses, there might be cases in which economies with relatively sound fundamentals have their currencies come under attack. Clearly, these currency crises would be more difficult to predict. Events that are largely unrelated to domestic economic fundamentals include sudden adverse shifts in market sentiment that become self-fulfilling prophecies and contagion from crises in other markets. A crisis may spread to a country when, for example, the country devalues its currency to keep its exports competitive with those of another country that devalued.

Recognizing that no single model can correctly anticipate the onset of all crisis episodes, an early warning system might nevertheless be useful in assisting investors in structuring and/or hedging their global portfolios. An ideal early warning system would need to incorporate a number of important features. First, it should have a strong record of predicting actual crises but also should not issue false alarms. Second, it should include macroeconomic indicators whose data are available on a timely basis. If data arrive with a long lag, a crisis could be under way before the early warning system starts flashing red. Third, because currency crises tend to be triggered in countries with a number of economic problems, not just one, an ideal early warning system should be broad based, incorporating a wide range of symptoms that crisis-prone currencies might exhibit.

Many studies have been conducted to develop an early warning system for currency crises, typically by constructing a model in which a number of variables constitute the early warning system. Various definitions of currency crises have been used. Although the variables and methodologies differ from one study to the next, the following conditions were identified in one or more studies (Babecký, Havránek, Matějů, Rusnák, Šmídková, and Vašíček 2013 and 2014; Daniels and VanHoose 2018):

1. Prior to a currency crisis, the capital markets have been liberalized to allow the free flow of capital.

2. There are large inflows of foreign capital (relative to GDP) in the period leading up to a crisis, with short-term funding denominated in a foreign currency being particularly problematic.
3. Currency crises are often preceded by (and often coincide with) banking crises.
4. Countries with fixed or partially fixed exchange rates are more susceptible to currency crises than countries with floating exchange rates.
5. Foreign exchange reserves tend to decline precipitously as a crisis approaches.
6. In the period leading up to a crisis, the currency has risen substantially relative to its historical mean.
7. The ratio of exports to imports (known as “the terms of trade”) often deteriorates before a crisis.
8. Broad money growth and the ratio of M2 (a measure of money supply) to bank reserves tend to rise prior to a crisis.
9. Inflation tends to be significantly higher in pre-crisis periods compared with tranquil periods.

These factors are usually interrelated and often feed off one another. For example, in the case of the first five factors, large inflows of foreign capital occur because the financial markets have been liberalized and domestic banks have borrowed abroad. If the borrowing is denominated in a foreign currency and the domestic currency initially depreciates, the bank may have trouble servicing its debt, especially when the debt is of shorter maturity. This scenario may cause foreign investors to withdraw capital and speculators to short the currency, with their actions causing further declines in the currency. If the government is trying to maintain the currency’s value, it could increase interest rates to stem capital outflows or defend its currency using direct intervention. The former action may worsen the banking industry’s condition and slow down the economy. In the latter approach, the government will have to spend down its foreign currency reserves to buy its own currency in the foreign exchange markets. If the government appears unwilling or unable to defend its currency, then capital outflows and speculative attacks will increase.

The fifth through seventh factors are related because an overvalued currency may make the country’s exports less competitive. With fewer exports, the country is not able to earn as much foreign currency. Other interrelationships occur because these factors often coincide.

Models cannot predict every crisis, and they sometimes generate false alarms. Nevertheless, an early warning system can be useful in assessing and preparing for potential negative tail risks. As with any analytical tool, the implementation of an early warning system requires integration with other analysis and judgment that cannot be easily quantified or conceptualized.

ICELAND’S CURRENCY CRISIS OF 2008

Iceland, a country with a population of 320,000, had traditionally relied on the fishing, energy, and aluminum industries for economic growth. That began to change in 2001, when the banking industry was liberalized. Three banks dominated the Icelandic banking industry: Glitnir, Kaupthing, and Landsbanki. Given Iceland’s small population, these banks sought growth by offering short-term, internet-based deposit accounts to foreign investors. These accounts offered attractive interest rates and were denominated in foreign currencies. In particular, many of the depositors were British, Dutch, and other European citizens who held deposit accounts denominated in pounds and euros.

With government guarantees on their deposit accounts, the banking industry grew rapidly. The largest bank, Kaupthing, experienced asset growth of 30 times between 2000 and 2008. The three banks increased lending rapidly, with many of their loans being long term, resulting in a maturity mismatch of assets and liabilities. The banks' assets were more than 14 times the country's GDP, while foreign debt was five times GDP. The three banks constituted more than 70% of the national stock market capitalization.

The economy expanded at a real growth rate above 20% annually between 2002 and 2005, and many Icelanders left traditional industries to work in the banks. Iceland earned the nickname "Nordic Tiger" as per capita GDP approached USD 70,000 in 2007. The Icelandic krona increased in value against the US dollar by 40% between 2001 and 2007. By 2007, the unemployment rate was less than 1%. Icelanders went on a shopping spree for consumer goods, in part by using loans tied to the value of foreign currencies, motivated by lower interest rates abroad. A 2002 trade surplus turned into a trade deficit in the years 2003–2007. Iceland's external debt in 2008 was more than 7 times its GDP and 14 times its export revenue. Broad-based monetary aggregates grew at a rate of 14%–35% annually from 2002 to 2007. By the fall of 2008, inflation had reached 14%.

As the global financial crisis unfolded in 2008, interbank lending declined and Icelandic banks were unable to roll over their short-term debt. Anxious foreign depositors began withdrawing their funds. In the first half of 2008, the krona depreciated by more than 40% against the euro. As the Icelandic currency declined in value, it became more difficult for the banks to meet depositors' liquidity demands, while at the same time the banks' depreciating krona-denominated assets could not be used for collateral financing.

The three banks collapsed in 2008. Unfortunately for foreign depositors, because of the relative size of the banks, the government guaranteed only domestic deposits. Iceland's central bank became technically insolvent, as its EUR 2 billion in assets was dwarfed by Iceland's debt to foreign banks of EUR 50 billion. Trading in the stock market was suspended in October 2008. When it reopened several days later, the Icelandic Stock Market Index fell by more than 77% as a result of the elimination of the three banks' equity value.

The government attempted to peg the krona to the euro in October 2008 but abandoned the peg one day later. When trading in the currency was resumed later that month, the currency value fell by more than 60% and trading was eventually suspended. Iceland increased interest rates to 18% to stem outflows of krona and imposed capital controls on the selling of krona for foreign currency. The Icelandic economy contracted, and per capita GDP fell 9.2% in 2009. By the spring of 2009, unemployment was 9%. The country subsequently required a bailout from the IMF and its neighbors of USD 4.6 billion.

Source: Federal Reserve Bank of St. Louis database; Bekaert and Hodrick 2018; Matsangou 2015; Daniels and VanHoose 2017.

EXAMPLE 11

Currency Crises

Monique Kwan now turns her attention to the likelihood of crises in various emerging market currencies. She discusses this matter with a research associate, who tells her that the historical record of currency crises shows that most of these episodes were not very well anticipated by investors (in terms of their

positioning), by the bond markets (in terms of yield spreads between countries), or by major credit rating agencies and economists (in terms of the sovereign credit ratings and forecasts, respectively).

1. The research associate is *most likely*:

- A. correct.
- B. incorrect, because most credit rating agencies and economists typically change their forecasts prior to a crisis.
- C. incorrect, because investor positioning and international yield differentials typically shift prior to a crisis.

Solution

A is correct. Currency crises often catch most market participants and analysts by surprise.

2. Kwan delves further into the historical record of currency crises. She concludes that even countries with relatively sound economic fundamentals can fall victim to these crisis episodes and that these attacks can occur when sentiment shifts for reasons unrelated to economic fundamentals.

Kwan's conclusion is *most likely*:

- A. correct.
- B. incorrect, because there are few historical crises involving currencies of countries with sound economic fundamentals.
- C. incorrect, because there are few historical episodes in which a sudden adverse shift in market sentiment occurs that is unrelated to economic fundamentals.

Solution

A is correct. Even countries with sound economic fundamentals can be subject to a currency crisis, including instances when market sentiment shifts for non-economic reasons.

3. To better advise the firm's clients on the likelihood of currency crises, Kwan tries to formulate an early warning system for these episodes. She recognizes that a typical currency crisis tends to be triggered by a number of economic problems, not just one.

Kwan's early warning system is *least likely* to indicate an impending crisis when there is:

- A. an expansionary monetary policy.
- B. an overly appreciated exchange rate.
- C. a rising level of foreign exchange reserves at the central bank.

Solution

C is correct. A high level of foreign exchange reserves held by a country typically decreases the likelihood of a currency crisis.

4. Kwan's early warning system would *most likely* be better if it:

- A. had a strong record of predicting actual crises, even if it generates a lot of false signals.

- B. included a wide variety of economic indicators, including those for which data are available only with a significant lag.
- C. started flashing well in advance of an actual currency crisis to give market participants time to adjust or hedge their portfolios before the crisis hits.

Solution

C is correct. Early warnings are a positive factor in judging the effectiveness of the system, whereas false signals and the use of lagged data would be considered negative factors.

SUMMARY

Exchange rates are among the most difficult financial market prices to understand and therefore to value. There is no simple, robust framework that investors can rely on in assessing the appropriate level and likely movements of exchange rates.

Most economists believe that there is an equilibrium level or a path to that equilibrium value that a currency will gravitate toward in the long run. Although short- and medium-term cyclical deviations from the long-run equilibrium path can be sizable and persistent, fundamental forces should eventually drive the currency back toward its long-run equilibrium path. Evidence suggests that misalignments tend to build up gradually over time. As these misalignments build, they are likely to generate serious economic imbalances that will eventually lead to correction of the underlying exchange rate misalignment.

We have described how changes in monetary policy, fiscal policy, current account trends, and capital flows affect exchange rate trends, as well as what role government intervention and capital controls can play in counteracting potentially undesirable exchange rate movements. We have made the following key points:

- Spot exchange rates apply to trades for the next settlement date (usually $T + 2$) for a given currency pair. Forward exchange rates apply to trades to be settled at any longer maturity.
- Market makers quote bid and offer prices (in terms of the *price currency*) at which they will buy or sell the *base currency*.
 - The offer price is always higher than the bid price.
 - The counterparty that asks for a two-sided price quote has the option (but not the obligation) to deal at either the bid or offer price quoted.
 - The bid–offer spread depends on (1) the currency pair involved, (2) the time of day, (3) market volatility, (4) the transaction size, and (5) the relationship between the dealer and the client. Spreads are tightest in highly liquid currency pairs, when the key market centers are open, and when market volatility is relatively low.
- Absence of arbitrage requires the following:
 - The bid (offer) shown by a dealer in the interbank market cannot be higher (lower) than the current interbank offer (bid) price.
 - The cross-rate bids (offers) posted by a dealer must be lower (higher) than the implied cross-rate offers (bids) available in the interbank market. If they are not, then a triangular arbitrage opportunity arises.

- Forward exchange rates are quoted in terms of points to be added to the spot exchange rate. If the points are positive (negative), the base currency is trading at a forward premium (discount). The points are proportional to the interest rate differential and approximately proportional to the time to maturity.
- International parity conditions show us how expected inflation, interest rate differentials, forward exchange rates, and expected future spot exchange rates are linked. In an ideal world,
 - relative expected inflation rates should determine relative nominal interest rates,
 - relative interest rates should determine forward exchange rates, and
 - forward exchange rates should correctly anticipate the path of the future spot exchange rate.
- International parity conditions tell us that countries with high (low) expected inflation rates should see their currencies depreciate (appreciate) over time, that high-yield currencies should depreciate relative to low-yield currencies over time, and that forward exchange rates should function as unbiased predictors of future spot exchange rates.
- With the exception of covered interest rate parity, which is enforced by arbitrage, the key international parity conditions rarely hold in either the short or medium term. However, the parity conditions tend to hold over relatively long horizons.
- According to the theory of covered interest rate parity, a foreign-currency-denominated money market investment that is completely hedged against exchange rate risk in the forward market should yield exactly the same return as an otherwise identical domestic money market investment.
- According to the theory of uncovered interest rate parity, the expected change in a domestic currency's value should be fully reflected in domestic–foreign interest rate spreads. Hence, an unhedged foreign-currency-denominated money market investment is expected to yield the same return as an otherwise identical domestic money market investment.
- According to the *ex ante* purchasing power parity condition, expected changes in exchange rates should equal the difference in expected national inflation rates.
- If both *ex ante* purchasing power parity and uncovered interest rate parity held, real interest rates across all markets would be the same. This result is real interest rate parity.
- The international Fisher effect says that the nominal interest rate differential between two currencies equals the difference between the expected inflation rates. The international Fisher effect assumes that risk premiums are the same throughout the world.
- If both covered and uncovered interest rate parity held, then forward rate parity would hold and the market would set the forward exchange rate equal to the expected spot exchange rate: The forward exchange rate would serve as an unbiased predictor of the future spot exchange rate.
- Most studies have found that high-yield currencies do not depreciate and low-yield currencies do not appreciate as much as yield spreads would suggest over short to medium periods, thus violating the theory of uncovered interest rate parity.

- Carry trades overweight high-yield currencies at the expense of low-yield currencies. Historically, carry trades have generated attractive returns in benign market conditions but tend to perform poorly (i.e., are subject to crash risk) when market conditions are highly volatile.
- According to a balance of payments approach, countries that run persistent current account deficits will generally see their currencies weaken over time. Similarly, countries that run persistent current account surpluses will tend to see their currencies appreciate over time.
- Large current account imbalances can persist for long periods of time before they trigger an adjustment in exchange rates.
- Greater financial integration of the world's capital markets and greater freedom of capital to flow across national borders have increased the importance of global capital flows in determining exchange rates.
- Countries that institute relatively tight monetary policies, introduce structural economic reforms, and lower budget deficits will often see their currencies strengthen over time as capital flows respond positively to relatively high nominal interest rates, lower inflation expectations, a lower risk premium, and an upward revision in the market's assessment of what exchange rate level constitutes long-run fair value.
- Monetary policy affects the exchange rate through a variety of channels. In the Mundell–Fleming model, it does so primarily through the interest rate sensitivity of capital flows, strengthening the currency when monetary policy is tightened and weakening it when monetary policy is eased. The more sensitive capital flows are to the change in interest rates, the greater the exchange rate's responsiveness to the change in monetary policy.
- In the monetary model of exchange rate determination, monetary policy is deemed to have a direct impact on the actual and expected path of inflation, which, via purchasing power parity, translates into a corresponding impact on the exchange rate.
- Countries that pursue overly easy monetary policies will see their currencies depreciate over time.
- In the Mundell–Fleming model, an expansionary fiscal policy typically results in a rise in domestic interest rates and an increase in economic activity. The rise in domestic interest rates should induce a capital inflow, which is positive for the domestic currency, but the rise in economic activity should contribute to a deterioration of the trade balance, which is negative for the domestic currency. The more mobile capital flows are, the greater the likelihood that the induced inflow of capital will dominate the deterioration in trade.
- Under conditions of high capital mobility, countries that simultaneously pursue expansionary fiscal policies and relatively tight monetary policies should see their currencies strengthen over time.
- The portfolio balance model of exchange rate determination asserts that increases in government debt resulting from a rising budget deficit will be willingly held by investors only if they are compensated in the form of a higher expected return. The higher expected return could come from (1) higher interest rates and/or a higher risk premium, (2) depreciation of the currency to a level sufficient to generate anticipation of gains from subsequent currency appreciation, or (3) some combination of the two.
- Surges in capital inflows can fuel boom-like conditions, asset price bubbles, and currency overvaluation.

- Many consider capital controls to be a legitimate part of a policymaker's toolkit. The IMF believes that capital controls may be needed to prevent exchange rates from overshooting, asset price bubbles from forming, and future financial conditions from deteriorating.
- The evidence indicates that government policies have had a significant impact on the course of exchange rates. Relative to developed countries, emerging markets may have greater success in managing their exchange rates because of their large foreign exchange reserve holdings, which appear sizable relative to the limited turnover of FX transactions in many emerging markets.
- Although each currency crisis is distinct in some respects, the following factors were identified in one or more studies:
 1. Prior to a currency crisis, the capital markets have been liberalized to allow the free flow of capital.
 2. There are large inflows of foreign capital (relative to GDP) in the period leading up to a crisis, with short-term funding denominated in a foreign currency being particularly problematic.
 3. Currency crises are often preceded by (and often coincide with) banking crises.
 4. Countries with fixed or partially fixed exchange rates are more susceptible to currency crises than countries with floating exchange rates.
 5. Foreign exchange reserves tend to decline precipitously as a crisis approaches.
 6. In the period leading up to a crisis, the currency has risen substantially relative to its historical mean.
 7. The terms of trade (exports relative to imports) often deteriorate before a crisis.
 8. Broad money growth and the ratio of M2 (a measure of money supply) to bank reserves tend to rise prior to a crisis.
 9. Inflation tends to be significantly higher in pre-crisis periods compared with tranquil periods.

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APPENDIX

Currency Codes Used

USD	US dollar
EUR	euro
GBP	UK pound
JPY	Japanese yen
MXN	Mexican peso
CHF	Swiss franc
CAD	Canadian dollar
SEK	Swedish krona
AUD	Australian dollar

KRW	Korean won
NZD	New Zealand dollar

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PRACTICE PROBLEMS

The following information relates to questions 1-5

Ed Smith is a new trainee in the foreign exchange (FX) services department of a major global bank. Smith's focus is to assist senior FX trader Feliz Mehmet, CFA. Mehmet mentions that an Indian corporate client exporting to the United Kingdom wants to estimate the potential hedging cost for a sale closing in one year. Smith is to determine the premium/discount for an annual (360-day) forward contract using the exchange rate data presented in Exhibit 1.

Exhibit 1: Select Currency Data for GBP and INR

Spot (INR/GBP)	79.5093
Annual (360-day) MRR (GBP)	5.43%
Annual (360-day) MRR (INR)	7.52%

Mehmet is also looking at two possible trades to determine their profit potential. The first trade involves a possible triangular arbitrage trade using the Swiss, US, and Brazilian currencies, to be executed based on a dealer's bid/offer rate quote of 0.2355/0.2358 in CHF/BRL and the interbank spot rate quotes presented in Exhibit 2.

Exhibit 2: Interbank Market Quotes

Currency Pair	Bid/Offer
CHF/USD	0.9799/0.9801
BRL/USD	4.1698/4.1702

Mehmet is also considering a carry trade involving the USD and the EUR. He anticipates it will generate a higher return than buying a one-year domestic note at the current market quote due to low US interest rates and his predictions of exchange rates in one year. To help Mehmet assess the carry trade, Smith provides Mehmet with selected current market data and his one-year forecasts in Exhibit 3.

Exhibit 3: Spot Rates and Interest Rates for Proposed Carry Trade

Today's One-Year MRR	Currency Pair (Price/Base)	Spot Rate Today	Projected Spot Rate in One Year
USD 0.80%	CAD/USD	1.3200	1.3151
CAD 1.71%	EUR/CAD	0.6506	0.6567
EUR 2.20%			

Finally, Mehmet asks Smith to assist with a trade involving a US multinational customer operating in Europe and Japan. The customer is a very cost-conscious industrial company with an AA credit rating and strives to execute its currency trades at the most favorable bid–offer spread. Because its Japanese subsidiary is about to close on a major European acquisition in three business days, the client wants to lock in a trade involving the Japanese yen and the euro as early as possible the next morning, preferably by 8:05 a.m. New York time.

At lunch, Smith and other FX trainees discuss how best to analyze currency market volatility from ongoing financial crises. The group agrees that a theoretical explanation of exchange rate movements, such as the framework of the international parity conditions, should be applicable across all trading environments. They note such analysis should enable traders to anticipate future spot exchange rates. But they disagree on which parity condition best predicts exchange rates, voicing several different assessments. Smith concludes the discussion on parity conditions by stating to the trainees,

I believe that in the current environment both covered and uncovered interest rate parity conditions are in effect.

1. Based on Exhibit 1, the forward premium (discount) for a 360-day INR/GBP forward contract is *closest* to:
 - A. -1.546.
 - B. 1.546.
 - C. 1.576.
2. Based on Exhibit 2, the *most* appropriate recommendation regarding the triangular arbitrage trade is to:
 - A. decline the trade, because no arbitrage profits are possible.
 - B. execute the trade, buy BRL in the interbank market, and sell BRL to the dealer.
 - C. execute the trade, buy BRL from the dealer, and sell BRL in the interbank market.
3. Based on Exhibit 3, the potential all-in USD return on the carry trade is *closest* to:
 - A. 0.83%.
 - B. 1.23%.
 - C. 1.63%.
4. The factor *least likely* to lead to a narrow bid–offer spread for the industrial company's needed currency trade is the:
 - A. timing of its trade.
 - B. company's credit rating.
 - C. pair of currencies involved.
5. If Smith's statement on parity conditions is correct, future spot exchange rates are *most likely* to be forecast by:
 - A. current spot rates.

- B. forward exchange rates.
 - C. inflation rate differentials.
-

The following information relates to questions 6-13

Anna Goldsworthy is the chief financial officer of a manufacturing firm headquartered in the United Kingdom. She is responsible for overseeing exposure to price risk in both the commodity and currency markets. Goldsworthy is settling her end-of-quarter transactions and creating reports. Her intern, Scott Underwood, assists her in this process.

The firm hedges input costs using forward contracts that are priced in US dollars (USD) and Mexican pesos (MXN). Processed goods are packaged for sale under licensing agreements with firms in foreign markets. Goldsworthy is expecting to receive a customer payment of JPY 225,000,000 (Japanese yen) that she wants to convert to pounds sterling (GBP). Underwood gathers the exchange rates from Dealer A in Exhibit 1.

Exhibit 1: Dealer A's Spot Exchange Rates

Currency Pair (Price/Base)	Spot Exchange Rates		
	Bid	Offer	Midpoint
JPY/GBP	129.65	129.69	129.67
MXN/USD	20.140	20.160	20.150
GBP/EUR	0.9467	0.9471	0.9469
USD/EUR	1.1648	1.1652	1.1650
USD/GBP	1.2301	1.2305	1.2303

The firm must also buy USD to pay a major supplier. Goldsworthy calls Dealer A with specific details of the transaction and asks to verify the USD/GBP quote. Dealer A calls her back later with a revised USD/GBP bid–offer quote of 1.2299/1.2307.

Goldsworthy must purchase MXN 27,000,000 to pay an invoice at the end of the quarter. In addition to the quotes from Dealer A, Underwood contacts Dealer B, who provides a bid–offer price of GBP/MXN 0.0403/0.0406. To check whether the dealer quotes are reflective of an efficient market, Underwood examines whether the prices allow for an arbitrage profit.

In three months, the firm will receive EUR 5,000,000 from another customer. Six months ago, the firm sold EUR 5,000,000 against the GBP using a nine-month forward contract at an all-in price of GBP/EUR 0.9526. To mark the position to market, Underwood collects the GBP/EUR forward rates in Exhibit 2.

Exhibit 2: GBP/EUR Forward Rates

Maturity	Forward Points
One month	4.40/4.55
Three months	14.0/15.0
Six months	29.0/30.0

Goldsworthy also asks for the current 90-day MRRs for the major currencies. Selected three-month MRRs (annualized) are shown in Exhibit 3. Goldsworthy studies Exhibit 3 and says, “We have the spot rate and the 90-day forward rate for GBP/EUR. As long as we have the GBP 90-day MRR, we will be able to calculate the implied EUR 90-day MRR.”

Exhibit 3: 90-Day MRR

Currency	Annualized Rate
GBP	0.5800%
JPY	0.0893%
USD	0.3300%

After reading a draft report, Underwood notes, “We do not hedge the incoming Japanese yen cash flow. Your report asks for a forecast of the JPY/GBP exchange rate in 90 days. We know the JPY/GBP spot exchange rate.” He asks, “Does the information we have collected tell us what the JPY/GBP exchange rate will be in 90 days?”

Goldsworthy replies, “The JPY/GBP exchange rate in 90 days would be a valuable piece of information to know. An international parity condition can be used to provide an estimate of the future spot rate.”

6. Using the quotes in Exhibit 1, the amount received by Goldsworthy from converting JPY 225,000,000 will be *closest* to:
 - A. GBP 1,734,906.
 - B. GBP 1,735,174.
 - C. GBP 1,735,442.

7. Using Exhibit 1, which of the following would be the *best* reason for the revised USD/GBP dealer quote of 1.2299/1.2307?
 - A. A request for a much larger transaction
 - B. A drop in volatility in the USD/GBP market
 - C. A request to trade when both New York and London trading centers are open

8. Using the quotes from Dealer A and B, the triangular arbitrage profit on a transaction of MXN 27,000,000 would be *closest* to:
 - A. GBP 0.
 - B. GBP 5,400.

- C. GBP 10,800.
9. Based on Exhibits 1, 2, and 3, the mark-to-market gain for Goldsworthy's forward position is *closest* to:
- A. GBP 19,971.
 - B. GBP 20,500.
 - C. GBP 21,968.
10. Based on Exhibit 2, Underwood should conclude that three-month EUR MRR is:
- A. below three-month GBP MRR.
 - B. equal to three-month GBP MRR.
 - C. above three-month GBP MRR.
11. Based on the exchange rate midpoint in Exhibit 1 and the rates in Exhibit 3, the 90-day forward premium (discount) for the USD/GBP would be *closest* to:
- A. -0.0040.
 - B. -0.0010.
 - C. +0.0010.
12. Using Exhibits 1, 2, and 3, which international parity condition would Goldsworthy *most likely* use to calculate the EUR MRR?
- A. Real interest rate parity
 - B. Covered interest rate parity
 - C. Uncovered interest rate parity
13. The international parity condition Goldsworthy will use to provide the estimate of the future JPY/GBP spot rate is *most likely*:
- A. covered interest rate parity.
 - B. uncovered interest rate parity.
 - C. relative purchasing power parity.
-

The following information relates to questions

14-20

Connor Wagener, a student at the University of Canterbury in New Zealand, has been asked to prepare a presentation on foreign exchange rates for his international business course. Wagener has a basic understanding of exchange rates but would like a practitioner's perspective, and he has arranged an interview with currency trader Hannah McFadden. During the interview, Wagener asks McFadden,

Could you explain what drives exchange rates? I'm curious as to why our New

Zealand dollar was affected by the European debt crisis in 2011 and what other factors impact it.

In response, McFadden begins with a general discussion of exchange rates. She notes that international parity conditions illustrate how exchange rates are linked to expected inflation, interest rate differences, and forward exchange rates as well as current and expected future spot rates. McFadden makes the following statement:

Statement 1: “Fortunately, the international parity condition most relevant for FX carry trades does not always hold.”

McFadden continues her discussion:

FX carry traders go long (i.e., buy) high-yield currencies and fund their position by shorting—that is, borrowing in—low-yield currencies. Unfortunately, crashes in currency values can occur which create financial crises as traders unwind their positions. For example, in 2008, the New Zealand dollar was negatively impacted when highly leveraged carry trades were unwound. In addition to investors, consumers and business owners can also affect currency exchange rates through their impact on their country’s balance of payments. For example, if New Zealand consumers purchase more goods from China than New Zealand businesses sell to China, New Zealand will run a trade account deficit with China.

McFadden further explains,

Statement 2: “A trade surplus will tend to cause the currency of the country in surplus to appreciate, while a deficit will cause currency depreciation. Exchange rate changes will result in immediate adjustments in the prices of traded goods as well as in the demand for imports and exports. These changes will immediately correct the trade imbalance.”

McFadden next addresses the influence of monetary and fiscal policy on exchange rates:

Countries also exert significant influence on exchange rates both through the initial mix of their fiscal and monetary policies and by subsequent adjustments to those policies. Various models have been developed to identify how these policies affect exchange rates. The Mundell–Fleming model addresses how changes in both fiscal and monetary policies affect interest rates and ultimately exchange rates in the short term.

McFadden describes monetary models by stating,

Statement 3: “Monetary models of exchange rate determination focus on the effects of inflation, price level changes, and risk premium adjustments.”

McFadden continues her discussion:

So far, we’ve touched on balance of payments and monetary policy. The portfolio balance model addresses the impacts of sustained fiscal policy on exchange rates. I must take a client call but will return shortly. In the meantime, here is some relevant literature on the models I mentioned along with a couple of questions for you to consider:

Question 1: Assume an emerging market (EM) country has restrictive monetary and fiscal policies under low capital mobility conditions. Are these policies likely to lead to currency appreciation or currency depreciation or to have no impact?

Question 2: Assume a developed market (DM) country has an expansive fiscal policy under high capital mobility conditions. Why is its currency most likely to depreciate in the long run under an integrated Mundell–Fleming and portfolio balance approach?

Upon her return, Wagener and McFadden review the questions. McFadden notes that capital flows can have a significant impact on exchange rates and have contributed to currency crises in both EM and DM countries. She explains that central banks, such as the Reserve Bank of New Zealand, use FX market inter-

vention as a tool to manage exchange rates. McFadden states,

Statement 4: "Some studies have found that EM central banks tend to be more effective in using exchange rate intervention than DM central banks, primarily because of one important factor."

McFadden continues her discussion:

Statement 5: "I mentioned that capital inflows could cause a currency crisis, leaving fund managers with significant losses. In the period leading up to a currency crisis, I would predict that an affected country's:

Prediction 1: foreign exchange reserves will increase.

Prediction 2: broad money growth will increase.

Prediction 3: exchange rate will be substantially higher than its mean level during tranquil periods."

After the interview, McFadden agrees to meet the following week to discuss more recent events on the New Zealand dollar.

14. The international parity condition McFadden is referring to in Statement 1 is:

- A. purchasing power parity.
- B. covered interest rate parity.
- C. uncovered interest rate parity.

15. In Statement 2, McFadden is *most likely* failing to consider the:

- A. initial gap between the country's imports and exports.
- B. effect of an initial trade deficit on a country's exchange rates.
- C. lag in the response of import and export demand to price changes.

16. The *least* appropriate factor used to describe the type of models mentioned in Statement 3 is:

- A. inflation.
- B. price level changes.
- C. risk premium adjustments.

17. The best response to Question 1 is that the policies will:

- A. have no impact.
- B. lead to currency appreciation.
- C. lead to currency depreciation.

18. The most likely response to Question 2 is a(n):

- A. increase in the price level.
- B. decrease in risk premiums.
- C. increase in government debt.

19. The factor that McFadden is *most likely* referring to in Statement 4 is:

- A. FX reserve levels.

- B. domestic demand.
- C. the level of capital flows.
20. Which of McFadden's predictions in Statement 5 is *least likely to be correct*?
- A. Prediction 1
- B. Prediction 2
- C. Prediction 3
-

SOLUTIONS

1. C is correct. The equation to calculate the forward premium (discount) is:

$$F_{f/d} - S_{f/d} = S_{f/d} \left(\frac{\frac{[Actual]}{360}}{1 + i_d \left[\frac{[Actual]}{360} \right]} \right) (i_f - i_d).$$

$S_{f/d}$ is the spot rate with GBP the base currency or d and INR the foreign currency or f . $S_{f/d}$ per Exhibit 1 is 79.5093, i_f is equal to 7.52%, and i_d is equal to 5.43%.

With GBP as the base currency (i.e., the “domestic” currency) in the INR/GBP quote, substituting in the relevant base currency values from Exhibit 1 yields the following:

$$F_{f/d} - S_{f/d} = 79.5093 \left(\frac{\frac{[360]}{360}}{1 + 0.0543 \left[\frac{[360]}{360} \right]} \right) (0.0752 - 0.0543).$$

$$F_{f/d} - S_{f/d} = 79.5093 \left(\frac{1}{1.0543} \right) (0.0752 - 0.0543).$$

$$F_{f/d} - S_{f/d} = 1.576.$$

2. B is correct. The dealer is posting a bid rate to buy BRL at a price that is too high. This overpricing is determined by calculating the interbank implied cross rate for the CHF/BRL using the intuitive equation-based approach:

$$\text{CHF/BRL} = \text{CHF/USD} \times (\text{BRL/USD})^{-1}, \text{ or}$$

$$\text{CHF/BRL} = \text{CHF/USD} \times \text{USD/BRL}.$$

Inverting the BRL/USD given the quotes in Exhibit 2 determines the USD/BRL bid–offer rates of 0.23980/0.23982. (The bid of 0.23980 is the inverse of the BRL/USD offer, calculated as 1/4.1702; the offer of 0.23982 is the inverse of the BRL/USD bid, calculated as 1/4.1698.) Multiplying the CHF/USD and USD/BRL bid–offer rates then leads to the interbank implied CHF/BRL cross rate:

$$\text{Bid: } 0.9799 \times 0.23980 = 0.2349.$$

$$\text{Offer: } 0.9801 \times 0.23982 = 0.23505.$$

Since the dealer is willing to buy BRL at 0.2355 but BRL can be purchased from the interbank market at 0.23505, there is an arbitrage opportunity to buy BRL in the interbank market and sell BRL to the dealer for a profit of 0.0045 CHF (0.2355 – 0.23505) per BRL transacted.

3. A is correct. The carry trade involves borrowing in a lower-yielding currency to invest in a higher-yielding one and netting any profit after allowing for borrowing costs and exchange rate movements. The relevant trade is to borrow USD and lend in EUR. To calculate the all-in USD return from a one-year EUR MRR deposit, first determine the current and one-year-later USD/EUR exchange rates. Because one USD buys CAD 1.3200 today and one CAD buys EUR 0.6506 today, today's EUR/USD rate is the product of these two numbers: $1.3200 \times 0.6506 = 0.8588$. The projected rate one year later is $1.3151 \times 0.6567 = 0.8636$. Accordingly, measured in dollars, the investment return for the unhedged EUR MRR deposit is equal to

$$\begin{aligned}
 & (1.3200 \times 0.6506) \times (1 + 0.022) \times [1/(1.3151 \times 0.6567)] - 1 \\
 &= 0.8588 \times (1.022)(1/0.8636) - 1 = 1.01632 - 1 \\
 &= 1.632\%.
 \end{aligned}$$

However, the borrowing costs must be charged against this *gross* return to fund the carry trade investment (one-year USD MRR was 0.80%). The *net* return on the carry trade is therefore $1.632\% - 0.80\% = 0.832\%$.

4. B is correct. While credit ratings can affect spreads, the trade involves spot settlement (i.e., two business days after the trade date), so the spread quoted to this highly rated (AA) firm is not likely to be much tighter than the spread that would be quoted to a somewhat lower-rated (but still high-quality) firm. The relationship between the bank and the client, the size of the trade, the time of day the trade is initiated, the currencies involved, and the level of market volatility are likely to be more significant factors in determining the spread for this trade.
5. B is correct. By rearranging the terms of the equation defining covered interest rate parity and assuming that uncovered interest rate parity is in effect, the forward exchange rate is equal to the expected future spot exchange rate— $F_{f/d} = S_{f/d}^e$ —with the expected percentage change in the spot rate equal to the interest rate differential. Thus, the forward exchange rate is an unbiased forecast of the future spot exchange rate.
6. A is correct. Goldsworthy has been given a bid–offer spread. Because she is buying the base currency—in this case, GBP—she must pay the offer price of JPY 129.69 per GBP.

$$\frac{\text{JPY } 225,000,000}{129.69 \text{ JPY/GBP}} = \text{GBP } 1,734,906.$$

7. A is correct. Posted quotes are typically for transactions in 1 million units of the base currency. Larger transactions may be harder for the dealer to sell in the interbank market and would likely require the dealer to quote a wider spread (lower bid price and higher offer price).
8. A is correct. Using quotes from Dealer A, she can find

$$\frac{\text{MXN}}{\text{GBP}} = \frac{\text{MXN}}{\text{USD}} \times \frac{\text{USD}}{\text{GBP}}.$$

The bid from Dealer A for MXN/GBP is effectively

$$\begin{aligned}
 \left(\frac{\text{MXN}}{\text{GBP}}\right)_{\text{bid}} &= \left(\frac{\text{MXN}}{\text{USD}}\right)_{\text{bid}} \times \left(\frac{\text{USD}}{\text{GBP}}\right)_{\text{bid}} \\
 &= 20.140 \times 1.2301 = 24.7742.
 \end{aligned}$$

The offer from Dealer A is

$$\begin{aligned}
 \left(\frac{\text{MXN}}{\text{GBP}}\right)_{\text{offer}} &= \left(\frac{\text{MXN}}{\text{USD}}\right)_{\text{offer}} \times \left(\frac{\text{USD}}{\text{GBP}}\right)_{\text{offer}} \\
 &= 20.160 \times 1.2305 = 24.8069.
 \end{aligned}$$

To compare with Dealer B's quote, she must take the inverse of MXN/GBP, so she has an offer to sell MXN at a rate of $1/24.7742 = \text{GBP } 0.0404$ and a bid to purchase MXN at a rate of $1/24.8069 = \text{GBP } 0.0403$. Dealer A is effectively quoting GBP/MXN at $0.0403/0.0404$. Although she can effectively buy MXN more cheaply from Dealer A (GBP 0.0404 from Dealer A, versus GBP 0.0406 from Dealer B), she cannot resell them to Dealer B for a higher price than GBP 0.0403. There is no profit from triangular arbitrage.

9. A is correct. Marking her nine-month contract to market six months later

requires buying GBP/EUR three months forward. The GBP/EUR spot rate is 0.9467/0.9471, and the three-month forward points are 14.0/15.0. The three-month forward rate to use is $0.9471 + (15/10000) = 0.9486$. Goldsworthy sold EUR 5,000,000 at 0.9526 and bought at 0.9486. The net cash flow at the settlement date will equal $\text{EUR } 5,000,000 \times (0.9526 - 0.9486) \text{ GBP/EUR} = \text{GBP } 20,000$. This cash flow will occur in three months, so we discount at the three-month GBP MRR of 58 bps:

$$\frac{\text{GBP } 20,000}{1 + 0.0058\left(\frac{90}{360}\right)} = \text{GBP } 19,971.04.$$

10. A is correct. The positive forward points for the GBP/EUR pair shown in Exhibit 2 indicate that the EUR trades at a forward premium at all maturities, including three months. Covered interest rate parity,

$$F_{fd} = S_{fd} \left(\frac{1 + i_f \left[\frac{\text{Actual}}{360} \right]}{1 + i_d \left[\frac{\text{Actual}}{360} \right]} \right),$$

suggests a forward rate greater than the spot rate requires a non-domestic risk-free rate (in this case, the GBP MRR) greater than the domestic risk-free rate (EUR MRR). When covered interest rate parity is violated, traders can step in and conduct arbitrage.

11. B is correct. Using covered interest rate parity, the forward rate is

$$\begin{aligned} F_{fd} &= S_{fd} \left(\frac{1 + i_f \left[\frac{\text{Actual}}{360} \right]}{1 + i_d \left[\frac{\text{Actual}}{360} \right]} \right) \\ &= 1.2303 \left(\frac{1 + 0.0033 \left[\frac{90}{360} \right]}{1 + 0.0058 \left[\frac{90}{360} \right]} \right) = 1.2295. \end{aligned}$$

Because the domestic MRR is higher than the non-domestic MRR, the forward rate will be less than the spot rate, giving a forward discount of

$$F_{fd} - S_{fd} = 1.2295 - 1.2303 = -0.0008.$$

12. B is correct. The covered interest rate parity condition,

$$F_{fd} = S_{fd} \left(\frac{1 + i_f \left[\frac{\text{Actual}}{360} \right]}{1 + i_d \left[\frac{\text{Actual}}{360} \right]} \right), \text{ (Equation 1)}$$

specifies the forward exchange rate that must hold to prevent arbitrage given the spot exchange rate and the risk-free rates in both countries. If the forward and spot exchange rates, as well as one of the risk-free rates, are known, the other risk-free rate can be calculated.

13. B is correct. According to uncovered interest rate parity,

$$\% \Delta S_{fd}^e = i_f - i_d, \text{ (Equation 2)}$$

the expected change in the spot exchange rate should reflect the interest rate spread between the two countries, which can be found in Exhibit 3. Given the spot exchange rate (from Exhibit 1) and the expected future change, she should be able to estimate the future spot exchange rate.

14. C is correct. The carry trade strategy is dependent on the fact that uncovered interest rate parity does not hold in the short or medium term. If uncovered interest rate parity held, it would mean that investors would receive identical returns

from either an unhedged foreign currency investment or a domestic currency investment because the appreciation/depreciation of the exchange rate would offset the yield differential. However, during periods of low volatility, evidence shows that high-yield currencies do not depreciate enough and low-yield currencies do not appreciate enough to offset the yield differential.

15. C is correct. McFadden states that exchange rates will *immediately* correct the trade imbalance. She is describing the flow supply/demand channel, which assumes that trade imbalances will be corrected as the deficit country's currency depreciates, causing its exports to become more competitive and its imports to become more expensive. Studies indicate that there can be long lags between exchange rate changes, changes in the prices of traded goods, and changes in the trade balance. In the short run, exchange rates tend to be more responsive to investment and financing decisions.
16. C is correct. Risk premiums are more closely associated with the portfolio balance approach. The portfolio balance approach addresses the impact of a country's net foreign asset/liability position. Under the portfolio balance approach, investors are assumed to hold a diversified portfolio of assets including foreign and domestic bonds. Investors will hold a country's bonds as long as they are compensated appropriately. Compensation may come in the form of higher interest rates and/or higher risk premiums.
17. B is correct. The currency is likely to appreciate. The emerging market country has both a restrictive monetary policy and a restrictive fiscal policy under conditions of low capital mobility. Low capital mobility indicates that interest rate changes induced by monetary and fiscal policy will not cause large changes in capital flows. Implementation of restrictive policies should result in an improvement in the trade balance, which will result in currency appreciation.
18. C is correct. Expansionary fiscal policies result in currency depreciation in the long run. Under a portfolio balance approach, the assumption is that investors hold a mix of domestic and foreign assets including bonds. Fiscal stimulus policies result in budget deficits, which are often financed by debt. As the debt level rises, investors become concerned as to how the ongoing deficit will be financed. The country's central bank may need to create more money in order to purchase the debt, which would cause the currency to depreciate. Or the government could adopt a more restrictive fiscal policy, which would also depreciate the currency.
19. A is correct. EM countries are better able to influence their exchange rates because their reserve levels as a ratio of average daily FX turnover are generally much greater than those of DM countries. This means that EM central banks are in a better position to affect currency supply and demand than DM countries, where the ratio is negligible. EM policymakers use their foreign exchange reserves as a kind of insurance to defend their currencies, as needed.
20. A is correct. Prediction 1 is least likely to be correct. Foreign exchange reserves tend to decline precipitously, not increase, as a currency crisis approaches. Broad money growth tends to rise in the period leading up to a currency crisis, and the exchange rate is substantially higher than its mean level during tranquil periods.

LEARNING MODULE

2

Economic Growth

by Paul R. Kutasovic, PhD, CFA.

Paul R. Kutasovic, PhD, CFA, is at New York Institute of Technology (USA).

LEARNING OUTCOMES

Mastery	<i>The candidate should be able to:</i>
<input type="checkbox"/>	compare factors favoring and limiting economic growth in developed and developing economies
<input type="checkbox"/>	describe the relation between the long-run rate of stock market appreciation and the sustainable growth rate of the economy
<input type="checkbox"/>	explain why potential GDP and its growth rate matter for equity and fixed income investors
<input type="checkbox"/>	contrast capital deepening investment and technological progress and explain how each affects economic growth and labor productivity
<input type="checkbox"/>	demonstrate forecasting potential GDP based on growth accounting relations
<input type="checkbox"/>	explain how natural resources affect economic growth and evaluate the argument that limited availability of natural resources constrains economic growth
<input type="checkbox"/>	explain how demographics, immigration, and labor force participation affect the rate and sustainability of economic growth
<input type="checkbox"/>	explain how investment in physical capital, human capital, and technological development affects economic growth
<input type="checkbox"/>	compare classical growth theory, neoclassical growth theory, and endogenous growth theory
<input type="checkbox"/>	explain and evaluate convergence hypotheses
<input type="checkbox"/>	describe the economic rationale for governments to provide incentives to private investment in technology and knowledge
<input type="checkbox"/>	describe the expected impact of removing trade barriers on capital investment and profits, employment and wages, and growth in the economies involved

1

AN INTRODUCTION TO GROWTH IN THE GLOBAL ECONOMY

Forecasts of long-run economic growth are important for global investors. Equity prices reflect expectations of the future stream of earnings, which depend on expectations of future economic activity. This dynamic means that in the long term, the same factors that drive economic growth will be reflected in equity values. Similarly, the expected long-run growth rate of real income is a key determinant of the average real interest rate level in the economy, and therefore the level of real returns in general. In the shorter term, the relationship between actual and potential growth (i.e., the degree of slack in the economy) is a key driver of fixed-income returns. Therefore, in order to develop global portfolio strategies and investment return expectations, investors must be able to identify and forecast the factors that drive long-term sustainable growth trends. Based on a country's long-term economic outlook, investors can then evaluate the long-term investment potential and risk of investing in the securities of companies located or operating in that country.

In contrast to the short-run fluctuations of the business cycle, the study of economic growth focuses on the long-run trend in aggregate output as measured by potential GDP. Over long periods, the actual growth rate of GDP should equal the rate of increase in potential GDP because, by definition, output in excess of potential GDP requires employing labor and capital beyond their optimum levels. Thus, the growth rate of potential GDP acts as an upper limit to growth and determines the economy's sustainable rate of growth. Increasing the growth rate of potential GDP is the key to raising the level of income, the level of profits, and the living standard of the population. Even small differences in the growth rate translate into large differences in the level of income over time.

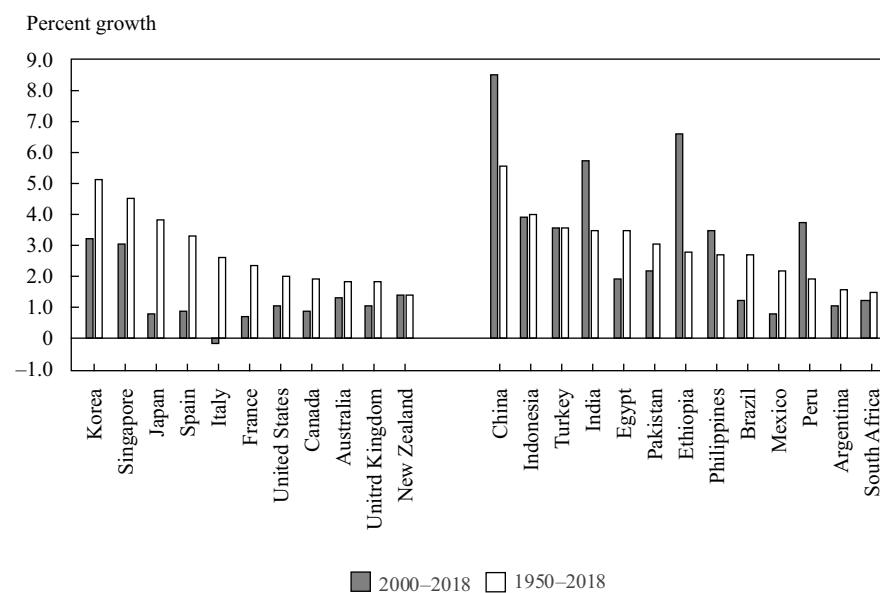
What drives long-run growth? What distinguishes the "winners" from the "losers" in the long-run growth arena? Will poor countries catch up with rich countries over time? Can policies have a permanent effect on the sustainable growth rate? If so, how? If not, why not? These and other key questions are addressed in detail in this reading.

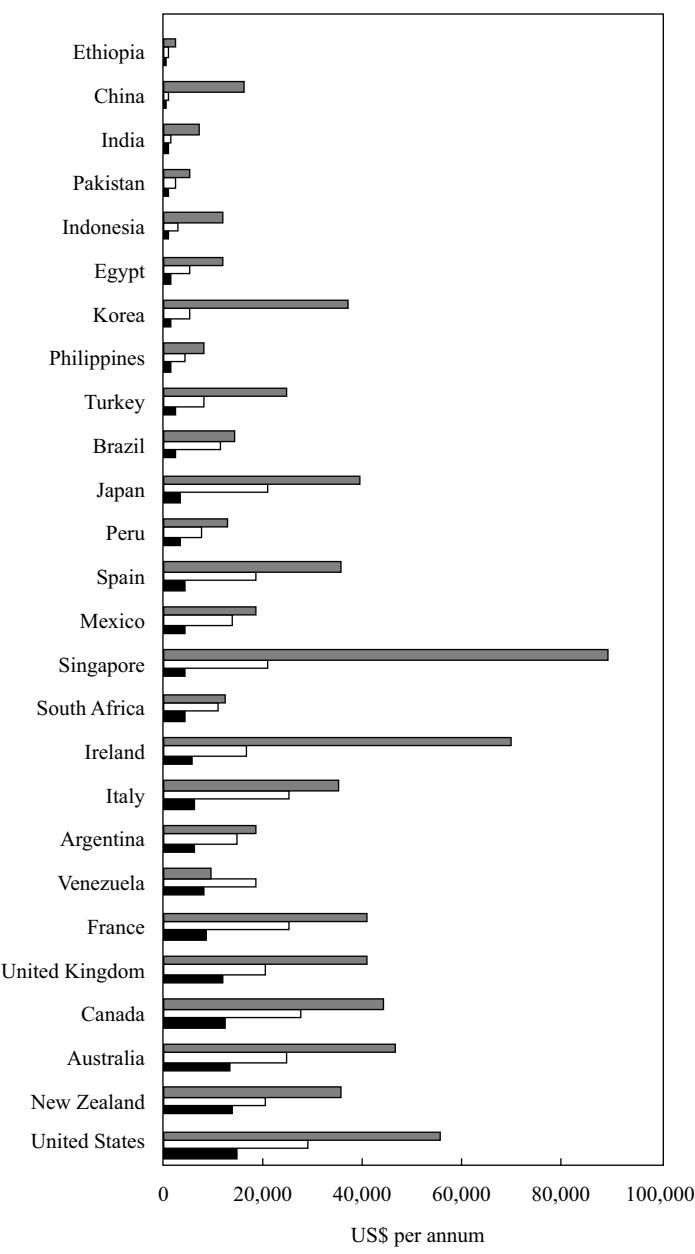
We first examine the long-term growth record, focusing on the extent of growth variation across countries and across decades. We then discuss the importance of economic growth to global investors and examine the relationship between investment returns and economic growth. We next turn to the factors that determine long-run economic growth before presenting the classical, neoclassical, and endogenous growth models. We also discuss whether poorer countries are converging to the higher income levels of the richer countries. Finally, we look at the impact of international trade on economic growth.

Growth in the Global Economy: Developed vs. Developing Economies

The first step in our study of long-term growth is to compare the economic performance of countries. GDP and per capita GDP are the best indicators economists have for measuring a country's standard of living and its level of economic development. Economic growth is calculated as the annual percentage change in real GDP or in real per capita GDP. Growth in real GDP measures how rapidly the total economy is expanding. Real per capita GDP reflects the average standard of living in each country—essentially the average level of material well-being. Growth in real GDP per capita (i.e., real GDP growing faster than the population) implies a rising standard of living.

Exhibit 1 presents data on the level of per capita GDP and the growth rate of GDP for a selection of economies. Because each economy reports its data in its own currency, each one's data must be converted into a common currency, usually the US dollar. One can convert the GDP data into dollars using either current market exchange rates or the exchange rates implied by **purchasing power parity (PPP)**. Purchasing power parity is the idea that exchange rates move to equalize the purchasing power of different currencies. At the exchange rates implied by PPP, the cost of a typical basket of goods and services is the same across all economies. In other words, exchange rates should be at a level where you can buy the same goods and services with the equivalent amount of any economy's currency.

Exhibit 1: Divergent Real GDP Growth among Selected Economies and Real GDP per Capita, in US\$



■ 2018 □ 1980 ■ 1950

Note: The measure of GDP per capita is in constant US dollar market prices for 2011 and adjusted for cross-economy differences in the relative prices of goods and services using PPP.

Sources: International Monetary Fund, World Economic Outlook database for growth rates, and Conference Board, Total Economy Database (September 2019).

In general, the simple method of taking a country's GDP measured in its own currency and then multiplying by the current exchange rate to express it in another currency is not appropriate. Using market exchange rates has two problems. First, market exchange rates are very volatile. Changes in the exchange rate could result in large swings in measured GDP even if there is little or no growth in the country's economy. Second, market exchange rates are determined by financial flows and flows in tradable goods and services. This dynamic ignores the fact that much of global consumption is for non-tradable goods and services. Prices of non-traded goods and services differ by country. In particular, non-traded goods are generally less expensive in developing countries than in developed countries. For example, because labor is cheaper in Mexico City than in London, the prices of labor-intensive products, such

as haircuts or taxi rides, are lower in Mexico City than in London. Failing to account for differences in the prices of non-traded goods and services across countries tends to underestimate the standard of living of consumers in developing countries. To compare standards of living across time or across countries, we need to use a common set of prices among a wide range of goods and services. Thus, cross-country comparisons of GDP should be based on purchasing power parity rather than current market exchange rates.

The economies in Exhibit 1 are divided into two categories: developed (or advanced) economies and developing economies. Developed economies tend to be those with high per capita GDP. There are no universally agreed-upon criteria, however, for classifying economies as advanced or developing. The International Monetary Fund (IMF) classifies 39 economies as advanced and 155 as developing. It says that “this classification is not based on strict criteria, economic or otherwise, and has evolved over time” (IMF 2019). Developed countries include the United States, Canada, Australia, Japan, and major economies in Europe. Growth in the large, developed economies generally slowed over the last few decades, with US growth exceeding that of Europe and Japan. Also included in this group are countries such as Singapore, Ireland, and Spain, which were poor in the 1950s but now have relatively high per capita real GDPs because of high growth rates over the past 50 years.

The second group of countries is the developing countries of Africa, Asia, and Latin America. Per capita GDP in these countries is lower than in the advanced countries, but GDP is generally growing faster than in the developed countries. Although the growth rates of the developing countries exceed those of the advanced countries, there is significant variation in economic performance among the developing countries. China and India have been growing at a rapid rate. Meanwhile, growth in Latin America, Africa, and the Middle East has lagged behind Asia.

What explains the diverse experiences among the developing countries and between the developed and developing ones? Singapore, for example, had less than half the per capita GDP of the United States in 1970 but now has per capita GDP that exceeds that of the United States. In contrast, such countries as Ethiopia and Kenya have remained poor, with little growth in per capita GDP. The literature on economic growth focuses primarily on the role of capital and labor resources and the use of technology as sources of growth. In addition to these purely economic drivers, developed and developing countries differ with respect to the presence or absence of appropriate institutions that support growth. These institutions enable developing countries to raise their standards of living and eventually move into the ranks of the developed countries. We now examine some of the key institutions and requirements for growth.

2

FACTORS FAVORING AND LIMITING ECONOMIC GROWTH



compare factors favoring and limiting economic growth in developed and developing economies

One of the major problems for some of the developing countries is a low level of capital per worker. Countries accumulate capital through private and public sector (e.g., infrastructure) investment. But increasing the investment rate may be difficult in developing countries because low levels of disposable income can make it difficult to generate significant saving. The low saving rate contributes to a vicious cycle of poverty: Low savings lead to low levels of investment, which leads to slow GDP growth, which

implies persistently low income and savings. Therefore, it is very difficult to design policies to increase domestic saving and investment rates in developing countries. The good news is that the savings of domestic residents are not the only source of investment funds. A developing country can break out of the cycle of low savings by attracting foreign investment.

Financial Markets and Intermediaries

In addition to the saving rate, growth depends on how efficiently saving is allocated within the economy. A role of the financial sector in any economy is to channel funds from savers to investment projects. Financial markets and intermediaries, such as banks, can promote growth in at least three ways.

- By screening those who seek funding and monitoring those who obtain funding, the financial sector channels financial capital (savings) to projects that are likely to generate the highest risk-adjusted returns.
- The financial sector may encourage savings and assumption of risk by creating attractive investment instruments that facilitate risk transfer and diversification and enhance liquidity.
- The existence of well-developed financial markets and intermediaries can mitigate the credit constraints that companies might otherwise face in financing capital investments. For example, banks can aggregate small amounts of savings into a larger pool enabling them to finance larger projects that can exploit economies of scale.

Evidence suggests that countries with better-functioning financial markets and intermediaries grow at a faster rate (Levine, 2005). Not all financial sector developments promote economic growth, however. Financial sector intermediation that results in declining credit standards and/or increasing leverage will increase risk and not necessarily increase long-run growth.

Political Stability, Rule of Law, and Property Rights

Stable and effective government, a well-developed legal and regulatory system, and respect for property rights are key ingredients for economic growth. Property rights are the legal arrangements that govern the protection of private property, including intellectual property. Clearly established property rights create the incentive for domestic households and companies to invest and save. A legal system—substantive and procedural laws—is needed to establish and protect these rights. Substantive law focuses on the rights and responsibilities of entities and relationships among entities, and procedural law focuses on the protection and enforcement of the substantive laws. In developed countries these rights and arrangements are well established, but they may be lacking or ineffective in developing countries.

In addition, economic uncertainty increases when wars, military coups, corruption, and other sources of political instability are widespread. These factors raise investment risk, discourage foreign investment, and weaken growth. In many developing countries, especially those in Africa, the first priority in trying to enhance growth is to enact a legal system that establishes, protects, and enforces property rights.

Education and Health Care Systems

Inadequate education at all levels is a major impediment to growth for many developing countries. Many workers are illiterate, and few workers have the skills needed to use the latest technology. At the same time, many developing countries also suffer

from a “brain drain,” in which the most highly educated individuals leave the developing country for more-advanced countries. Basic education raises the skill level of the workforce and thus contributes to the country’s potential for growth. In addition, because physical capital and human capital are often complementary, education can raise growth by increasing the productivity of existing physical capital. Thus, improving education, through both formal schooling and on-the-job training, is an important component of a sustainable growth strategy for a developing country. China and India are investing large amounts in education and have successfully graduated large numbers of students majoring in engineering and technology-related areas of study. This effort is significantly improving the quality of their workforces.

Empirical studies show that the allocation of education spending among different types and levels (primary, secondary, and post-secondary) of education is a key determinant of growth, especially in comparing growth in developed countries with growth in developing ones. The impact of education spending depends on whether the country is on the leading edge of technology and fostering innovation or simply relying on imitation as a source of growth. Typically, developed countries, such as the United States, Japan, and western European nations, are on the leading edge of technology and need to invest in post-secondary education to encourage innovation and growth. For these countries, incremental spending on primary and secondary education will have a relatively small impact on growth. In contrast, the developing countries, which largely apply technology developed elsewhere, should emphasize primary and secondary education. Such spending will improve growth by improving the countries’ ability to absorb new technologies and to organize existing tasks more efficiently.

Poor health is another obstacle to growth in the developing countries. Life expectancy rates are substantially lower in many developing countries than in developed ones. In Africa, tropical diseases are rampant and AIDS has had a devastating impact. The GDP growth rate in Botswana, a huge success story in the 1970s and 1980s, slowed dramatically during the following two decades as a result, at least in part, of the AIDS epidemic.

Tax and Regulatory Systems

Tax and regulatory policies have an important impact on growth and productivity, especially at the company level. Analysis suggests that limited regulations encourage entrepreneurial activity and the entry of new companies. There is also a strong positive correlation between the entry of new companies and average productivity levels. Studies by the Organisation for Economic Co-Operation and Development (OECD) indicate that low administrative startup cost is a key factor encouraging entrepreneurship (OECD 2003).

Free Trade and Unrestricted Capital Flows

Opening an economy to capital and trade flows has a major impact on economic growth. In an open economy, world savings can finance domestic investment. As a potential source of funds, foreign investment can break the vicious cycle of low income, low domestic savings, and low investment. Foreign investment can occur in two ways:

- Foreign companies can invest directly in a domestic economy (so-called foreign direct investment, or FDI) by building or buying property, plant, and equipment.
- Foreign companies and individuals can invest indirectly in a domestic economy by purchasing securities (equity and fixed income) issued by domestic companies.

Both of these forms of foreign investment will potentially increase the developing economy's physical capital stock, leading to higher productivity, employment, and wages, and perhaps even increased domestic savings. This suggests that developing countries would benefit from policies that encourage investment from abroad, such as eliminating high tariffs on imports (especially capital goods) and removing restrictions on foreign direct and indirect investments.

Brazil and India are examples of developing countries that have benefited from foreign investment. Foreign companies directly invested \$48.5 billion in Brazil in 2010, an important source of investment spending for the Brazilian economy (see Exhibit 19). Foreign direct investment also provides developing countries with access to advanced technology developed and used in the advanced countries. In 1999, India enacted new regulations that liberalized direct and indirect foreign investments in Indian companies. Foreign institutional and venture capital investors were given greater flexibility to invest directly in Indian entities as well as in the Indian capital markets. These changes also made it easier for foreign companies to invest in plant and equipment. These developments contributed to the acceleration in India's economic growth over the last decade (see Exhibit 1).

Capital flows are just one way that the international economy affects economic growth. The other is through trade in goods and services. In general, free trade benefits an economy by providing its residents with more goods at lower costs. With free trade, domestic companies face increased competition, which limits their price discretion, but they also obtain access to larger markets. The evidence of the benefits of open markets is discussed later in the reading.

Summary of Factors Limiting Growth in Developing Countries

Developing countries differ significantly from developed countries in terms of their institutional structure and their legal and political environments. Lack of appropriate institutions and poor legal and political environments restrain growth in the developing economies and partially explain why these countries are poor and experience slow growth. Factors limiting growth include the following:

- Low rates of saving and investment
- Poorly developed financial markets
- Weak, or even corrupt, legal systems and failure to enforce laws
- Lack of property rights and political instability
- Poor public education and health services
- Tax and regulatory policies discouraging entrepreneurship
- Restrictions on international trade and flows of capital

Although these factors are not necessarily absent in developed countries, they tend to be more prevalent in developing countries. Policies that correct these issues, or mitigate their impact, enhance the potential for growth. In addition to these institutional restraints, as we will see later, growth in developing countries may be limited by a lack of physical, human, and public capital, as well as little or no innovation.

EXAMPLE 1

Why Growth Rates Matter

In 1950, Argentina and Venezuela were relatively wealthy countries with per capita GDP levels of \$6,164 and \$8,104, respectively. Per capita GDPs in these Latin American countries were well above those of Japan, South Korea, and

Singapore, which had per capita GDPs of \$3,048, \$1,185, and \$4,299, respectively. By 2018, however, a dramatic change occurred in the relative GDPs per capita of these countries.

Real GDP Per Capita in US Dollars

	Venezuela	Argentina	Singapore	Japan	South Korea
1950	\$8,104	\$6,164	\$4,299	\$3,048	\$1,185
2018	\$9,487	\$18,255	\$66,189	\$39,313	\$36,756

1. Calculate the annual growth rate in per capita GDP for each of the five countries over the period 1950–2018.

Solution

The annual growth rates for the five countries are calculated as follows:

Argentina	$[(\$18,255/\$6,164)^{1/68}] - 1 = 1.6\%$
Venezuela	$[(\$9,487/\$8,104)^{1/68}] - 1 = 0.2\%$
Japan	$[(\$39,313/\$3,048)^{1/68}] - 1 = 3.8\%$
Singapore	$[(\$66,189/\$4,299)^{1/68}] - 1 = 4.1\%$
South Korea	$[(\$36,756/\$1,185)^{1/68}] - 1 = 5.2\%$

2. Explain the implication of the growth rates for these countries.

Solution

Differences in GDP growth rates sustained over a number of decades will significantly alter the relative incomes of countries. Nations that experience sustained periods of high growth will eventually become high-income countries and move up the income ladder. In contrast, countries with slow growth will experience relative declines in living standards. This dynamic is well illustrated in this example by a historical comparison of growth in Argentina and Venezuela with Japan, Singapore, and South Korea. In 1950, Argentina and Venezuela were relatively wealthy countries with per capita GDP levels well above those of Japan, South Korea, and Singapore. Over the next 60 years, however, the rate of growth in per capita GDP was significantly slower in Venezuela and Argentina in comparison to the three Asian countries. This disparity resulted in a dramatic change in these countries' relative incomes. The per capita GDP of the three Asian countries rose sharply as each joined the ranks of developed countries. In contrast, Argentina and Venezuela stagnated and moved from the ranks of developed countries to developing country status. By 2018, per capita income in Singapore was more than seven times higher than in Venezuela.

Over the long run, the economic growth rate is an extremely important variable. Even small differences in growth rates matter because of the power of compounding. Thus, policy actions that affect the long-term growth rate even by a small amount will have a major economic impact.

3. Suppose that GDP per capita in Argentina had grown at the same rate as in Japan from 1950 to 2018. How much larger would real per capita GDP have been in Argentina in 2018?

Solution:

Assuming Argentina had grown at the same rate as Japan since 1950, its GDP per capita in 2018 would have been $(\$6,164)(1 + 0.038)^{68} = (\$6,164)(12.63) = \$77,854$, versus \$18,255 from Exhibit 1.

If Argentina had grown at the same rate as Japan, it would have had one of the highest standards of living in the world in 2018. The question is why the growth rates in Argentina and Venezuela diverged so much from the three Asian countries.

4. Venezuela plans to stimulate growth in its economy by substantially increasing spending on infrastructure, education, and health care. Nevertheless, foreign investment is discouraged, and reforms such as strengthening the legal system and encouraging private ownership have been largely ignored. Explain whether the measures described here could lead to faster economic growth.

Solution

The preconditions for economic growth are well-functioning financial markets, clearly defined property rights and rule of law, open international trade and flows of capital, an educated and healthy population, and tax and regulatory policies that encourage entrepreneurship. Investment in infrastructure would increase Venezuela's stock of physical capital, which would raise labor productivity and growth. Better education and health care would increase human capital and also increase productivity and growth. These measures would raise Venezuela's growth prospects. Missing, however, are a legal system that could better enforce property rights, openness to international trade and foreign investment, and well-functioning capital markets. Without changes in these preconditions, a significant improvement in Venezuela's growth is unlikely to occur. The following table summarizes these preconditions:

Preconditions for Growth	Impact of Planned Policy Action in Venezuela
Saving and investment	Improve growth potential
Developed financial markets	No impact
Legal systems	No impact
Property rights and political stability	No impact
Education and health	Improve growth potential
Tax and regulatory policies discouraging entrepreneurship	No impact
Restrictions on international trade and flows of capital	No impact

It should be noted that the global economy is evolving rapidly and past trends may or may not be sustained. Nonetheless, in order to provide concrete answers that do not require the reader to bring in additional information, our exercise solutions must assume past patterns are indicative of the future.

3

WHY POTENTIAL GROWTH MATTERS TO INVESTORS

- describe the relation between the long-run rate of stock market appreciation and the sustainable growth rate of the economy
- explain why potential GDP and its growth rate matter for equity and fixed income investors

The valuations of both equity and fixed-income securities are closely related to the growth rate of economic activity. Anticipated growth in aggregate earnings is a fundamental driver of the equity market. Growth in an economy's productive capacity, measured by **potential GDP**, places a limit on how fast the economy can grow. The idea is that potential GDP is the maximum amount of output an economy can sustainably produce without inducing an increase in the inflation rate. A key question for equity investors, therefore, is whether earnings growth is also bounded or limited by the growth rate of potential GDP.

For earnings growth to exceed GDP growth, the ratio of corporate profits to GDP must trend upward over time. It should be clear that the share of profits in GDP cannot rise forever. At some point, stagnant labor income would make workers unwilling to work and would also undermine demand, making further profit growth unsustainable. Thus, in the long run, real earnings growth cannot exceed the growth rate of potential GDP.

The relationship between economic growth and the return on equities is not straightforward. One way to capture the relationship of equity returns and economic growth is to use the Grinold-Kroner (2002) decomposition of the return to equity.

$$\begin{aligned} E(R_e) &= \text{dividend yield} + \text{expected capital gain} \\ &= \text{dividend yield} + \text{expected repricing} + \text{earnings growth per share} \\ &= \text{dividend yield} + \text{expected repricing} \\ &\quad + \text{inflation rate} + \text{real economic growth} - \text{change in shares outstanding} \\ &= dy + \Delta(P/E) + i + g - \Delta S \end{aligned}$$

Over time, the dividend yield, dy , has been found to be fairly stable and a significant contributor to equity market returns. The expected repricing term, $\Delta(P/E)$, relates to changes to the P/E ratios in the market. There is some evidence that with increasing GDP growth rates, P/E ratios trend higher as investors perceive the country and its economy to be less risky and are willing to pay a higher price for earnings. However, the primary impact of this repricing term is the volatility in the market's P/E ratio over market cycles.

Earnings growth per share is the primary channel through which economic growth can impact equity returns. Earnings growth per share can be expressed as a function of inflation, real economic growth, and change in the number of shares traded in the market.

When the number of shares outstanding in a market is constant, real economic growth translates into higher expected returns on equity. The empirical evidence on the existence of a direct relationship between economic growth and equity returns is conflicting and suggests that the change in shares outstanding, ΔS , termed the dilution effect, plays an important role in determining expected equity returns. These dilution effects vary significantly across countries for a variety of reasons, including the level of development of the economy and the sophistication of the financial markets.

This wedge between economic growth and equity returns arises for at least two reasons. The first reason is that publicly traded companies either buy back their shares and increase equity returns by decreasing shares outstanding, or issue new shares and dilute existing shareholder returns. Net buybacks, or nbb , captures the net result of buybacks and new equity issuance at the national stock market level. The second effect is due to some part of economic growth coming from small- and medium-sized entrepreneurial firms that are not traded publicly on the stock market. The greater this effect, termed the relative dynamism of the economy, rd , the greater the divergence between economic growth in the economy as a whole and the earnings growth of companies listed on the stock market. Expanding the ΔS dilution effect term to focus on both components:

$$\Delta S = nbb + rd$$

Exhibit 2 illustrates the divergence possible between real economic growth and equity returns across a variety of markets, highlighting the differences in nbb and rd that are observed across markets.

Exhibit 2: Indexes with Significant Dilution Effects, 1997–2017

Country	Real Return in Local Currency, r	Real per Capita GDP Growth, g		Net Buy- backs, nbb	Relative Dynamism, rd	Comments
		Real Return in Local Currency, r	Real per Capita GDP Growth, g			
Chile	4.8	2.9		1.1	0.0	Privatization of Telefónica Chile with reduction in number of companies in index from 32 (1997) to 19 (2017).
China	0.7	8.2		-26.5	14.9	Privatization of large state-owned enterprises. Change in number of companies in index from 28 (1997) to 152 (2017).
Czech Repub.	6.3	2.2		6.0	-11.7	Reduction in number of companies in index from 19 (1997) to 4 (2017). Loss of 38% of initial market cap.
Egypt	9.4	2.3		5.5	-3.9	Delistings. Reduction in number of companies in index from 13 (1997) to 3 (2017).
Greece	-8.7	0.5		-12.7	0.2	Privatizations, reclassification to emerging market, and bank recapitalizations.

Country	Real Return in Local Currency, r	Real per Capita GDP Growth, g	Net Buy- backs, nbb	Relative Dynamism, rd	Comments
Ireland	-0.8	3.8	-7.6	-1.9	Privatization of telecom operator Elrcom, secondary equity offerings in 1996–1997
Poland	1.9	3.9	-11.9	7.1	Privatizations in 1997–1998 of state-owned commodity firm and state-owned bank.
United States	6.1	1.4	-1.8	2.4	For comparison purposes.

Note: All percent figures expressed in log form.

Source: Table derived from data presented in L'Her, Masmoudi, and Krishnamoorthy, "Net Buybacks and the Seven Dwarfs," *Financial Analysts Journal* 74, no. 4 (2018).

Exhibit 2 illustrates the complexity in the relationship between economic growth and equity returns. China has the highest real economic growth rate over the period (8.2% annual) but a relatively low real return to equity (0.7%), because of significant dilution effects arising from the privatization of large state-owned enterprises. In contrast, Egypt experienced much lower economic growth (2.3%) but had a much higher real return to equity (9.4%), primarily because of a reduction of listed companies in the market index. Exhibit 2 illustrates how diverse the experience with net buybacks and relative dynamism is across countries and serves as evidence that this dispersion weakens the observed relationship between economic growth and equity returns.

The relationship between economic growth and returns to equity is thus a complex question. All else equal, higher economic growth should be associated with higher equity returns. It is clear, however, that all else is seldom equal and that equity returns are significantly influenced by dilution—coming from the need to raise new capital to support growth, changes in equity market composition such as large-scale privatizations, merger waves, and share buybacks. In addition, the companies traded on equity markets represent only one part of the economy. Outside of these firms, economic growth creates new firms, brings in new investors, and reshapes market valuations. Economic growth in and of itself does not guarantee that existing equity investors capture the new wealth created.

Estimates of potential GDP and its growth rate are widely available. Both the OECD and the International Monetary Fund (IMF) include these estimates in their intermediate-term and long-term economic growth forecasts for each country. Simply extrapolating past GDP growth into the future can produce incorrect forecasts because a country's GDP growth rate can, and frequently does, change over time. The rapid pace of economic transformation, privatizations, and increased economic liberalization in several Latin American and European countries in the late 1990s spurred brisk economic growth that translated into sizable stock market returns. For many of these countries, however, this high-growth period was followed by much lower long-run growth.

Factors or policies that cause potential growth to increase or decrease by even a small amount will have a large compounded impact on living standards, economic conditions, and the future level of economic activity. This reality has implications for long-run stock market returns, as shown earlier. Being able to recognize changes in economic factors and policies is critical for global equity investors.

Estimates of an economy's growth potential are also relevant for global fixed-income investors. Potential GDP forecasts can gauge inflationary pressures in the economy that arise from cyclical variations in actual output growth relative to the economy's long-term potential growth rate. Specifically, actual GDP growth above (below) the potential GDP growth rate puts upward (downward) pressure on inflation, which puts corresponding pressure on nominal interest rates and bond prices.

The growth rate of potential GDP is also an important factor for the level of real interest rates and, therefore, real asset returns in general. Faster growth in potential GDP translates into higher real interest rates and higher expected real asset returns in general. Higher real interest rates are required to induce savings to fund capital accumulation, which in turn can fuel higher potential GDP growth rates.

Potential GDP and its growth rate enter into fixed-income analysis in other ways as well. Among them are the following:

1. A higher rate of potential GDP growth improves the general credit quality of fixed-income securities. Credit rating agencies use the growth rate of potential GDP in evaluating the credit risk of sovereign debt. All else equal, slower estimated potential GDP growth raises the perceived risk of these bonds.
2. Monetary policy decisions are affected by the difference between an economy's estimated potential output and its actual operating level (referred to as the output gap) and by the growth of actual GDP relative to the long-term sustainable growth rate. Thus, fixed-income investors need to closely monitor the output gap and growth rates of actual and potential GDP to assess the likelihood of a change in central bank policy.
3. Government budget deficits typically increase during recessions and decrease during expansions. In examining fiscal policy, actual fiscal positions are often judged relative to structural or cyclically adjusted deficits, a theoretical budgetary balance that would exist if the economy were operating at its potential GDP.

EXAMPLE 2

Impact on Equity and Fixed Income Investors

Your firm subscribes to asset class risk and return estimates generated by a vendor. The equity market return estimates are based primarily on long-term average index returns. Following a multi-year period of very high equity returns driven by unusually high earnings growth and expanding P/E multiples, capital's share of total income as well as valuation multiples are near all-time highs. Based on the latest data, the vendor projects that over the long run, your domestic equity market will return 13.5% per year—11% annual appreciation and 2.5% dividend yield—forever.

Your firm also subscribes to a macroeconomic forecasting service that provides, in addition to shorter-term projections, estimates of the long-term growth rate of potential GDP and the long-term inflation rate. This service forecasts 3.25% real growth in the future and 3.75% inflation, down from 4.0% and 5.0%, respectively, over the last 75 years.

1. Why might you have greater confidence in the macroeconomic service's forecasts than in the vendor's equity market return forecast?

Solution

High volatility makes equity returns very hard to predict based on their own history. Extrapolating historical equity returns does not factor in changes in economic conditions, valuation changes, and the potential for economic growth.

Long-term real GDP growth rates tend to be far less volatile, especially for developed economies such as the United States or the euro area, because long-term potential growth is driven by slowly evolving fundamental economic forces. Similarly, for countries with prudent monetary policies, inflation rates are much less volatile than stock prices. Thus, one could reasonably place much higher confidence in forecasts of long-term real and nominal (real growth plus inflation) GDP growth than in equity market return forecasts based on historical equity returns.

2. Assuming the macroeconomic forecasts are accurate, what implicit assumptions underlie the vendor's forecast of 11% equity market appreciation?

Solution

Using the Grinold-Kroner framework, equity market returns can be attributed to (1) dividend yield, (2) expansion/contraction of the price-to-earnings ratio, (3) nominal GDP growth, and (4) change in shares outstanding. The macroeconomic forecast indicates that nominal GDP will grow at 7% (3.25% real + 3.75% inflation). So, the vendor's forecast of 11% equity market appreciation implies a 4% annual combined contribution from expansion in the P/E multiple and/or change in shares outstanding of GDP over the long run, an assumption that cannot hold.

3. Assuming the macroeconomic forecasts are accurate, what would be a more reasonable forecast for long-term equity returns?

Solution

Neither the P/E nor the profit share of GDP can grow at a high rate forever. A much more reasonable forecast of long-term equity market returns would be the projected 7% growth rate of nominal GDP plus the 2.5% dividend yield. A projected equity return of 9.5% over the long run is much more reasonable, subject to variability in dividend yields and price-to-earnings ratios.

4. In addition to its long-term potential GDP forecast, the macroeconomic forecasting service estimates sluggish 1.5% GDP growth for the next year. Based on this short-term GDP forecast, the bond analyst at your firm recommends that the firm increase its fixed-income investments. What assumptions underlie the bond analyst's forecast?

Solution

With forecasted actual GDP growth well below the growth in potential GDP, the bond analyst assumes a growing output gap or slack in the economy (i.e., there may be a slowdown in the economic cycle). This slack may place downward pressure on inflation and reduce inflationary expectations. To close this gap, the central bank may need to lower short-term interest rates and ease policy. In such an environment, bond prices should rise.

PRODUCTION FUNCTION AND GROWTH ACCOUNTING

4

- contrast capital deepening investment and technological progress and explain how each affects economic growth and labor productivity
- demonstrate forecasting potential GDP based on growth accounting relations

What are the forces driving long-run economic growth? The following sections discuss labor, physical and human capital, technology, and other factors, such as natural resources and public infrastructure, as inputs to economic growth and production functions and how changes in such inputs affect growth. We begin the discussion by presenting one of the simplest useful models of the production function.

Production Function

A production function is a model of the quantitative link between the inputs (factors of production), technology, and output. A two-factor aggregate production function with labor and capital as the inputs can be represented as

$$Y = AF(K, L), \quad (1)$$

where Y denotes the level of aggregate output in the economy, L is the quantity of labor or number of workers or hours worked in the economy, and K is an estimate of the capital services provided by the stock of equipment and structures used to produce goods and services. The function $F()$ embodies the fact that capital and labor can be used in various combinations to produce output.

In the production function above, A is a multiplicative scale factor referred to as **total factor productivity (TFP)**. Note that an increase in TFP implies a proportionate increase in output for any combination of inputs. Hence, TFP reflects the general level of productivity or technology in the economy. The state of technology embodies the cumulative effects of scientific advances, applied research and development, improvements in management methods, and ways of organizing production that raise the productive capacity of factories and offices.

It is worth noting that both the function $F()$ and the scale factor A reflect technology. An innovation that makes it possible to produce the same output with the same amount of capital but fewer workers would be reflected in a change in the function $F()$ because the relative productivity of labor and capital has been altered. In contrast, an increase in TFP does not affect the relative productivity of the inputs. As is standard in the analysis of economic growth, *unless stated otherwise, the level of "technology" should be interpreted as referring to TFP*.

To obtain concrete results, it is useful to use a specific functional form for the production function. The **Cobb-Douglas production function**, given by

$$F(K, L) = K^\alpha L^{1-\alpha}, \quad (2)$$

is widely used because it is easy to analyze and does a good job of fitting the historic data relating inputs and output. The parameter α determines the shares of output (factor shares) paid by companies to capital and labor and is assumed to have a value between 0 and 1. The reason for this follows from basic microeconomics. In a competitive economy, factors of production are paid their marginal product. Profit maximization requires that the marginal product of capital equal the **rental price**

of capital and the marginal product of labor equal the (real) wage rate. In the case of capital, the marginal product of capital (MPK) for the Cobb–Douglas production function is¹

$$\text{MPK} = \alpha AK^{\alpha-1}L^{1-\alpha} = \alpha Y/K.$$

Setting the MPK equal to the rental price (r) of capital,

$$\alpha Y/K = r.$$

If we solve this equation for α , we find that it equals the ratio of capital income, rK , to output or GDP, Y . Thus, α is the share of GDP paid out to the suppliers of capital. A similar calculation shows that $1 - \alpha$ is the share of income paid to labor. This result is important because it is easy to estimate α for an economy by simply looking at capital's share of income in the national income accounts.

The Cobb–Douglas production function exhibits two important properties that explain the relationship between the inputs and the output. First, the Cobb–Douglas production function exhibits **constant returns to scale**. This means that if all the inputs into the production process are increased by the same percentage, then output rises by that percentage. Under the assumption of constant returns to scale, we can modify the production function (Equation 1) and examine the determinants of the quantity of output per worker. Multiplying the production function by $1/L$ gives

$$Y/L = AF(K/L, L/L) = AF(K/L, 1).$$

Defining $y = Y/L$ as the output per worker or (average) **labor productivity** and $k = K/L$ as the capital-to-labor ratio, the expression becomes

$$y = AF(k, 1).$$

Specifying the Cobb–Douglas production function in output per worker terms, where again lower case letters denote variables measured on a per capita basis, we get

$$y = Y/L = A(K/L)^{\alpha}(L/L)^{1-\alpha} = Ak^{\alpha}. \quad (3)$$

This equation tells us that the amount of goods a worker can produce (labor productivity) depends on the amount of capital available for each worker (capital-to-labor ratio), technology or TFP, and the share of capital in GDP (α). It is important to note that this equation contains two different measures of productivity or efficiency. Labor productivity measures the output produced by a unit of labor, dividing the output (GDP) by the labor input used to produce that output ($y = Y/L$). TFP is a scale factor that multiplies the impact of the capital and labor inputs. Changes in TFP are estimated using a growth accounting method discussed in the next section.

A second important property of the model is the relation between an individual input and the level of output produced. The Cobb–Douglas production function exhibits **diminishing marginal productivity** with respect to each individual input. Marginal productivity is the extra output produced from a one-unit increase in an input keeping the other inputs unchanged. It applies to any input as long as the other inputs are held constant. For example, if we have a factory of a fixed size and we add more workers to the factory, the marginal productivity of labor measures how much additional output each additional worker will produce. Diminishing marginal productivity means that at some point, the extra output obtained from each additional unit of the input will decline. To continue our example, if we hire more workers at the existing factory (fixed capital input in this case), each additional worker adds less to output than the previously hired worker does, and average labor productivity (y) falls.

¹ The marginal product of capital is simply the derivative of output with respect to capital. This relationship can be approximated as $\Delta Y/\Delta K \approx [A(K + \Delta K)^{\alpha}L^{1-\alpha} - AK^{\alpha}L^{1-\alpha}]/\Delta K \approx [A\alpha K^{\alpha-1}\Delta K L^{1-\alpha}]/\Delta K = A\alpha K^{\alpha-1}L^{1-\alpha} = \alpha Y/K$. The approximation becomes exact for very small increments, ΔK .

The significance of diminishing marginal returns in the Cobb–Douglas production function depends on the value of α . A *value of α close to zero means diminishing marginal returns to capital are very significant and the extra output made possible by additional capital declines quickly as capital increases*. In contrast, a value of α close to one means that the next unit of capital increases output almost as much as the previous unit of capital. In this case, diminishing marginal returns still occur but the impact is relatively small. Note that the exponents on the K and L variables in the Cobb–Douglas production function sum to one, indicating constant returns to scale—that is, there are no diminishing marginal returns if both inputs are increased proportionately.

Growth Accounting

Since the publication of Solow's seminal work (Solow 1957), growth accounting has been used to analyze the performance of economies. The growth accounting equation is essentially the production function written in the form of growth rates. It starts with the Cobb–Douglas production function and decomposes the percentage change in output into components attributable to capital, labor, and technology:

$$\Delta Y/Y = \Delta A/A + \alpha \Delta K/K + (1 - \alpha) \Delta L/L \quad (4)$$

The **growth accounting equation** states that the growth rate of output equals the rate of technological change plus α times the growth rate of capital plus $(1 - \alpha)$ multiplied by the growth rate of labor. Because a 1% increase in capital leads to an $\alpha\%$ increase in output, α is the elasticity of output with respect to capital. Similarly, $(1 - \alpha)$ is the elasticity of output with respect to labor. Thus, in the Cobb–Douglas production function, the exponents α and $(1 - \alpha)$ play dual roles as both output elasticities and the shares of income paid to each factor. Note that the impact of any unspecified inputs (e.g., natural resources) is subsumed into the TFP component.

Data on output, capital, labor, and the elasticities of capital and labor are available for most developed countries. The rate of technological change is not directly measured and must therefore be estimated. The elasticities of capital and labor in the growth accounting equation are the relative shares of capital (α) and labor ($1 - \alpha$) in national income and are estimated from the GDP accounts. For the United States, the relative shares of labor and capital are approximately 0.7 and 0.3, respectively. This means that an increase in the growth rate of labor will have a significantly larger impact—roughly double—on potential GDP growth than will an equivalent increase in the growth rate of capital, holding all else equal. For example, because capital's share in GDP in the US economy is 0.3, a 1% increase in the amount of capital available for each worker increases output by only 0.3%. An equivalent increase in the labor input would boost growth by 0.7%.

The growth accounting equation has a number of uses in studying an economy. First, Solow used the equation to estimate the contribution of technological progress to economic growth. Solow estimated the growth in TFP as a residual in the preceding equation by plugging in $\Delta Y/Y$, $\Delta K/K$, $\Delta L/L$, and α and solving for $\Delta A/A$. This residual measures the amount of output that cannot be explained by growth in capital or labor and can thus be regarded as progress in TFP.

Second, the growth accounting equation is used to empirically measure the sources of growth in an economy. In such studies, the growth accounting equation is used to quantify the contribution of each factor to long-term growth in an economy and answer such questions as the following: How important are labor and demographic factors to growth? What is the contribution of capital, and how important is capital deepening as a source of growth? What is the impact of TFP? The growth accounting

equation can be expanded by considering different forms of capital and labor inputs, such as human capital and knowledge capital, and by considering the quality of the inputs as well.

Finally, the growth accounting equation is used to measure potential output. Potential GDP is estimated using Equation 4 with trend estimates of labor and capital and α estimated as one minus the labor share of GDP. The difficult task is estimating the growth rate of TFP, which, by definition, is a residual in the growth accounting equation. TFP is computed as the growth in output less the growth in the factor inputs. These inputs include labor and capital in the traditional Solow two-factor production model. If the production function is expanded by including more inputs, the weighted growth rates of these inputs would also be subtracted from the growth in output. The standard methodology treats TFP as exogenous and estimates its growth rate using various time-series models.

An alternative method of measuring potential GDP is the **labor productivity growth accounting equation**. It is very similar to the Solow approach but is simpler and models potential GDP as a function of the labor input and the productivity of the labor input. It avoids the need to estimate the capital input and the difficulty associated with computing total factor productivity. The disadvantage is that it incorporates both capital deepening and TFP progress in the productivity term in a way that can be difficult to analyze and to predict over long periods. Under this approach, the equation for estimating potential GDP is

$$\begin{aligned} \text{Growth rate in potential GDP} &= \text{Long-term growth rate of labor force} \\ &+ \text{Long-term growth rate in labor productivity} \end{aligned} \quad . \quad (5)$$

Thus, potential GDP growth is a combination of the long-term growth rate of the labor force and the long-term growth rate of labor productivity. If the labor force is growing at 1% per year and productivity per worker is rising at 2% per year, then potential GDP is rising at 3% per year.

Extending the Production Function

As a simplification, the production function in Equation 1 focused on only the labor and capital inputs. A more complete specification of the production function expands the list of inputs to include the following:

- Raw materials: natural resources such as oil, lumber, and available land (N)
- Quantity of labor: the number of workers in the country (L)
- Human capital: education and skill level of these workers (H)
- Information, computer, and telecommunications (ICT) capital: computer hardware, software, and communication equipment (K_{IT})
- Non-ICT capital: transport equipment, metal products and plant machinery other than computer hardware and communications equipment, and non-residential buildings and other structures (K_{NT})
- Public capital: infrastructure owned and provided by the government (K_P)
- Technological knowledge: the production methods used to convert inputs into final products, reflected by total factor productivity (A)

The expanded production function is expressed mathematically as

$$Y = AF(N, L, H, K_{IT}, K_{NT}, K_P).$$

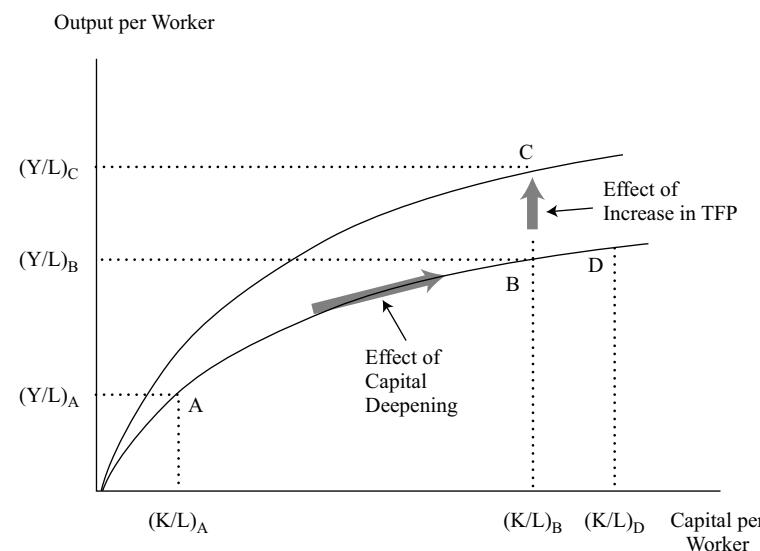
The impact of each of these inputs on economic growth is addressed in the following sections.

CAPITAL DEEPENING VS. TECHNOLOGICAL PROGRESS

5

The property of diminishing marginal returns plays an important role in assessing the contribution of capital and technology to economic growth. Exhibit 3 shows the relationship between per capita output and the capital-to-labor ratio. It shows that adding more and more capital to a fixed number of workers increases per capita output but at a decreasing rate. Looking at Exhibit 3 and Example 3, we can think of growth in per capita output coming from two sources: capital deepening and an improvement in technology, often referred to as technological progress.

Exhibit 3: Per Capita Production Function Capital Deepening vs. Technological (TFP) Progress



Capital deepening, an increase in the capital-to-labor ratio, is reflected in the exhibit by a move along the production function from point A to point B. The increase in the capital-to-labor ratio reflects rising investment in the economy. The ratio will increase as long as the growth rate of capital (net investment) exceeds the growth rate of labor. Once the capital-to-labor ratio becomes very high, however, as at point B, further additions to capital have relatively little impact on per capita output (e.g., moving to point D). This dynamic occurs because the marginal product of capital declines as more capital is added to the labor input.

At the point at which the marginal product of capital equals its marginal cost, profit maximizing producers will stop adding capital (i.e., stop increasing the capital-to-labor ratio). As we will discuss later, this point is very significant in the neoclassical model of growth because per capita growth in the economy will come to a halt. Once the economy reaches this steady state, capital deepening cannot be a source of sustained growth in the economy. Only when the economy is operating below the steady state and when the marginal product of capital exceeds its marginal cost can capital deepening raise per capita growth. Note that once technological progress (TFP growth) is introduced, the capital-to-labor ratio will have to keep increasing just to keep the

marginal productivity of capital equal to its marginal cost. But the point remains: Once that equality is attained, companies will not increase the capital-to-labor ratio faster than is necessary to maintain that equality.

The neoclassical model's stark implication that more-rapid capital accumulation—that is, higher rates of investment—cannot result in a permanently higher rate of per capita growth is somewhat disappointing. As we will see in our discussion of endogenous growth, capital accumulation can result in a permanently higher growth rate if the investment results not just in *more* capital (i.e., pure capital deepening) but also in new, innovative products and processes. That is, if the additional capital embodies new, more efficient methods of production or previously unavailable products, then more rapid capital accumulation can result in a permanently higher growth rate of per capita output.

In contrast to moves along a given production function, an improvement in TFP causes a proportional upward shift in the entire production function. As a result, the economy can produce higher output per worker for a given level of capital per worker. This dynamic is shown in Exhibit 3 by the move from B to C. Technological progress also increases the marginal product of capital relative to its marginal cost. This increase makes additional capital investments profitable and tends to mitigate the limits imposed on growth by diminishing marginal returns. In addition, continued growth in per capita output is possible even in the steady state as long as there is ongoing technological progress (increases in TFP). In summary, *sustained growth in per capita output requires progress in TFP*.

EXAMPLE 3

Capital Deepening vs. Technological Progress

One of main differences between developed and developing countries is the amount of capital available for each worker. Country A is an advanced economy with \$100,000 of capital available for each worker and thus a high capital-to-labor ratio. In contrast, Country B is a developing country with only \$5,000 of capital available for each worker.

What impact will the following developments have on the growth rate of potential GDP?

1. An increase in business investment in both countries

Solution

An increase in business investment will raise the capital-to-labor ratio in both countries. It results in capital deepening and a movement along the per worker production function. The impact on growth, however, will be significantly different for the two countries. Country B will experience an increase in output per worker and thus in the growth rate of potential GDP. This is because Country B operates at a low level of capital per worker, at a point like A in Exhibit 3. Diminishing returns to capital are small, so any addition to capital has a major impact on growth. Country A operates at a point like B in Exhibit 3, so additions to capital have little impact on growth because of diminishing returns.

2. An increase in the amount of spending on university research in both countries

Solution

An increase in spending on university research will increase TFP and cause an upward shift in the production function in both countries. This can be

seen in the move from point B to point C in Exhibit 3. The shift in the production function will raise growth in both countries and offset the negative impact of diminishing returns. This result shows that developing countries have the potential to grow through both capital deepening and technological progress, whereas improvement in potential GDP growth in developed countries is largely driven by technological progress.

3. An elimination of restrictions in Country B on the inflow of foreign investment

Solution

The elimination of restrictions will result in higher foreign investment, which has the same impact as an increase in domestic business investment. This is again a movement along the production function such as from point A to B in Exhibit 3. With diminishing returns insignificant at low levels of capital to labor, the higher level of foreign investment will boost growth of potential GDP in Country B.

NATURAL RESOURCES

6

- explain how natural resources affect economic growth and evaluate the argument that limited availability of natural resources constrains economic growth

Raw materials, including everything from available land to oil to water, are an essential input to growth. There are two categories of natural resources:

1. **Renewable resources** are those that can be replenished, such as a forest. For example, if a tree is cut, a seedling can be planted and a new forest harvested in the future.
2. **Non-renewable resources** are finite resources that are depleted once they are consumed. Oil and coal are examples.

Although it seems intuitive that countries with more natural resources will be wealthier, the relation between resource endowment and growth is not so straightforward. Natural resources do account for some of the differences in growth among countries. Today, Middle Eastern countries and such countries as Brazil and Australia have relatively high per capita incomes because of their resource base. Countries in the Middle East have large pools of oil. Brazil has an abundance of land suitable for large-scale agricultural production, allowing it to be a major exporter of coffee, soybeans, and beef.

Even though *access* to natural resources (e.g., via trade) is important, *ownership and production of natural resources is not necessary for a country to achieve a high level of income*. Countries in East Asia, such as South Korea, have experienced rapid economic growth but have few natural resources. In contrast, both Venezuela and Saudi Arabia have large oil reserves and are major producers of oil, yet both countries have experienced subpar growth compared with the natural-resource-poor countries of Singapore and South Korea. As was examined earlier, economic growth in Venezuela over the last 60 years was well below that of Singapore, Japan, and South Korea.

For some countries, the presence of natural resources may even restrain growth, resulting in a “resource curse.” Venezuela and Nigeria are two examples of countries blessed with resources yet with sluggish economic growth. There are two main reasons why this may occur. First, countries rich in natural resources may fail to develop the economic institutions necessary for growth. Second, countries rich in resources may suffer the **Dutch disease**, where currency appreciation driven by strong export demand for resources makes other segments of the economy, in particular manufacturing, globally uncompetitive. The name for this phenomenon comes from the experience of the Netherlands: Following the discovery of large natural gas fields in the Netherlands, the Dutch guilder (the nation’s currency at that time) appreciated and the manufacturing sector contracted. Because of this contraction, the resource-rich country does not participate in the TFP progress that occurs in countries with more vigorous manufacturing sectors.

In contrast, there is a longstanding concern that non-renewable natural resources will eventually limit growth. The idea is that a combination of rapid economic growth and a fixed stock of resources will cause resource depletion as the available pool of resources is used up. These concerns are probably overstated. Technological progress (TFP from all sources) enables the economy to use fewer resources per unit of output and to develop substitutes. The growing scarcity of specific resources will increase their price and encourage a shift toward more plentiful substitutes. Finally, the share of national income going to land and resources has been declining for most countries, especially as the composition of output in the global economy shifts toward the use of more services.

EXAMPLE 4

Impact of Natural Resources

The table below shows the share of world proved oil reserves as of 1990 for a selection of countries, along with the growth rate of real per capita GDP from 1990 to 2018. The simple correlation between the share of oil reserves and subsequent growth is not statistically different from zero.

	Percentage of World Proved Oil Reserves, 1990	Avg. Real Per Capita GDP Growth (%) 1990–2018		Percentage of World Proved Oil Reserves, 1990	Avg. Real Per Cap- ita GDP Growth (%) 1990–2018
Saudi Arabia	25.75	0.4	Germany	0.04	1.4
Venezuela	5.85	2.8	France	0.02	1.1
Mexico	5.64	1.3	New Zealand	0.01	1.6
United States	2.62	1.5	Pakistan	0.01	2.1
China	2.40	9.1	Japan	0.01	0.9
Nigeria	1.60	2.1	Spain	0.00	1.6
Indonesia	0.82	3.7			
India	0.75	5.2	Botswana	0.00	2.5
Canada	0.61	1.3	Ethiopia	0.00	4.6
Egypt	0.45	2.1	Ireland	0.00	4.6
United Kingdom	0.43	1.5	Kenya	0.00	0.9
Brazil	0.28	1.1	Singapore	0.00	3.7
Argentina	0.23	2.0	South Africa	0.00	2.7
Australia	0.17	1.8	South Korea	0.00	4.4

Sources: US Energy Information Administration (www.eia.gov) and IMF.

1. What might account for the fact that real per capita GDP growth appears to be unrelated to oil reserves, perhaps the single most economically important natural resource (aside from water)?

Solution

Energy is a vital input for any economy. Thus, *access* to energy resources is critical. *Ownership* of raw energy resources, however, is not. Countries that are not self-sufficient in oil or other resources acquire what they need through trade. It should be noted that countries that lack oil may possess other types of energy resources, such as natural gas, coal, hydropower, or geothermal energy. In addition, countries can grow by emphasizing less energy intensive products, especially services, and adopting more energy efficient production methods. In sum, natural resources are important but not necessary for growth.

LABOR SUPPLY

7

- explain how demographics, immigration, and labor force participation affect the rate and sustainability of economic growth

As noted earlier, economic growth is affected by increases in inputs, mainly labor and capital. Growth in the number of people available for work (quantity of workforce) is an important source of economic growth and partially accounts for the superior growth performance of the United States among the advanced economies—in particular, relative to Europe and Japan. Most developing countries, such as China, India, and Mexico, have a large potential labor supply. We can measure the potential size of the labor input as the total number of hours available for work. This, in turn, equals the labor force times the average hours worked per worker. The **labor force** is defined as the working age population (ages 16 to 64) that is either employed or available for work but not working (i.e., unemployed). Thus, growth in the labor input depends on four factors: population growth, labor force participation, net migration, and average hours worked.

Population Growth

Long-term projections of the labor supply are largely determined by the growth of the working age population. Population growth is determined by fertility rates and mortality rates. Population growth rates are significantly lower in the developed countries than in the developing countries. As a result, there is an ongoing decline in the developed countries' share of the world's population. Note that although population growth may increase the growth rate of the overall economy, it has no impact on the rate of increase in *per capita* GDP.

The age mix of the population is also important. The percentage of the population over the age of 65 and the percentage below the age of 16 are key considerations. Some of the developed countries, especially European countries, Japan, and South Korea, are facing a growing demographic burden as the portion of non-working elders (over 65) grows as a share of the population. In contrast, growth in many developing countries will receive a demographic boost as the fraction of the population below the age of 16 begins to decline. Interestingly, China is similar to the advanced economies, with a growing proportion of the population over age 65.

Exhibit 4: Population Data for Selected Countries (in millions, except growth rate)

	2000	2009	2018	Annual Growth (%), 2000–2018
France	59.1	64.4	66.9	0.69
Germany	82.2	81.9	82.9	0.05
Ireland	3.8	4.5	4.9	1.42
Spain	40.3	46.4	46.7	0.82
United Kingdom	58.9	62.3	66.4	0.67
Russia	146.7	141.9	144.5	-0.08
Japan	126.9	128.0	126.4	-0.02
United States	282.2	306.8	327.2	0.83
Mexico	98.4	112.1	125.3	1.35
China	1,267.4	1,352.1	1,415.0	0.61
India	1,024.3	1,214.3	1,354.1	1.56

Source: OECD.Stat.

Labor Force Participation

In the short run, the labor force growth rate may differ from population growth because of changes in the participation rate. The **labor force participation rate** is defined as the percentage of the working age population in the labor force. It has trended upward in most countries over the last few decades because of rising participation rates among women. In contrast to population, an increase in the participation rate may raise the growth of per capita GDP. In many southern European countries, such as Greece and Italy, the participation rate among women is well below the rates in the United States and northern European countries (see Exhibit 5). Thus, rising participation rates among women in these countries could increase growth in the labor force and in potential GDP. This has been the case for Spain, where the female labor force participation rate rose from 52.0% in 2000 to 67.9% in 2018. It should be noted, however, that rising or falling labor force participation is likely to represent a transition to a new higher or lower level of participation rather than a truly permanent rate of change. Thus, although trends in participation may contribute to or detract from potential growth for substantial periods, one should be cautious in extrapolating such trends indefinitely.

Exhibit 5: Labor Force Data for Selected Countries (2018)

	Percentage of Population under Age 15	Percentage of Population over Age 65	Participation Rate: Male	Participation Rate: Female
France	18.0%	19.9%	75.4%	69.7%
Germany	13.5	21.5	83.1	76.5
Greece	14.4	21.8	75.6	59.7
Ireland	20.8	13.6	77.3	66.6
Italy	13.2	22.7	73.9	55.6

	Percentage of Population under Age 15	Percentage of Population over Age 65	Participation Rate: Male	Participation Rate: Female
Spain	14.5	19.3	77.7	67.9
Sweden	17.8	19.9	84.9	83.2
United Kingdom	17.9	18.3	81.9	74.2
Japan	12.2	28.1	71.2	51.4
United States	18.6	16.0	76.2	68.3
Mexico	26.5	7.2	81.8	47.3
Turkey	23.5	8.6	78.6	38.4

Source: OECD Stat Extracts.

EXAMPLE 5

Impact of the Age Distribution on Growth: Mexico vs. Germany

Exhibit 4 and Exhibit 5 provide population data for selected countries. The data show that the rate of population growth and the age composition vary significantly among countries. Thus, demographic factors can be expected to have a significant impact on relative growth rates across countries. This effect is very clear in the cases of Mexico and Germany. There was essentially zero growth in Germany's population from 2000 to 2018, while Mexico's population increased by 1.35% annually. The age composition of the two countries is also very different.

1. How will the age distribution impact growth over the next decade?

Solution

What is important for growth is the number of workers available to enter the workforce. Over the next decade, Mexico will receive a demographic benefit because of the high percentage of young people entering the workforce. This is because 26.5% of the population in 2018 was below the age of 15. In contrast, only 13.5% of the German population was below the age of 15. In addition, Germany is facing a demographic challenge given the high and growing share of its population over the age of 65. In Mexico, only 7.2% of the population is above the age of 65, compared with 21.5% in Germany. In sum, the lack of population growth and a rapidly aging population in Germany will limit its potential rate of growth. Germany must rely on high labor productivity growth, increase its workforce participation rate, or encourage immigration if it is to increase its near-term potential rate of growth. Meanwhile, potential GDP growth in Mexico should receive a boost from its favorable population trends.

Net Migration

Another factor increasing economic and population growth, especially among the developed countries, is immigration. Heightened immigration is a possible solution to the slowing labor force growth being experienced by many developed countries with low

birthrates within the native population. The growth rate of the labor force in Ireland, Spain, the United Kingdom, and the United States has increased between 2000 and 2010 because of immigration, although it slowed substantially in the 2010–2018 period. Focusing on the decade starting in 2000, Exhibit 4 shows the population growth rates for Ireland and Spain at 1.71% and 1.35%, respectively. The population growth rates were well above the population growth rates in other European countries. As shown in Exhibit 6, this is because of the impact of immigration. The open-border policies of both countries led to a significant population of immigrants that contributed to a large increase in labor input for both countries. As a consequence, both countries experienced GDP growth above the European average during this period (see Exhibit 1).

Exhibit 6: Ireland and Spain: Net Migration

	2000–2007	2008	2009	2010	Total 2000–2010	Total 2011–2016
Ireland	357,085	38,502	-7,800	-12,200	375,587	186,724
Spain	4,222,813	460,221	181,073	111,249	4,975,356	1,243,375

Source: OECD Stat Extracts

EXAMPLE 6

Potential Growth in Spain: Labor Input

The scenario below is set in early 2011. The Investment Policy Committee of Global Invest Inc. reviewed a report on the growth prospects for Spain and noted that, with total hours worked growing at a 1.2% annual rate between 2000 and 2010, labor input had been a major source of growth for the economy. Some members expect the growth rate of labor to slow considerably given projection from the OECD and IMF that immigration into Spain will fall to essentially zero over the next few years. A research assistant at the firm gathered demographic data on Spain from Exhibit 4–Exhibit 6 and other sources. The data are presented in the following table:

	2000	2010	Annual Growth (2000–2010)
Population (millions)	40.3	46.1	1.35%
Immigration since 2000 (millions)		4.975	
Percentage of population under 15		15.0%	
Percentage of population over 65		17.0%	
Male labor force participation rate		80.4%	
Female labor force participation rate		66.1%	
Unemployment rate		20.1%	

Using this information for Spain and Exhibit 4 and Exhibit 5 for relevant comparison data, determine the following:

1. Whether a change in the trend growth rate of the labor input is likely over the next few years.

Solution

The growth in the labor input depends on a number of factors, including the population growth rate, the labor force participation rate, and the percentage of the population below the age of 15. The labor force in Spain expanded sharply between 2000 and 2010, mainly because of a population increase of 5.8 million, going from 40.3 million in 2000 to 46.1 million in 2010. Looking ahead, growth in the labor force is set to slow substantially for a number of reasons:

- The population increase between 2000 and 2010 is very misleading because it is not likely to be repeated in the future. Between 2000 and 2010, immigration raised the population of Spain by nearly 5 million people. Without the immigrants, the population would have grown by only about 825,000 people during this period, or at an annual rate of 0.2%. With immigration, the population growth rate was 1.35%. The pace of immigration that occurred between 2000 and 2010 is not sustainable and is likely to slow, which will result in slower growth in both the population and the labor force.
- In the short run, the growth rate of the labor force may differ from population growth because of changes in the participation rate. Looking at the data, the male participation rate in Spain, at 80.4%, is very high and, as shown in Exhibit 5, is above the male participation rates in France, Greece, and Italy and slightly below that of Germany. The female participation rate is low in comparison to northern European countries, such as Sweden. But it is higher than in Italy, which is probably a better comparison. Thus, little increase is likely in the male or female participation rates.
- Only 15% of the Spanish population is below the age of 15. The comparable figure from Exhibit 5 for the United Kingdom is 17.9%, for France 18.0%, for the United States 18.6%, and for Mexico 26.5%. Thus, Spain does not appear poised for a notable surge in young adults entering the labor force.

In summary, growth in the labor input in Spain should slow over the next few years, and the growth rate of potential GDP should do the same.

2. How the high unemployment rate of 20.1% is likely to affect the growth rate of the labor force.

Solution

Reducing the unemployment rate would mitigate some of the negative demographic factors because a reduction in the number of unemployed workers would boost utilization of the existing labor supply. This shift would represent a transition to a higher level of employment rather than a permanent increase in the potential growth rate. Nonetheless, it could boost potential growth for a substantial period.

Average Hours Worked

The contribution of labor to overall output is also affected by changes in the average hours worked per worker. Average hours worked is highly sensitive to the business cycle. The long-term trend in average hours worked, however, has been toward a shorter work week in the advanced countries. This development is the result of legislation, collective bargaining agreements, the growth of part-time and temporary work, and the impact of both the “wealth effect” and high tax rates on labor income, which cause workers in high-income countries to value leisure time relatively more highly than labor income.

Exhibit 7 provides data on average hours worked per year per person in the labor force for selected years since 1995. For most countries, the average number of hours worked per year has been declining. There is also a significant difference in hours worked across countries. In 2018, average hours worked per year in South Korea, at 1,993 hours, were 46.1% more than the 1,363 average hours worked per year in Germany. The increase in female labor force participation rates may be contributing to the shorter average workweek because female workers disproportionately take on part-time, rather than full-time, jobs.

Exhibit 7: Average Hours Worked per Year per Person in Selected Countries

	1995	2005	2018
France	1,651	1,559	1,520
Germany	1,534	1,435	1,363
Greece	2,123	2,081	1,956
Ireland	1,875	1,654	1,782
Italy	1,859	1,819	1,723
Spain	1,733	1,688	1,701
Sweden	1,609	1,607	1,474
United Kingdom	1,743	1,676	1,538
Japan	1,884	1,775	1,680
South Korea	2,658	2,364	1,993
Canada	1,761	1,738	1,708
United States	1,840	1,795	1,786
Mexico	1,857	1,909	2,148
Turkey	1,876	1,918	1,832

Source: OECD data.

Labor Quality: Human Capital

In addition to the quantity of labor, the quality of the labor force is an important source of growth for an economy. **Human capital** is the accumulated knowledge and skills that workers acquire from education, training, or life experience. In general, better-educated and more-skilled workers will be more productive and more adaptable to changes in technology or other shifts in market demand and supply.

An economy's human capital is increased through investment in education and on-the-job training. Like physical capital, investment in education is costly, but studies show that there is a significant return on that investment. That is, people with more education earn higher wages. In addition, education may also have a spillover or

externality impact. Increasing the educational level of one person raises not only the output of that person but also the output of those around that person. The spillover effect operates through the link between education and advances in technology. Education not only improves the quality of the labor force, and thus the stock of human capital, but also encourages growth through innovation. Importantly, increased education, obtained both formally and via on-the-job training, could result in a permanent increase in the growth rate of an economy if the more educated workforce results in more innovations and a faster rate of technological progress. Investment in the population's health is also a major contributor to human capital, especially in developing countries.

ICT, NON-ICT, AND TECHNOLOGY AND PUBLIC INFRASTRUCTURE

8

- explain how investment in physical capital, human capital, and technological development affects economic growth

The physical capital stock increases from year to year as long as net investment (gross investment less the depreciation of the capital) is positive. Thus, countries with a higher rate of investment should have a growing physical capital stock and a higher rate of GDP growth. Note that the impact on growth of per capita GDP will be somewhat smaller if the population is growing because a proportion of net investment simply provides the capital needed to maintain the capital-to-labor ratio. Exhibit 8 shows the level of gross non-residential investment as a share of GDP. The exhibit shows significant variation across countries, with the investment share in the United States being low in comparison to other developed countries.

Exhibit 8: Business Investment as a Percentage of GDP

	Investment Percentage of GDP		
	2000	2008	2018
Developed Countries			
France	19.5	24.1	22.8
Germany	21.5	20.9	21.2
Ireland	23.9	24.4	24.5
Italy	20.3	21.8	18.0
Spain	26.2	29.6	21.9
United Kingdom	17.1	17.2	17.2
Australia	22.0	28.4	24.2
Japan	25.4	24.5	24.4
South Korea	30.6	33.0	30.2
Singapore	33.1	30.5	27.0

	Investment Percentage of GDP		
	2000	2008	2018
Developed Countries			
Canada	19.2	24.1	23.0
United States	19.9	21.1	21.1
Developing Countries			
Brazil	18.3	21.9	15.4
China	35.1	47.9	44.2
India	24.3	36.5	31.6
Mexico	25.5	22.8	23.0
South Africa	15.1	19.5	17.9

Source: IMF.

The correlation between economic growth and investment is high. Countries that devote a large share of GDP to investment, such as China, India, and South Korea, have high growth rates. Some of the fastest-growing countries in Europe in the 1990s and for long periods since the year 2000, including Ireland and Spain, have some of the highest investment-to-GDP ratios. Countries that devote a smaller share of GDP to investment, such as Brazil and Mexico, have slower growth rates. The data show why the Chinese economy has expanded at such a rapid rate: annual GDP growth rate in excess of 10% over long periods. Investment spending in China on new factories, equipment, and infrastructure as a percentage of GDP is the highest in the world, at more than 40% of GDP.

As we discussed earlier, long-term sustainable growth cannot rely on pure capital deepening. How can we reconcile this notion with the strong correlation between investment spending and economic growth across countries? First, although diminishing marginal productivity will eventually limit the impact of capital deepening, investment-driven growth may last for a considerable period, especially in countries that start with relatively low levels of capital per worker.

A second, and closely related, explanation is that the impact of investment spending on available capital depends on the existing physical capital stock. As with the share of GDP devoted to investment, the stock of capital available per worker varies significantly across countries. In 2000, the average US worker had \$148,091 worth of capital, compared with \$42,991 in Mexico and \$6,270 in India (Heston, Summers, and Aten 2009). The wide difference in physical capital per worker suggests that the positive impact of changes in the physical capital stock on growth is very significant in developing countries. Mexican workers have relatively little access to machinery or equipment, so adding even a little can make a big percentage difference. In developed countries, such as the United States, Japan, Germany, France, and the United Kingdom, the physical capital stock is so large that positive net investment in any given year has only a small percentage effect on the accumulated capital stock. For the developed countries, a sustained high level of investment over many years is required to have a meaningful relative impact on the physical capital stock even though the absolute size of the increase in any given year is still larger than in the developing countries.

Third, because physical capital is not really homogeneous, the composition of investment spending and the stock of physical capital matters for growth and productivity. Insights obtained from the endogenous theory of growth (discussed later) and from studies attempting to obtain a more accurate measure of TFP show that the composition of the physical capital stock is very important. These studies suggest

that capital spending could be separated into two categories. The first is spending on information, computers, and telecommunications equipment (ICT investment). Capital spending on these goods is a measure of the impact of the information technology sector on economic growth. One of the key drivers of growth in the developed countries over the last decade has been the IT sector. Growth in the IT sector has been driven by technological innovation that has caused the price of key technologies, such as semiconductors, to fall dramatically. The steep decline in the price of high-technology capital goods has encouraged investment in IT at the expense of other assets.

The IT sector has grown very rapidly and has made a significant contribution to increasing the rate of economic and productivity growth. The greater use of IT equipment in various industries has resulted in **network externalities**. Computers allow people to interconnect through the internet and by email, enabling them to work more productively. *The more people in the network, the greater the potential productivity gains.* The effects of the network externalities are largely captured in TFP rather than observed as a distinct, direct effect. The share of ICT investment in GDP tends to be in the 3%–5% range for most developed economies. The IT sector is still relatively small in most countries, and IT spending actually declined as a share of GDP between 2000 and 2008 because the early 2000s recession disproportionately affected high-technology spending.

The other category of investment, non-ICT capital spending, includes non-residential construction, transport equipment, and machinery. High levels of capital spending for this category should eventually result in capital deepening and thus have less impact on potential GDP growth. In contrast, a growing share of ICT investments in the economy, through their externality impacts, may actually boost the growth rate of potential GDP.

It is worthwhile to note that there have been important “transformational technologies” at various stages of history. One need only consider the impact of the steam engine, the internal combustion engine, powered flight, atomic energy, vaccination, and so on, to realize that revolutionary advances are not unique to information, computers, and telecommunications. All of these are, to some extent, “general purpose technologies” (GPT) that affect production and/or innovation in many sectors of the economy. ICT capital clearly embodies this GPT characteristic. Nanotechnology could well become the next “super GPT,” at which point investing in ICT may begin to look like mere capital deepening.

Technology

The most important factor affecting growth of per capita GDP is technology, especially in developed countries. Technology allows an economy to overcome some of the limits imposed by diminishing marginal returns and results in an upward shift in the production function, as we noted in Exhibit 4. Technological progress makes it possible to produce more and/or higher-quality goods and services with the same resources or inputs. It also results in the creation of new goods and services. Technological progress can also be one of the factors improving how efficiently businesses are organized and managed.

Technological change can be embodied in human capital (knowledge, organization, information, and experience base) and/or in new machinery, equipment, and software. Therefore, high rates of investment are important, especially investment in ICT goods. Countries can also innovate through expenditures, both public and private, on research and development (R&D). Expenditures on R&D and the number

of patents issued, although not directly measuring innovation, provide some useful insight into innovative performance. Exhibit 9 shows R&D spending as a share of GDP for various countries. The developed countries spend the highest percentage of GDP on R&D because they must rely on innovation and the development of new products and production methods for growth. In contrast, developing countries spend less on R&D because these countries can acquire new technology through imitation or copying the technology developed elsewhere. The embodiment of technology in capital goods can enable relatively poor countries to narrow the gap relative to the technology leaders. It should also be noted that the relationship between economic growth and R&D spending is not clear-cut. Although technological innovation resulting from high R&D spending raises output and productivity in the long run, it may result in a cyclical slowing of growth as companies and workers are displaced by the new technologies. This is the Schumpeterian concept of creative destruction, which captures the double-edged nature of technological innovation.

Exhibit 9: Research and Development as a Percentage of GDP in Selected Countries

	1990	2009	2016
France	2.3	2.2	2.2
Germany	2.6	2.8	2.9
Ireland	0.8	1.8	1.2
Italy	1.2	1.3	1.3
Spain	0.8	1.4	1.2
United Kingdom	2.1	1.9	1.7
Australia	1.3	2.2	1.9
Japan	3.0	3.4	3.1
South Korea	1.7	3.1	4.2
Singapore	1.1	2.9	2.2
Canada	1.5	2.0	1.6
United States	2.6	2.9	2.7
China	NA	1.7	2.1
India	NA	0.8	0.8
Mexico	NA	0.4	0.5

Source: OECD.

The state of technology, as reflected by total factor productivity, embodies the cumulative effects of scientific advances, applied research and development, improvements in management methods, and ways of organizing production that raise the productive capacity of factories and offices. Because it is measured as a residual, TFP estimates are very sensitive to the measurements of the labor and capital inputs. Empirical work at the Conference Board and the OECD accounts for changes in the composition and quality of both the labor and capital inputs. The resulting measure of TFP should capture the technological and organizational improvements that increase output for a given level of inputs. Exhibit 10 provides data for the periods 1995–2005 and 2005–2018 on the growth rate in labor productivity and total factor productivity. Labor productivity growth depends on both capital deepening and technological progress. The contribution of capital deepening can be measured as the difference between the growth rates of labor productivity and total factor productivity. For example, from 2005 to 2018, South Korea's labor productivity grew by 3.3% per year, of which 2.5% ($3.3\% - 0.8\%$)

came from capital deepening, with the rest coming from changes in TFP (note that rounding causes minor discrepancies in the calculations in the exhibit). The larger the difference between the productivity growth measures, the more important capital deepening is as a source of economic growth. As we discussed previously, however, growth in per capita income cannot be sustained perpetually by capital deepening.

Exhibit 10: Labor and Total Factor Productivity

	Growth in Hours Worked (%)	Growth in Labor Prod. (%)	Growth in TFP (%)	Growth from Capital Deepening (%)	Growth in GDP (%)	Productivity Level 2018; GDP per Hour Worked (\$)
Germany						70
1995–2005	-0.3	1.6	0.9	0.7	1.3	
2005–2018	0.8	0.8	0.2	0.7	1.6	
Ireland						84
1995–2005	3.2	4.1	1.7	2.4	7.3	
2005–2018	0.6	2.9	0.1	2.7	3.3	
United States						73
1995–2005	0.9	2.4	0.9	1.5	3.3	
2005–2018	0.9	1.2	0.0	1.3	1.9	
Japan						47
1995–2005	-1.0	2.1	0.4	1.7	1.1	
2005–2018	0.0	1.0	-0.1	1.1	1.0	
South Korea						39
1995–2005	0.0	4.3	2.4	1.9	4.3	
2005–2018	0.1	3.3	0.8	2.5	3.3	
China						15
1995–2005	1.1	6.7	1.5	5.2	7.8	
2005–2018	0.2	9.2	4.3	5.0	9.0	
India						9
1995–2005	2.1	4.2	1.9	2.3	6.3	
2005–2018	1.2	6.3	1.8	4.5	7.2	
Brazil						19
1995–2005	2.1	0.3	-0.3	0.6	2.4	
2005–2018	0.8	1.3	-0.7	1.9	2.0	
Mexico						21
1995–2005	2.2	1.4	0.4	1.0	3.6	
2005–2018	2.1	0.1	-0.2	0.4	2.2	

Source: Conference Board Total Economy Database.

Exhibit 10 also provides data on the *level* of labor productivity or the amount of GDP produced per hour of work. The level of productivity depends on the accumulated stock of human and physical capital and is much higher among the developed countries. For example, China has a population of more than 1.3 billion people, compared

with slightly more than 300 million people in the United States. Although the United States has significantly fewer workers than China because of its smaller population, its economy as measured by real GDP is much larger. This is because US workers have historically been more productive than Chinese workers as measured by GDP per hour worked, as shown in Exhibit 10. In contrast to the *level* of productivity, the *growth rate* of productivity will typically be higher in the developing countries, where human and physical capital are scarce but growing rapidly and the impact of diminishing marginal returns is relatively small.

An understanding of productivity trends is critical for global investors. A permanent increase in the rate of labor productivity growth will increase the sustainable rate of economic growth and raise the upper boundary for earnings growth and the potential return on equities. In contrast, a low growth rate of labor productivity, if it persists over a number of years, suggests poor prospects for equity prices. A slowdown in productivity growth lowers both the long-run potential growth rate of the economy and the upper limit for earnings growth. Such a development would be associated with slow growth in profits and correspondingly low equity returns.

EXAMPLE 7

Why the Sluggish Growth in the Japanese Economy?

Annual growth in real GDP in Japan averaged about 1% since 1990. This growth is in sharp contrast to the 4.2% annual growth rate experienced from 1971 to 1990. The sluggish growth in Japan should not be surprising. Japan's economy is growing at its potential rate of growth, which is limited by the following:

1. The labor input is not growing. Population growth has been essentially zero since 2000 (Exhibit 5), and average hours worked per year per person is declining (Exhibit 8).
2. There has been a lack of technological innovation. The lack of growth in the labor input could be offset through higher productivity derived from innovation and more efficient use of available inputs. However, this is not occurring in Japan. Total factor productivity (Exhibit 10) increased at a sluggish 0.4% annual rate from 1995 to 2005 and declined slightly between 2005 and 2018.
3. Diminishing returns to capital are very significant. Despite the negative growth in TFP, labor productivity growth remained relatively high. This means that all the growth in labor productivity in Japan resulted from capital deepening (Exhibit 10). The problem for Japan, as discussed in earlier, is that once the capital-to-labor ratio becomes high, further additions to capital have little impact on per capita output. Thus, the growth in labor productivity should slow.

1. Use the data for 2005–2018 and the labor productivity growth accounting equation to estimate the growth rate in potential GDP for Japan.

Solution

To estimate the growth rate in potential GDP, we use Equation 5, given by

$$\text{Growth rate of potential GDP} = \text{Long-term growth rate of labor force} + \text{Long-term growth rate in labor productivity}$$

To use this equation, we need to project the growth rate in the labor input and labor productivity.

The hours worked data in Exhibit 10 are a potential source to use to estimate the growth rate of the labor input. Exhibit 10 shows the labor input for Japan

unchanged between 2005 and 2018. This was partly caused by the negative impact of the global recession on hours worked. As an alternative, the labor input should grow at the same rate as the population plus the net change in immigration. The population data in Exhibit 5 show essentially zero population growth in Japan for the period 2000–2018. This trend is likely to continue. Thus, a reasonable estimate for potential GDP growth in Japan is around 1%. We get this estimate by assuming no growth in the labor input and a 1% annual increase in labor productivity (using data from Exhibit 10 for 2005–2018).

Public Infrastructure

The final expansion of the definition of the capital input is public infrastructure investment. Roads, bridges, municipal water, dams and, in some countries, electric grids are all examples of public capital. They have few substitutes and are largely complements to the production of private sector goods and services. Ashauer (1990) found that infrastructure investment is an important source of productivity growth and should be included as an input in the production function. As with R&D spending, the full impact of government infrastructure investment may extend well beyond the direct benefits of the projects because improvements in the economy's infrastructure generally boost the productivity of private investments.

SUMMARY OF ECONOMIC GROWTH DETERMINANTS

9

Long-term sustainable growth is determined by the rate of expansion of real potential GDP. Expansion of the supply of factors of production (inputs) and improvements in technology are the sources of growth. The factors of production include human capital, ICT and non-ICT capital, public capital, labor, and natural resources. Data for the sources of growth are available from the OECD and the Conference Board. Exhibit 11 provides data from the Conference Board on the sources of output growth for various countries. These estimates are based on the growth accounting formula.

Exhibit 11: Sources of Output Growth

	Contribution from:					
	Labor Quantity (%)	Labor Quality (%)	Non-ICT Capital (%)	ICT Capital (%)	TFP (%)	Growth in GDP (%)
Germany						
1995–2005	-0.2	0.1	0.3	0.2	0.9	1.3
2005–2018	0.4	0.1	0.6	0.3	0.2	1.6
Ireland						
1995–2005	2.0	0.3	2.6	0.7	1.7	7.3
2005–2018	0.0	0.3	2.5	0.3	0.1	3.3
United States						
1995–2005	0.6	0.3	0.7	0.8	0.9	3.3
2005–2018	0.4	0.3	0.7	0.5	0.0	1.9

	Contribution from:					
	Labor Quantity (%)	Labor Quality (%)	Non-ICT Capital (%)	ICT Capital (%)	TFP (%)	Growth in GDP (%)
Japan						
1995–2005	-0.6	0.4	0.6	0.3	0.4	1.1
2005–2018	0.0	0.3	0.5	0.3	-0.1	1.0
South Korea						
1995–2005	-0.5	0.8	1.1	0.5	2.4	4.3
2005–2018	0.0	0.1	1.9	0.5	0.8	3.3
China						
1995–2005	0.5	0.2	4.5	1.1	1.5	7.8
2005–2018	0.1	0.3	3.9	0.4	4.3	9.0
India						
1995–2005	1.0	0.2	2.7	0.5	1.9	6.3
2005–2018	0.7	0.6	3.4	0.8	1.8	7.2
Brazil						
1995–2005	0.8	0.1	1.1	0.7	-0.3	2.4
2005–2018	0.4	0.8	1.2	0.4	-0.7	2.0
Mexico						
1995–2005	1.2	0.2	1.4	0.4	0.4	3.6
2005–2018	1.0	0.1	1.1	0.2	-0.2	2.2

Notes: A standard growth accounting model (expanded version of Equation 4) is used to compute the contribution of each input to aggregate output (GDP) growth. The inputs include both the quantity and quality of labor and ICT and non-ICT capital. Each input is weighted by its share in national income, and TFP captures all sources of growth that are left unexplained by the labor and capital inputs. Rounding is used throughout.

Source: Conference Board Total Economy Database.

EXAMPLE 8

The Irish Economy

As shown in Exhibit 1, economic growth in Ireland since 1980 has been significantly higher than that experienced in the major European economies of Germany, France, and the United Kingdom. In 1970, the per capita GDP of Ireland, at \$9,869, was 45.2% below the per capita GDP of the United Kingdom. By 2010, per capita GDP in Ireland caught up with or exceeded most other developed European countries. Like most of the global economy, Ireland fell into a deep recession in 2009, with GDP contracting by more than 7%, before staging a recovery and reaching annual growth of more than 5% for several years in the 2010–2018 period. To understand the factors driving the Irish economy and the prospects for future equity returns, use the data in Exhibit 11 and the following population data to address these questions:

- Using the growth accounting framework data, evaluate the sources of growth for the Irish economy starting from 1995.

Solution

The sources of growth for an economy include labor quantity, labor quality, non-ICT capital, ICT capital, and TFP. The growth accounting data in Exhibit 11 indicate that economic growth in Ireland from 1995 to 2018 is explained by the following factors:

Input	Contribution: 1995–2005	Contribution: 2005–2018
Labor	2.3%	0.3%
Labor quantity	2.0%	0.0%
Labor quality	0.3%	0.3%
Capital/Investment	3.3%	2.8%
Non-ICT capital	2.6%	2.5%
ICT capital	0.7%	0.3%
TFP	1.7%	0.1%
Total: GDP growth	7.3%	3.3%

In sum, the main driver of growth for the Irish economy since 1995 has been capital spending. It accounted for more than 45% of growth in 1995–2005 and has been the dominant factor contributing to growth in the Irish economy since 2005. Another way to look at growth in Ireland for the period 2005–2018 is that all the growth is through capital deepening. As shown in Exhibit 11, capital deepening added 2.7% to growth, which caused an increase in labor productivity of 2.9%.

- What is likely to happen to the potential rate of growth for Ireland? What are the prospects for equity returns?

	2000	2010	2016	Avg. Annual Growth Rate
Population (millions)	3.8	4.5	4.9	1.6%
Net immigration total (2000–2010)		0.38m		
Net immigration total (2011–2016)		0.19m		
Population less immigrants (millions)	3.8	4.1	4.3	0.8%

Solution

If we look forward, prospects for the economy are not as favorable as in the past. To estimate the growth rate in potential GDP, we use Equation 5, given by

$$\text{Growth rate of potential GDP} = \text{Long-term growth rate of labor force} + \text{Long-term growth rate in labor productivity}$$

To use this equation, we need to project the growth rate in the labor input and labor productivity. The total hours worked data in Exhibit 11 are one potential source to use to estimate the growth rate of the labor input. Exhibit 11 shows the labor input increasing by 0.6% annually between 2005 and

2018. The problem here is that the decline in hours worked is overstated because of the negative impact of the 2008–2009 recession on hours worked. As an alternative, the labor input should grow at the same rate as the population plus the net change resulting from immigration. The population data for Ireland (given above) show that more than half of the population growth between 2000 and 2010 resulted from immigration. Since 2009, however, outward migration has replaced inward migration for a short period, and the rate of growth in labor input declined. Thus, a more reasonable, perhaps somewhat conservative, estimate for labor force growth is 0.3%. We also assume the following:

1. There is no increase in labor productivity coming from capital deepening as investment slows (resulting in essentially no growth in net investment and the physical capital stock).
2. TFP growth reverts to its average growth rate of 1.7% in the 1995–2005 period (see Exhibit 11).
3. Labor productivity grows at the same rate as TFP.

Thus, growth in potential GDP is $0.3\% + 1.7\% = 2.0\%$.

In summary, despite the projected rebound in TFP growth, overall potential growth in Ireland is likely to decline because labor input growth and capital deepening no longer contribute to overall growth. As discussed earlier, slower growth in potential GDP will limit potential earnings growth and equity price appreciation.

EXAMPLE 9

Investment Outlook for China and India

The Investment Policy Committee at Global Invest Inc. is interested in increasing the firm's exposure to either India or China because of their rapid rates of economic growth. Economic growth in China has been close to 9% over the last few years, and India has grown more than 7%. You are asked by the committee to do the following:

1. Determine the sources of growth for the two economies and review the data on productivity and investment using information from Exhibit 11. Which of the two countries looks more attractive based on the sources of growth?

Solution

The sources of economic growth include size of labor force, quality of labor force (human capital), ICT and non-ICT capital, natural resources, and technology. Looking at the sources of growth in Exhibit 11, we determine the following:

Input	Percent Contribution:	
	1995–2005	2005–2018
India		
Labor quantity	1.0	0.7
Labor quality	0.2	0.6
Non-ICT capital	2.7	3.4
ICT capital	0.5	0.8

Input	Percent Contribution:	Percent Contribution:
	1995–2005	2005–2018
India		
TFP	1.9	1.8
Total: GDP growth	6.3	7.2
China		
Labor quantity	0.5	0.1
Labor quality	0.2	0.3
Non-ICT capital	4.5	3.9
ICT capital	1.1	0.4
TFP	1.5	4.3
Total: GDP growth	7.8	9.0

■ The contribution of the labor quantity input is more important to growth in India than in China. Labor quantity contributed 1% to India's GDP growth over 1995–2005 and 0.7% over 2005–2018. The equivalent numbers for China are 0.5% and 0.1%, respectively. Looking ahead, we can project that labor is likely to be a major factor adding to India's growth. The population of India (Exhibit 5) is growing at a faster rate than that of China. The annual growth rate in population from 2005 to 2018 was 1.34% in India versus 0.50% in China. Also, hours worked in India (Exhibit 11) are growing at a faster rate than in China. Therefore, the workforce and labor quantity input should grow faster in India. The edge here goes to India.

■ The contribution to GDP made by the quality of the labor force is essentially identical in the two countries (0.2% in China versus 0.2% in India between 1995 and 2005 and 0.3% in China and 0.6% in India between 2005 and 2018). This factor is stronger in India.

■ The contribution of non-ICT capital investment is significantly higher in China (4.5% in China versus 2.7% in India between 1995 and 2005 and 3.9% in China and 3.4% in India between 2005 and 2018). The edge goes to China.

■ The contribution of ICT capital investment was significantly higher in China (1.1% in China versus 0.5% in India between 1995 and 2005). Since 2005, it has contributed 0.4% to growth in China and 0.8% in India, which has an edge.

■ Both countries spend a high percentage of GDP on capital investment (Exhibit 9). In 2018, investment spending as a percentage of GDP was 44% in China and 32% in India. The Chinese share is higher, and this provides China with an edge unless diminishing marginal returns to capital deepening become an issue. This scenario is not likely for a while, however, given the relatively low level of capital per worker in China. China and India still have a way to go to converge with the developed economies. The advantage goes to China.

■ The contribution of technological progress is measured by TFP. Comparing the two countries, we find that TPF growth was higher in India over the period 1995–2005 (1.9% in India versus 1.5% in China). For the period 2005–2018, however, TFP growth was significantly

higher in China (4.3% versus 1.8%). In addition, expenditures on R&D for 2016 (Exhibit 10) as a percentage of GDP were higher in China (2.1% in China and 0.8% in India). The edge here goes to China.

- Finally, growth in overall labor productivity (Exhibit 11) is considerably higher in China than India (9.2% in China versus 6.3% in India between 2005 and 2018). This dynamic resulted from both a greater increase in the capital-to-labor ratio in China (because of the high rate of investment, the physical capital stock is growing faster than the labor input) and faster technological progress in China. The edge here goes to China.

In sum, based on the sources of growth, China appears to be slightly better positioned for growth in the future.

-
2. Estimate the long-term sustainable earnings growth rate using data from 1995 to 2018.

Solution

Estimates of potential GDP using the inputs from Exhibit 11 for China and India are

Growth rate in potential GDP = Long-term growth rate of labor force (equals growth in hours worked in Exhibit 11) + Long-term growth rate in labor productivity.

China (using 1995–2018)

Growth in potential GDP = $0.6\% + 7.9\% = 8.5\%$ (calculated as geometric mean growth rates using data for the 1995–2005 and 2005–2018 subperiods).

India (using 1995–2018)

Growth in potential GDP = $1.6\% + 5.2\% = 6.8\%$

-
3. Make an investment recommendation.

Solution

Growth prospects in both countries are very attractive. China's growth potential is higher, however, because of its greater level of capital spending and the greater contribution of technological progress toward growth. Long-term earnings growth is closely tied to the growth rate in potential GDP. Therefore, based on the previous calculations, earnings in China would be projected to grow at an annual rate of 8.5%, compared with 6.8% in India. Over the next decade, ignoring current valuation, the Chinese equity market would be projected to outperform the Indian market as its higher rate of sustainable growth translates into a higher rate of appreciation in equity values. Note that the global economy is evolving rapidly, and past trends may or may not be sustained. This is especially true of China and India. To provide concrete answers that do not require the reader to bring in additional information, our exercise solutions must assume that past patterns are indicative of the future.

THEORIES OF GROWTH

10



compare classical growth theory, neoclassical growth theory, and endogenous growth theory

The factors that drive long-term economic growth and determine the rate of sustainable growth in an economy are the subject of much debate among economists. The academic growth literature includes three main paradigms with respect to per capita growth in an economy—the classical, neoclassical, and endogenous growth models. Per capita economic growth under the classical model is only temporary because an exploding population with limited resources brings growth to an end. In the neoclassical model, long-run per capita growth depends solely on exogenous technological progress. The final model of growth attempts to explain technology within the model itself—thus the term endogenous growth.

Classical Model

Classical growth theory was developed by Thomas Malthus in his 1798 publication *Essay on the Principle of Population*. Commonly referred to as the Malthusian theory, it is focused on the impact of a growing population in a world with limited resources. The concerns of resource depletion and overpopulation are central themes within the Malthusian perspective on growth. The production function in the classical model is relatively simple and consists of a labor input with land as a fixed factor. The key assumption underlying the classical model is that population growth accelerates when the level of per capita income rises above the subsistence income, which is the minimum income needed to maintain life. This means that technological progress and land expansion, which increase labor productivity, translate into higher population growth. But because the labor input faces diminishing marginal returns, the additional output produced by the growing workforce eventually declines to zero. Ultimately, the population grows so much that labor productivity falls and per capita income returns back to the subsistence level.

The classical model predicts that in the long run, the adoption of new technology results in a larger but not richer population. Thus, the standard of living is constant over time even with technological progress, and there is no growth in per capita output. As a result of this gloomy forecast, economics was labeled the “dismal science.”

The prediction from the Malthusian model failed for two reasons:

1. The link between per capita income and population broke down. In fact, as the growth of per capita income increased, population growth slowed rather than accelerating as predicted by the classical growth model.
2. Growth in per capita income has been possible because technological progress has been rapid enough to more than offset the impact of diminishing marginal returns.

Because the classical model’s pessimistic prediction never materialized, economists changed the focus of the analysis away from labor to capital and to the neoclassical model.

Neoclassical Model

Robert Solow devised the mainstream neoclassical theory of growth in the 1950s (Solow 1957). The heart of this theory is the Cobb–Douglas production function discussed earlier. As before, the potential output of the economy is given by

$$y = AF(K, L) = AK^\alpha L^{1-\alpha},$$

where K is the stock of capital, L is the labor input, and A is total factor productivity. In the neoclassical model, both capital and labor are variable inputs each subject to diminishing marginal productivity.

The objective of the neoclassical growth model is to determine the long-run growth rate of output per capita and relate it to (a) the savings/investment rate, (b) the rate of technological change, and (c) population growth.

Balanced or Steady-State Rate of Growth

As with most economic models, the neoclassical growth model attempts to find the equilibrium position toward which the economy will move. In the case of the Solow model, this equilibrium is the balanced or **steady-state rate of growth** that occurs when the output-to-capital ratio is constant. Growth is balanced in the sense that capital per worker and output per worker grow at the same rate.

We begin the analysis by using the per capita version of the Cobb–Douglas production function given earlier in Equation 3:

$$y = Y/L = Ak^\alpha,$$

where $k = K/L$. Using their definitions, the rates of change of capital per worker and output per worker are given by

$$\Delta k/k = \Delta K/K - \Delta L/L$$

and

$$\Delta y/y = \Delta Y/Y - \Delta L/L.$$

From the production function, the growth rate of output per worker is also equal to

$$\Delta y/y = \Delta A/A + \alpha \Delta k/k. \quad (6)$$

Note that these and other rate of change equations are exact only for changes over arbitrarily short periods (“continuous time”).

The physical capital stock in an economy will increase because of gross investment (I) and decline because of depreciation. In a closed economy, investment must be funded by domestic saving. Letting s be the fraction of income (Y) that is saved, gross investment is given by $I = sY$. Assuming the physical capital stock depreciates at a constant rate, δ , the change in the physical capital stock is given by

$$\Delta K = sY - \delta K.$$

Subtracting labor supply growth, $\Delta L/L \equiv n$, and rearranging gives

$$\Delta k/k = sY/K - \delta - n. \quad (7)$$

In the steady state, the growth rate of capital per worker is equal to the growth rate of output per worker. Thus,

$$\Delta k/k = \Delta y/y = \Delta A/A + \alpha \Delta k/k,$$

from which we get

$$\Delta y/y = \Delta k/k = (\Delta A/A)/(1 - \alpha).$$

Letting θ denote the growth rate of TFP (i.e., $\Delta A/A$), we see that the equilibrium sustainable growth rate of output per capita (= Growth rate of capital per worker) is a constant that depends only on the growth rate of TFP (θ) and the elasticity of output with respect to capital (α). Adding back the growth rate of labor (n) gives the sustainable growth rate of output.

$$\text{Growth rate of output per capita} = \frac{\theta}{1-\alpha} \quad (8)$$

$$\text{Growth rate of output} = \frac{\theta}{1-\alpha} + n$$

This is the key result of the neoclassical model. Note that $\theta/(1 - \alpha)$ is the steady-state growth rate of labor productivity, so Equation 8 is consistent with the labor productivity growth accounting equation discussed earlier.

Substituting $\theta/(1 - \alpha)$ into the left-hand side of Equation 7 and rearranging gives the equilibrium output-to-capital ratio, denoted by the constant Ψ .

$$\frac{Y}{K} = \left(\frac{1}{s}\right) \left[\left(\frac{\theta}{1-\alpha}\right) + \delta + n \right] \equiv \Psi \quad (9)$$

In the steady state, the output-to-capital ratio is constant and the capital-to-labor ratio (k) and output per worker (y) grow at the same rate, given by $\theta/(1 - \alpha)$. On the steady-state growth path, the marginal product of capital is also constant and, given the Cobb-Douglas production function, is equal to $\alpha(Y/K)$. The marginal product of capital is also equal to the real interest rate in the economy. Note that even though the capital-to-labor ratio (k) is rising at rate $\theta/(1 - \alpha)$ in the steady state, the increase in the capital-to-labor ratio (k) has no impact on the marginal product of capital, which is not changing. *Capital deepening is occurring, but it has no effect on the growth rate of the economy or on the marginal product of capital once the steady state is reached.*

EXAMPLE 10

Steady-State Rate of Growth for China, Japan, and Ireland

Earlier examples generated estimates of potential growth for China (8.5%), Japan (1.0%), and Ireland (2.0%). Given the following data, address these questions:

1. Calculate the steady-state growth rates from the neoclassical model for China, Japan, and Ireland.

Solution

Using Equation 8, the steady-state growth rate in the neoclassical model is given by

$$\Delta Y/Y = (\theta)/(1 - \alpha) + n = \text{Growth rate of TFP scaled by labor factor share} + \text{Growth rate in the labor force}$$

Using the preceding equation and data, we can estimate steady-state growth rates for the three countries as follows:

China: The labor share of output ($1 - \alpha$) is given by the average of the labor cost as a percentage of total factor cost, which is equal to 0.561 for China. The growth rate in the labor force is 1.2%, and the growth rate of TFP is 2.9%.

$$\text{Steady-state growth rate} = 2.9\%/0.561 + 1.2\% = 6.37\%$$

Japan: The labor share of output ($1 - \alpha$) for Japan is 0.538. The growth rate in the labor force is 0.0%, and TFP growth is 0.2%.

$$\text{Steady-state growth rate} = 0.2\% / 0.538 + 0.0\% = 0.37\%$$

Ireland: The labor share of output ($1 - \alpha$) is 0.574% for Ireland. The growth rate in the labor force is 0.3%, and TFP growth is 0.9%.

$$\text{Steady-state growth rate} = 0.9\% / 0.574 + 0.3\% = 1.87\%$$

2. Compare the steady-state growth rates to the growth rates in potential GDP estimated in Examples 7–9 and explain the results.

	Labor Cost in Total Factor Cost (%)	TFP Growth (%)	Labor Force Growth (%)
China	56.1	2.9	1.2
Japan	53.8	0.2	0.0
Ireland	57.4	0.9	0.3

Sources: Conference Board Total Economy Database; labor cost based on 2008–2018, TFP growth based on 1995–2018. Labor force growth based on assumptions and estimates from earlier examples.

Solution

The growth rate in potential GDP for China (8.5%, estimated in Example 9) is significantly above the estimated 6.37% steady-state growth rate. The reason for this is that the economy of China is still in the process of converging to the higher income levels of the United States and the major economies in Europe. The physical capital stock is below the steady state, and capital deepening is a significant factor increasing productivity growth (see Exhibit 11) and the growth in potential GDP.

This is not the case for Japan and Ireland. Both countries are operating at essentially the steady state. The estimated growth rate in potential GDP for Japan (1.0%, from Example 7) is only slightly above its 0.37% steady-state growth rate. Likewise, the estimated growth rate in potential GDP for Ireland (2.0%, from Example 8) is effectively equal to its estimated steady-state growth rate of 1.87%. Operating close to the steady state means that capital investment in these countries, which results in an increasing capital-to-labor ratio, has no significant effect on the growth rate of the economy. Only changes in the growth rates of TFP and labor and in the labor share of output have an impact on potential GDP growth.

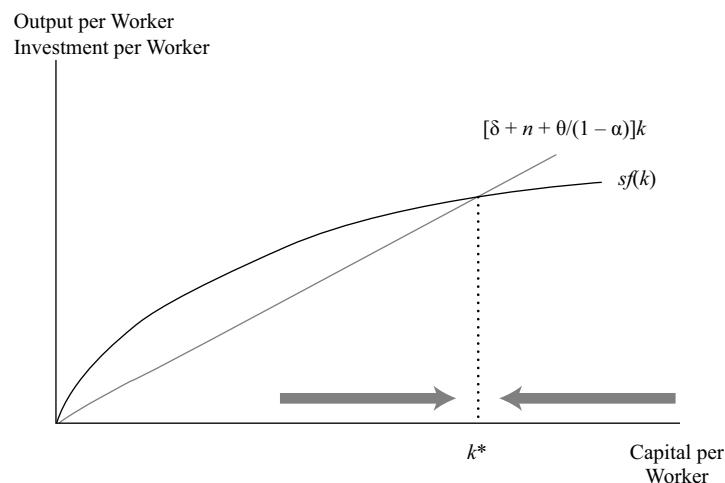
An intuitive way to understand the steady-state equilibrium given in Equation 9 is to transform it into a savings/investment equation:

$$sy = \left[\left(\frac{\theta}{1-\alpha} \right) + \delta + n \right] k$$

Steady-state equilibrium occurs at the output-to-capital ratio where the savings and actual gross investment per worker generated in the economy (sy) are just sufficient to (1) provide capital for new workers entering the workforce at rate n , (2) replace plant and equipment wearing out at rate δ , and (3) deepen the physical capital stock at the rate $\theta/(1 - \alpha)$ required to keep the marginal product of capital equal to the rental price of capital.

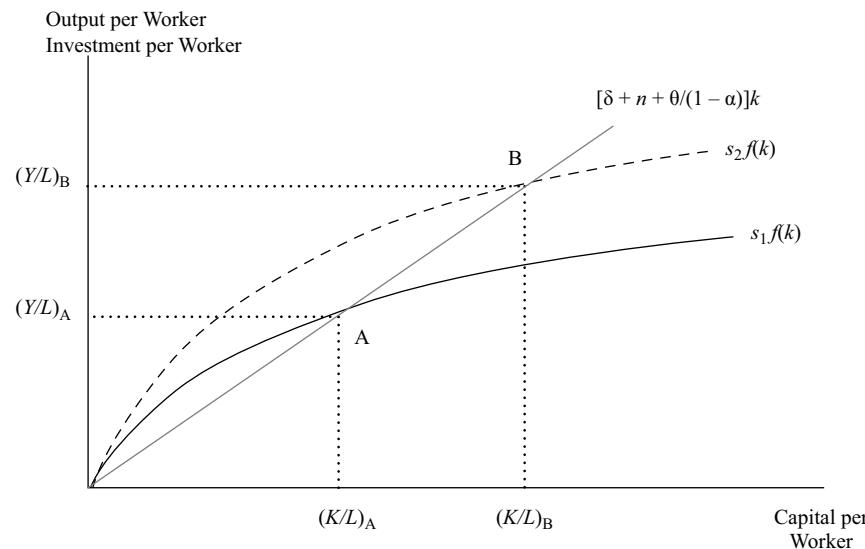
Exhibit 12 shows the steady-state equilibrium graphically. The straight line in the exhibit indicates the amount of investment required to keep the physical capital stock growing at the required rate. Because the horizontal axis is capital per worker, the slope of the line is given by $[\delta + n + \theta/(1 - \alpha)]$. The curved line shows the amount of actual investment per worker and is determined by the product of the saving rate

and the production function. It is curved because of diminishing marginal returns to the capital input in the production function. The intersection of the required investment and actual investment lines determines the steady state. Note that *this exhibit is a snapshot at a point in time*. Over time, the capital-to-labor ratio rises at rate $[\theta/(1 - \alpha)]$ as the actual saving/investment curve $[sf(k)]$ shifts upward because of TFP growth, and *the equilibrium moves upward and to the right along the straight line*.

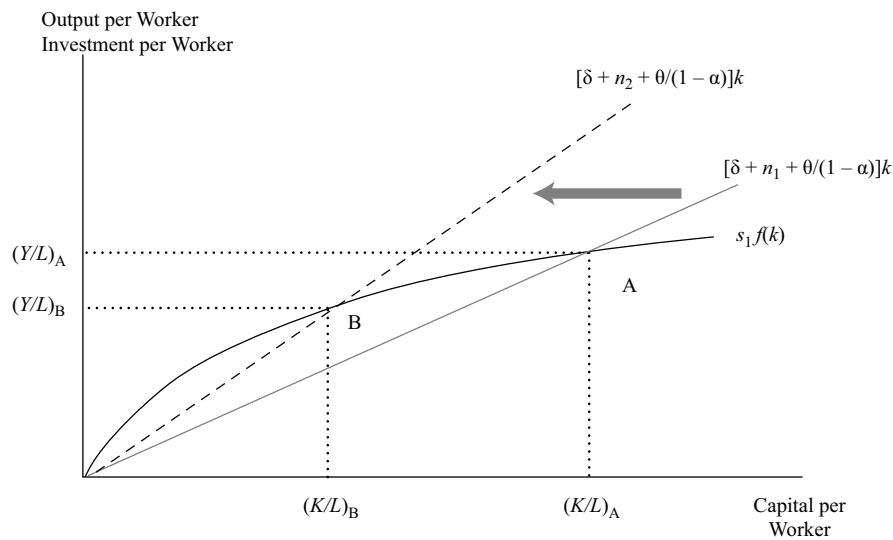
Exhibit 12: Steady State in the Neoclassical Model


The impact of the various parameters in the model on the steady state can also be seen in the exhibit. At any point in time when the economy is on its steady-state growth path, the exogenous factors—labor supply and TFP—are fixed. We would like to know what effect each of the parameters in the model has on the steady-state capital-to-labor ratio and therefore on output per worker. For example, if there are two economies that differ only with respect to one parameter, what does that imply about their per capita incomes? All else the same, we can say the following regarding the impact of the parameters:

- *Saving rate (s):* An increase in the saving rate implies a higher capital-to-labor ratio (k) and higher output per worker (y) because a higher saving rate generates more saving/investment at every level of output. In Exhibit 13, the saving/investment curve $[sf(k)]$ shifts upward from an initial steady-state equilibrium at point A to a new equilibrium at point B. At the new equilibrium point, it intersects the required investment line $[\delta + n + \theta/(1 - \alpha)]$ at higher capital-to-labor and output per worker ratios. Note that although the higher saving rate increases both k and y , it has no impact on the steady-state growth rates of output per capita or output (Equation 8).

Exhibit 13: Impact on the Steady State: Increase in the Saving Rate


- *Labor force growth (n):* An increase in the labor force growth rate reduces the equilibrium capital-to-labor ratio because a corresponding increase in the steady-state growth rate of capital is required. Given the gross saving/investment rate, this can be achieved only at a lower capital-to-labor ratio. Output per worker is correspondingly lower as well. In Exhibit 14, the higher population growth rate increases the slope of the required investment line. This shifts the steady-state equilibrium from point A to point B, where it intersects the supply of saving/investment curve at lower capital-to-labor and output per worker ratios.
- *Depreciation rate (δ):* An increase in the depreciation rate reduces the equilibrium capital-to-labor and output per worker ratios because a given rate of gross saving generates less net capital accumulation. Graphically, it increases the slope of the required investment line and affects the steady-state equilibrium in the same way as labor force growth (Exhibit 14).
- *Growth in TFP (θ):* An increase in the growth rate of TFP reduces the steady-state capital-to-labor ratio and output per worker for given levels of labor input and TFP. This result must be interpreted with care. Raising the growth rate of TFP means that output per worker will grow faster in the future (Equation 8), but at a given point in time, a given supply of labor, and a given level of TFP, output per worker is lower than it would be with a slower TFP growth rate. In effect, the economy is on a steeper trajectory off a lower base of output per worker. Graphically, it is identical to Exhibit 14 in that faster TFP growth steepens the required investment line (increases the slope), which intersects with the available saving/investment curve at lower capital-to-labor and investment per worker ratios.

Exhibit 14: Impact on the Steady State: Increase in Labor Force Growth


In sum, such factors as the saving rate, the growth rate of the labor force, and the depreciation rate change the *level* of output per worker but do not permanently change the *growth rate* of output per worker. A permanent increase in the growth rate in output per worker can occur only if there is a change in the growth rate of TFP.

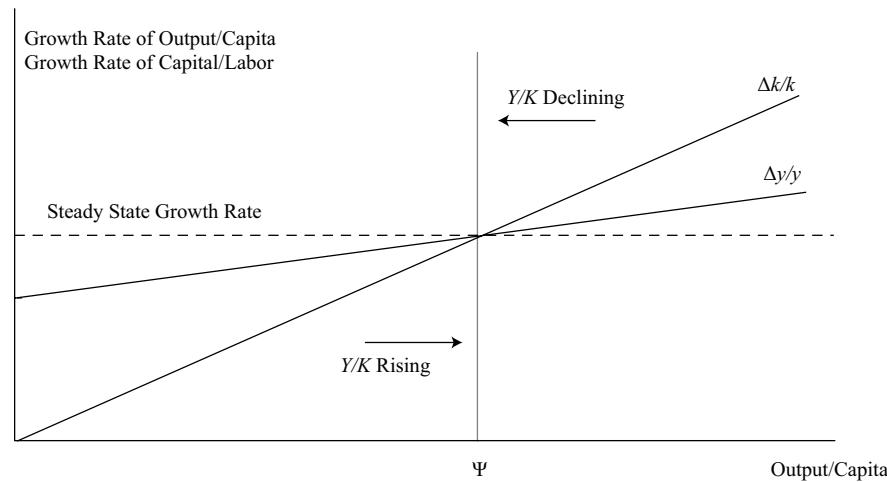
So far we have focused on the steady-state growth path. What happens if the economy has not yet reached the steady state? During the transition to the steady-state growth path, the economy can experience either faster or slower growth relative to the steady state. Using Equations 6, 7, and 9, we can write the growth rates of output per capita and the capital-to-labor ratio as, respectively,

$$\frac{\Delta y}{y} = \left(\frac{\theta}{1-\alpha} \right) + \alpha s \left(\frac{Y}{K} - \Psi \right) = \left(\frac{\theta}{1-\alpha} \right) + \alpha s(y/k - \Psi) \quad (10)$$

and

$$\frac{\Delta k}{k} = \left(\frac{\theta}{1-\alpha} \right) + s \left(\frac{Y}{K} - \Psi \right) = \left(\frac{\theta}{1-\alpha} \right) + s(y/k - \Psi), \quad (11)$$

where the second equality in each line follows from the definitions of y and k , which imply $(Y/K) = y/k$. These relationships are shown in Exhibit 15.

Exhibit 15: Dynamics in the Neoclassical Model


If the output-to-capital ratio is above its equilibrium level (ψ), the second term in Equations 10 and 11 is positive and the growth rates of output per capita and the capital-to-labor ratio are above the steady-state rate $\theta/(1 - \alpha)$. This corresponds to a situation in which actual saving/investment exceeds required investment and above-trend growth in per capita output is driven by an above-trend rate of capital deepening. This situation usually reflects a relatively low capital-to-labor ratio but could, at least in principle, arise from high TFP. Because $\alpha < 1$, capital is growing faster than output and the output-to-capital ratio is falling. Over time, the growth rates of both output per capita and the capital-to-labor ratio decline to the steady-state rate.

Of course, the converse is true if the output-to-capital ratio is below its steady-state level. Actual investment is insufficient to sustain the trend rate of growth in the capital-to-labor ratio, and both output per capita and the capital-to-labor ratio grow more slowly. This situation usually corresponds to a relatively high and unsustainable capital-to-labor ratio, but it could reflect relatively low TFP and hence relatively low output. Over time, output grows faster than capital, the output-to-capital ratio rises, and growth converges to the trend rate.

11

IMPLICATIONS OF NEOCLASSICAL MODEL

There are four major groups of conclusions from the neoclassical model:

1. Capital Accumulation
 - a. Capital accumulation affects the level of output but not the growth rate in the long run.
 - b. Regardless of its initial capital-to-labor ratio or initial level of productivity, a growing economy will move to a point of steady-state growth.
 - c. In a steady state, the growth rate of output equals the rate of labor force growth plus the rate of growth in TFP scaled by labor's share of income [$n + \theta/(1 - \alpha)$]. The growth rate of output does not depend on the accumulation of capital or the rate of business investment. Those familiar with the "labor-augmenting" technical change formulation of

the neoclassical model should note that in that formulation, the rate of labor-augmenting technical change is also the growth rate of labor productivity. In our formulation, the growth rate of labor productivity is $\theta/(1 - \alpha)$. So both formulations imply that long-run growth equals the growth rate of the labor supply (n) plus a constant growth rate of labor productivity.

2. Capital Deepening vs. Technology

- a. Rapid growth that is above the steady-state rate of growth occurs when countries first begin to accumulate capital; but growth will slow as the process of accumulation continues (see Exhibit 16).
- b. Long-term sustainable growth cannot rely solely on capital deepening investment—that is, on increasing the stock of capital relative to labor. If the capital-to-labor ratio grows too rapidly (i.e., faster than labor productivity), capital becomes less productive, resulting in slower rather than faster growth.
- c. More generally, increasing the supply of some input(s) too rapidly relative to other inputs will lead to diminishing marginal returns and cannot be the basis for sustainable growth.
- d. In the absence of improvements in TFP, the growth of labor productivity and per capita output would eventually slow.
- e. Because of diminishing marginal returns to capital, the only way to sustain growth in potential GDP per capita is through technological change or growth in total factor productivity. This results in an upward shift in the production function—the economy produces more goods and services for any given mix of labor and capital inputs.

3. Convergence

- a. Given the relative scarcity and hence high marginal productivity of capital and potentially higher saving rates in developing countries, the growth rates of developing countries should exceed those of developed countries.
- b. As a result, there should be a convergence of per capita incomes between developed and developing countries over time.

4. Effect of Savings on Growth

- a. The initial impact of a higher saving rate is to temporarily raise the rate of growth in the economy. Mathematically, this can be seen as follows: Equation 9 indicates that an increase in the saving rate (s) reduces the steady-state output-to-capital ratio (ψ). This makes the last term in Equations 10 and 11 positive, raising the growth rates of output per capita (y) and the capital-to-labor ratio (k) above the steady-state rate. In response to the higher saving rate, growth exceeds the steady-state growth rate during a transition period. However, the economy returns to the balanced growth path after the transition period.
- b. During the transition period, the economy moves to a higher level of per capita output and productivity.

- c. Once an economy achieves steady-state growth, the growth rate does not depend on the percentage of income saved or invested. Higher savings cannot permanently raise the growth rate of output.
- d. Countries with higher saving rates, however, will have a higher level of per capita output, a higher capital-to-labor ratio, and a higher level of labor productivity.

EXAMPLE 11

Comparative Statics and Transitional Growth in the Neoclassical Model

Beginning in steady-state equilibrium, an economy's saving rate suddenly increases from 20% of income to 30% of income. Other key parameters describing the economy are as follows:

Growth rate of TFP (θ)	= 0.02
Income share of capital (α)	= 0.35
Depreciation rate (δ)	= 0.10
Labor force growth rate (n)	= 0.01

The following table shows the output-to-capital ratio that will prevail in this economy at various points in time after the increase in the saving rate.

Years after Saving Rate Increase	Output-to-Capital Ratio
5	0.5947
10	0.5415
25	0.4857
50	0.4708
100	0.4693
New steady state	??

By rearranging the Cobb–Douglas production function (Equation 3), the proportional impact of the saving rate change on the capital-to-labor ratio can be expressed in terms of the proportional impact on the output-to-capital ratio. The proportional impact on per capita income can then be determined from the production function (Equation 3). Labeling the paths with and without the change in saving rate as “new” and “old” respectively, at each date we have:^a

$$\frac{k_{new}}{k_{old}} = \left[\frac{(Y/K)_{new}}{(Y/K)_{old}} \right]^{\frac{1}{\alpha-1}}$$

and

$$\frac{y_{new}}{y_{old}} = \left(\frac{k_{new}}{k_{old}} \right)^{\alpha}.$$

1. Using Equations 8 and 9, calculate the steady-state growth rate of per capita income and the steady-state output-to-capital ratio both before and after

the change in the saving rate. What happens to the capital-to-labor ratio and output per capita?

Solution

From Equation 8, the steady-state growth rate of per capita income, both before and after the increase in the saving rate, is $\Delta y/y = \theta/(1 - \alpha) = 0.02/(1 - 0.35) = 0.0308$, or 3.08%. From Equation 9, the steady-state output-to-capital ratio is

$$\frac{Y}{K} = \left(\frac{1}{s}\right) \left[\left(\frac{\theta}{1-\alpha}\right) + \delta + n \right] \equiv \psi.$$

Using the parameter values given, $\theta/(1 - \alpha) + \delta + n = 0.0308 + 0.10 + 0.01 = 0.1408$, so the steady-state output-to-capital ratio is $0.1408/0.2 = 0.7040$ with the initial 20% saving rate and $0.1408/0.30 = 0.4693$ with the new 30% saving rate. As shown in Exhibit 14, both the capital-to-labor ratio and output per worker are at higher *levels* in the new steady state. But once the new steady state is achieved, they do not grow any faster than they did in the steady state with the lower saving rate.

2. Use the output-to-capital ratios given in the preceding table along with Equation 10 and your answers to Question 1 to determine the growth rate of per capita income that will prevail immediately following the change in the saving rate and at each of the indicated times after the change. Explain the pattern of growth rates.

Solution

According to Equation 10, the growth rate of per capita income is given by

$$\frac{\Delta y}{y} = \left(\frac{\theta}{1-\alpha}\right) + \alpha s(y/k - \psi).$$

Immediately following the increase in the saving rate, the relevant value of ψ becomes the new steady-state output-to-capital ratio (0.4693). The actual output-to-capital ratio does not change immediately, so y/k is initially still 0.7040. Plugging these values into the foregoing growth equation gives the growth rate of per capita income:

$$\Delta y/y = 0.0308 + (0.35)(0.30)(0.7040 - 0.4693) = 0.0554, \text{ or } 5.54\%$$

Similar calculations using the output-to-capital ratios in the preceding table give the following:

Years after Saving Rate Increase	Output-to-Capital Ratio	Growth Rate of Per Capita Income (%)
0	0.7040	5.54
5	0.5947	4.39
10	0.5415	3.84
25	0.4857	3.25
50	0.4708	3.09
100	0.4693	3.08
New steady state	0.4693	3.08

The growth rate “jumps” from the steady-state rate of 3.08% to 5.54% when the saving rate increases because the increase in saving/investment results in more rapid capital accumulation. Over time, the growth rate slows because the marginal productivity of capital declines as the capital-to-labor

ratio increases. In addition, as the capital-to-labor ratio increases and the output-to-capital ratio declines, a greater portion of savings is required to maintain the capital-to-labor ratio, leaving a smaller portion for continued capital deepening. Roughly two-thirds of the growth acceleration has dissipated after 10 years.

- Using the output-to-capital ratios given in the preceding table, calculate the proportional impact of the increased saving rate on the capital-to-labor ratio and on per capita income over time. With respect to these variables, how will the new steady state compare with the old steady state?

Solution

Using the output-to-capital ratio that will prevail five years after the saving rate increase, the proportional impact on the capital-to-labor ratio and on per capita income will be

$$\frac{k_{new}}{k_{old}} = \left[\frac{(Y/K)_{new}}{(Y/K)_{old}} \right]^{\frac{1}{\alpha-1}} = \left[\frac{0.5947}{0.7040} \right]^{\frac{-1}{0.65}} = 1.2964$$

and

$$\frac{y_{new}}{y_{old}} = \left(\frac{k_{new}}{k_{old}} \right)^{\alpha} = 1.2964^{0.35} = 1.0951$$

Thus, after five years, the capital-to-labor ratio will be 29.64% higher than it would have been without the increase in the saving rate, and per capita income will be 9.51% higher. Similar calculations for the other periods give the following:

Years after Saving Rate Increase	Proportionate Increase (%) in:	
	Capital-to-Labor Ratio	Per Capita Income
0	0.00	0.00
5	29.64	9.51
10	49.74	15.18
25	77.01	22.12
50	85.71	24.19
100	86.68	24.42
New steady state	86.68	24.42

In the new steady state, the capital-to-labor ratio will be 86.68% higher at every point in time than it would have been in the old steady state. Per capita income will be 24.42% higher at every point in time. Both variables will be growing at the same rate (3.08%) as they would have been in the old steady state.

^a Note that the output-to-capital ratio would have been constant on the original steady state path. Because of the impact of total factor productivity, the capital-to-labor ratio and output per capita are not constant even in steady state. In comparing “paths” for these variables, we isolate the impact of the saving rate change by canceling out the effect of TFP growth. Mathematically, we cancel out A in Equation 3 to produce the equations shown here.

EXTENSION OF NEOCLASSICAL MODEL

12

Solow (1957) used the growth accounting equation to determine the contributions of each factor to economic growth in the United States for the period 1909–1949. He reached the surprising conclusion that more than 80% of the per capita growth in the United States resulted from TFP. Denison (1985) authored another study examining US growth for the period 1929–1982 using the Solow framework. His findings were similar to Solow's, with TFP explaining nearly 70% of US growth. The problem with these findings is that the neoclassical model provides no explicit explanation of the economic determinants of technological progress or how TFP changes over time. Because technology is determined outside the model (i.e., exogenously), critics argue that the neoclassical model ignores the very factor driving growth in the economy. Technology is simply the residual or the part of growth that cannot be explained by other inputs, such as capital and labor. This lack of an explanation for technology led to growing dissatisfaction with the neoclassical model.

The other source of criticism of the neoclassical model is the prediction that the steady-state rate of economic growth is unrelated to the rate of saving and investment. Long-run growth of output in the Solow model depends only on the rates of growth of the labor force and technology. Higher rates of investment and savings have only a transitory impact on growth. Thus, an increase in investment as a share of GDP from 10% to 15% of GDP will have a positive impact on the near-term growth rate but will not have a permanent impact on the ultimately sustainable percentage growth rate. This conclusion makes many economists uncomfortable. Mankiw (1995) provided evidence rebutting this hypothesis and showed that saving rates and growth rates are positively correlated across countries. Finally, the neoclassical model predicts that in an economy where the stock of capital is rising faster than labor productivity, the return to investment should decline with time. For the advanced countries, the evidence does not support this argument because returns have not fallen over time.

Critiques of the neoclassical model led to two lines of subsequent research on economic growth. The first approach, originated by Jorgenson (1966, 2000), is termed the augmented Solow approach. It remains in the neoclassical tradition in that diminishing marginal returns are critical and there is no explanation for the determinants of technological progress. Instead, this approach attempts to reduce empirically the portion of growth attributed to the unexplained residual labeled technological progress (TFP). The idea is to develop better measures of the inputs used in the production function and broaden the definition of investment by including human capital, research and development, and public infrastructure. In addition, the composition of capital spending is important. Higher levels of capital spending on high-technology goods will boost productivity more than spending on machine tools or structures.

By adding inputs such as human capital to the production function, the augmented Solow model enables us to more accurately measure the contribution of technological progress to growth. The economy still moves toward a steady-state growth path, however, because even broadly defined capital is assumed to eventually encounter diminishing marginal returns. In essence, this line of research uses the growth accounting methodology and increases the number of inputs in the production function in order to provide a more accurate measure of technological progress. The second approach is the endogenous growth theory, which we examine in the next section.

13

ENDOGENOUS GROWTH MODEL

The alternative to the neoclassical model is a series of models known as endogenous growth theory. These models focus on explaining technological progress rather than treating it as exogenous. In these models, self-sustaining growth emerges as a natural consequence of the model and the economy does not necessarily converge to a steady-state rate of growth. Unlike the neoclassical model, there are *no diminishing marginal returns to capital for the economy as a whole* in the endogenous growth models. So increasing the saving rate permanently increases the rate of economic growth. These models also allow for the possibility of increasing returns to scale.

Romer (1986) provided a model of technological progress and a rationale for why capital does not experience diminishing marginal returns. He argued that capital accumulation is the main factor accounting for long-run growth, once the definition of capital is broadened to include such items as human or knowledge capital and research and development (R&D). R&D is defined as investment in new knowledge that improves the production process. In endogenous growth theory, knowledge or human capital and R&D spending are factors of production, like capital and labor, and have to be paid for through savings.

Companies spend on R&D for the same reason they invest in new equipment and build new factories: to make a profit. R&D spending is successful if it leads to the development of a new product or method of production that is successful in the marketplace. There is a fundamental difference, however, between spending on new equipment and factories and spending on R&D. The final product of R&D spending is ideas. These ideas can potentially be copied and used by other companies in the economy. Thus, R&D expenditures have potentially large positive externalities or spillover effects. This means that spending by one company has a positive impact on other companies and increases the overall pool of knowledge available to all companies. Spending by companies on R&D and knowledge capital generates benefits to the economy as a whole that exceed the private benefit to the individual company making the R&D investment. Individual companies cannot fully capture all the benefits associated with creating new ideas and methods of production. Some of the benefits are external to the company, and so are the social returns associated with the investment in R&D and human capital.

This distinction between the private and social returns or benefits to capital is important because it solves an important microeconomic issue. The elimination of the assumption of diminishing marginal returns to capital implies constant returns to capital and increasing returns to all factors taken together. If individual companies could capture these scale economies, then all industries would eventually be dominated by a single company—a monopoly. There is simply no empirical evidence to support this implication. Separating private returns from social returns solves the problem. If companies face constant returns to scale for all private factors, there is no longer an inherent advantage for a company being large. But the externality or social benefit results in increasing returns to scale across the entire economy as companies benefit from the private spending of the other companies.

The role of R&D spending and the positive externalities associated with this spending have important implications for economic growth. In the endogenous growth model, the economy does not reach a steady growth rate equal to the growth of labor plus an exogenous rate of labor productivity growth. Instead, saving and investment decisions can generate self-sustaining growth at a permanently higher rate. This situation is in sharp contrast to the neoclassical model, in which only a transitory increase in growth above the steady state is possible. The reason for this

difference is that because of the externalities on R&D, diminishing marginal returns to capital do not set in. The production function in the endogenous growth model is a straight line given by

$$y_e = f(k_e) = ck_e, \quad (12)$$

where output per worker (y_e) is proportional to the stock of capital per worker (k_e), c is the (constant) marginal product of capital in the aggregate economy, and the subscript e denotes the endogenous growth model. In contrast, the neoclassical production function is a curved line that eventually flattens out (see Exhibit 4).

To understand the significance of introducing constant returns to aggregate capital accumulation, note that in this model the output-to-capital ratio is fixed ($= c$) and therefore output per worker (y_e) always grows at the same rate as capital per worker (k_e). Thus, faster or slower capital accumulation translates one for one into faster or slower growth in output per capita. Substituting Equation 12 into Equation 7 gives an equation for the growth rate of output per capita in the endogenous growth model:

$$\Delta y_e / y_e = \Delta k_e / k_e = sc - \delta - n$$

Because all the terms on the right-hand side of this equation are constant, this is both the long-run and the short-run growth rate in this model. Examination of the equation shows that *a higher saving rate (s) implies a permanently higher growth rate*. This is the key result of the endogenous growth model.

The positive externalities associated with spending on R&D and knowledge capital suggest that spending by private companies on these inputs may be too low from an overall societal point of view. This is an example of a market failure wherein private companies under-invest in the production of these goods. In this case, there may be a role for government intervention to correct for the market failure by direct government spending on R&D and/or providing tax breaks and subsidies for private production of knowledge capital. Higher levels of spending on knowledge capital could translate into faster economic growth even in the long run. Finally, according to the endogenous growth theory, there is *no reason why the incomes of developed and developing countries should converge*. Because of constant or even increasing returns associated with investment in knowledge capital, the developed countries can continue to grow as fast as, or faster than, the developing countries. As a result, there is no reason to expect convergence of income over time. We now turn to the convergence debate in more detail.

EXAMPLE 12

Neoclassical vs. Endogenous Growth Models

Consider again an economy with per capita income growing at a constant 3.08% rate and with a 20% saving rate, an output-to-capital ratio (c in the endogenous growth model, Equation 12) of 0.7040, a depreciation rate (δ) of 10%, and a 1% labor force growth (n).

1. Use the endogenous growth model to calculate the new steady-state growth rate of per capita income if the saving rate increases to 23.5%.

Solution

In the endogenous growth model, the new growth rate of per capita income is

$$\Delta y_e / y_e = sc - \delta - n = (0.235)(0.7040) - 0.10 - 0.01 = 0.0554, \text{ or } 5.54\%.$$

This is the same as the growth rate immediately following the increase in the saving rate (to 30% in that case) in the earlier example using the neoclassical

model (Example 11). Unlike in the neoclassical model, in the endogenous growth model this higher growth rate will be sustained.

2. How much higher will per capita income be in 10 years because of the higher saving rate? How does this compare with the impact calculated in Example 11 using the neoclassical model? What accounts for the difference?

Solution

According to the endogenous growth model, per capita income will grow 2.46% ($= 5.54\% - 3.08\%$) faster with the higher saving rate. After 10 years, the cumulative impact of the faster growth rate will be

$$\exp(0.0246 \times 10) = \exp(0.246) = 1.2789.$$

So, per capita income will be almost 28% higher than it would have been at the lower saving rate. This increase is substantially larger than the 15.18% cumulative increase after 10 years found in Example 11 assuming a much larger increase in the saving rate (to 30% instead of 23.5%) in the neoclassical model. The difference arises because the endogenous growth model assumes that capital accumulation is not subject to diminishing returns. Therefore, the growth rate is permanently, rather than temporarily, higher.

3. In an effort to boost growth, the government is considering two proposals. One would subsidize all private companies that increase their investment spending. The second would subsidize only investments in R&D and/or implementation of new technologies with potential for network externalities. Interpret these proposals in terms of the neoclassical and endogenous growth models and assess their likely impact on growth. (Focus only on "supply-side" considerations here.)

Solution

Subsidizing all private investment would tend to have a significant, pure capital deepening component. That is, companies would be encouraged to buy more, but not necessarily better, plant and equipment. The neoclassical model indicates that this scenario is likely to result in a temporary surge in growth, but even if the higher rate of investment/saving is sustained, growth will again decline over time. On the positive side, this proposal is very likely to succeed, at least for a while, because it does not require investment in unproven technologies or ill-defined network effects. The impact of the other proposal is more uncertain but potentially much more powerful. If the investments in R&D and/or new technologies lead to new knowledge, greater efficiency, new products and methods, and/or network externalities, then the endogenous growth model suggests that growth is likely to be permanently enhanced.

14

CONVERGENCE HYPOTHESES



explain and evaluate convergence hypotheses

As is evident in Exhibit 1, a wide gap separates the living standards in developed and developing nations. The question is, will this difference persist forever or will the per capita income levels of the developing countries converge to those of the developed countries? Convergence means that countries with low per capita incomes should grow at a faster rate than countries with high per capita incomes. Thus, over time the per capita income of developing countries should converge toward that of the developed countries. Whether convergence occurs has major implications for the future growth prospects of developed versus developing countries. It also has important investment implications.

There are three types of convergence commonly discussed in the economics literature: absolute, conditional, and club convergence. **Absolute convergence** means that developing countries, regardless of their particular characteristics, will eventually catch up with the developed countries and match them in per capita output. The neoclassical model assumes that all countries have access to the same technology. As a result, per capita income in all countries should eventually grow at the same rate. Thus, the model implies convergence of per capita *growth rates* among all countries. It does not, however, imply that the *level* of per capita income will be the same in all countries regardless of underlying characteristics; that is, it does not imply absolute convergence.

Conditional convergence means that convergence is conditional on the countries having the same saving rate, population growth rate, and production function. If these conditions hold, the neoclassical model implies convergence to the same *level* of per capita output as well as the same steady-state growth rate. In terms of Exhibit 13, these economies would have the same k^* and thus the same steady state. If they start with different capital-to-labor ratios, their growth rates will differ in the transition to the steady state. The economy with a lower capital-to-labor ratio will experience more rapid growth of productivity and per capita income, but the differential will diminish until they finally converge. Countries with different saving rates or population growth rates and thus different steady-state values for k^* will have different steady-state *levels* of per capita income, but their growth rates of per capita output will still converge.

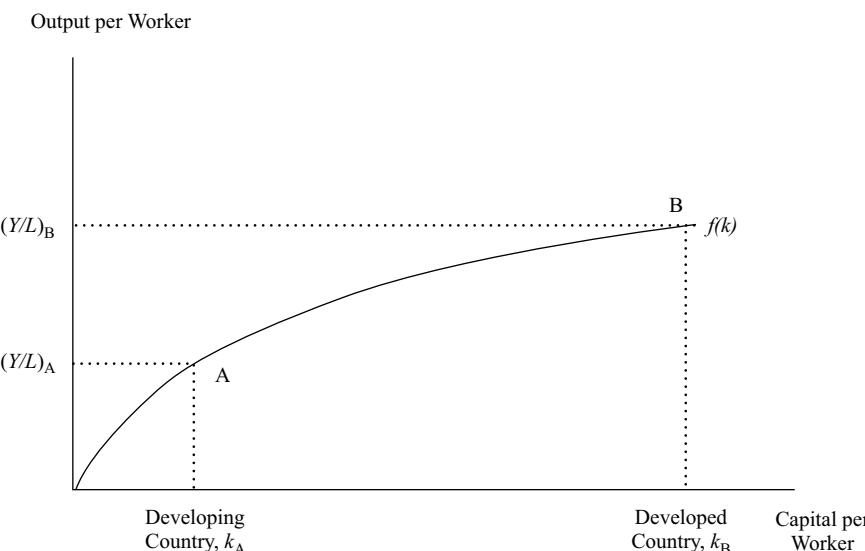
The data (see Exhibit 17) indicate that some of the poorer countries are diverging rather than converging to the income levels of the developed countries. Thus, we have the notion of **club convergence**, where only rich and middle-income countries that are members of the club are converging to the income level of the world's richest countries. This means that the countries with the lowest per capita income in the club grow at the fastest rate. In contrast, countries outside the club continue to fall behind. Poor countries can join the club if they make appropriate institutional changes, such as those summarized earlier in our discussion of factors limiting growth in developing economies. Finally, countries may fall into a **non-convergence trap** if they do not implement necessary institutional reforms. For example, failure to reform labor markets has undermined growth in some European countries that have experienced weak growth in employment and high rates of unemployment over the last two decades. Certain institutional arrangements that initially enhance growth may later generate non-convergence traps if maintained too long. Import substitution policies enabled the Latin American countries to grow rapidly in the 1950s and 1960s but caused them to stagnate in the 1970s and 1980s.

If convergence, and especially club convergence, does occur, investing in countries with lower per capita incomes that are members of the club should, over long periods, provide a higher rate of return than investing in higher-income countries. Convergence means that the rate of growth of potential GDP should be higher in developing countries that have made the institutional changes that are a precondition for growth and that enable these countries to become members of the convergence club. With higher long-term growth in these economies, corporate profits should also grow at a faster rate. Given the faster rate of growth in earnings, stock prices may

also rise at a faster rate. Of course, risk is also likely to be higher in these markets. Nonetheless, it is reasonable to conclude that long-term investors should allocate a risk-tolerance-appropriate portion of their assets to those developing economies that have become members of the convergence club.

Convergence between the developed and developing countries can occur in two ways. First, convergence takes place through capital accumulation and capital deepening. Exhibit 16 illustrates the difference between developed and developing countries using the per capita neoclassical production function. The developed countries operate at point B, so increases in capital have almost no impact on productivity. In contrast, developing countries operate at point A, where increases in capital significantly boost labor productivity.

Exhibit 16: Per Capita Production Function Developed vs. Developing Countries



A second source of convergence is that developing countries can imitate or adopt technology already widely utilized in the advanced countries. Developing countries can learn from advanced countries as scientific and management practices spread with globalization. By importing technology from the advanced countries, the developing countries can achieve faster economic growth and converge to the income of the advanced countries. Technology transfers will narrow the income gap between developed and developing countries only if the poor countries invest the resources to master the technology and apply it to their economies. This spending is similar to R&D spending and allows the country to join the convergence club. The steady-state rate of growth for members of the convergence club will be determined by the global rate of technological progress. Without such spending, the country will be left out and will continue to fall behind the developed countries.

In contrast to the neoclassical model, the endogenous growth model makes no prediction that convergence should occur. This model allows for countries that start with high per capita income and more capital to grow faster and stay ahead of the developing countries. If the externalities associated with knowledge and human capital are large, the higher-income country can maintain its lead through high rates of investment in these capital inputs.

If the convergence hypothesis is correct, there should be an inverse relation between the initial level of per capita real GDP and the growth rate in per capita GDP. Exhibit 17 shows the countries in Exhibit 1 in descending order of per capita income in 1950. If incomes are converging across countries, the poor countries in 1950 should have a higher growth rate between 1950 and 2018 than the rich countries.

Exhibit 17: Real Per Capita GDP by Selected Economy

	Real GDP Per Capita (in US dollars)				Avg. Annual Growth in Per Capita GDP (%)			
	1950	1980	2000	2018	1950–80	1980–2000	2000–18	1950–2018
United States	14,559	29,136	45,640	55,650	2.3	2.3	1.1	2.0
New Zealand	13,795	20,526	27,514	35,676	1.3	1.5	1.5	1.4
Australia	13,219	24,403	36,469	46,555	2.1	2.0	1.4	1.9
Canada	12,053	27,356	37,555	44,135	2.8	1.6	0.9	1.9
United Kingdom	11,602	20,547	33,531	40,627	1.9	2.5	1.1	1.9
France	8,266	24,901	35,778	40,689	3.7	1.8	0.7	2.4
Venezuela	8,104	18,247	14,469	9,487	2.7	-1.2	-2.3	0.2
Argentina	6,164	14,710	15,011	18,255	2.9	0.1	1.1	1.6
Italy	5,954	24,937	36,085	35,233	4.9	1.9	-0.1	2.6
Ireland	5,496	16,707	39,345	70,032	3.8	4.4	3.3	3.8
South Africa	4,361	10,781	9,715	12,156	3.1	-0.5	1.3	1.5
Singapore	4,299	20,626	51,748	89,196	5.4	4.7	3.1	4.6
Mexico	4,180	13,546	15,811	18,313	4.0	0.8	0.8	2.2
Spain	3,964	18,353	30,347	35,679	5.2	2.5	0.9	3.3
Peru	3,464	7,314	6,498	12,644	2.5	-0.6	3.8	1.9
Japan	3,048	20,769	33,875	39,313	6.6	2.5	0.8	3.8
Brazil	2,365	11,372	11,470	14,360	5.4	0.0	1.3	2.7
Turkey	2,327	7,990	13,258	24,850	4.2	2.6	3.6	3.5
Philippines	1,296	4,390	4,277	7,943	4.2	-0.1	3.5	2.7
Korea	1,185	5,084	20,757	36,756	5.0	7.3	3.2	5.2
Egypt	1,132	5,228	8,452	11,881	5.2	2.4	1.9	3.5
Indonesia	804	2,911	5,863	11,760	4.4	3.6	3.9	4.0
Pakistan	666	2,080	3,406	5,049	3.9	2.5	2.2	3.0
India	658	1,297	2,546	6,999	2.3	3.4	5.8	3.5
China	402	722	3,682	16,098	2.0	8.5	8.5	5.6
Ethiopia	314	727	653	2,073	2.8	-0.5	6.6	2.8

Note: GDP per capita, constant prices at 2011 in US dollars, adjusted for PPP.

Source: IMF.

The results for the convergence hypothesis are mixed. The economies with the highest per capita income in 1950 were the United States, New Zealand, Australia, and Canada. The markets with the fastest growth rate over the period 1950–2018 were China and Korea, each growing at a rate above 5%. This result strongly supports convergence because the per capita incomes of these economies in 1950 were well below that of the United States. In addition, the results for Japan, Singapore, Spain, and Korea showed a convergence to the level of income in the advanced economies. In total, 17 of the 27 economies in our sample grew faster than the United States during the period.

However, South Africa, Argentina, Venezuela, and New Zealand were among those that fell further behind the United States. Interestingly, since 2000, convergence has been relatively strong overall, with 16 countries in our sample (60%) growing faster than the United States—including Ethiopia, the Philippines, Peru, Turkey, South Africa, Australia, and New Zealand—but has not continued among the most advanced economies: France, Japan, and Italy all lagged the United States, Canada, and Australia.

The evidence seems to suggest that poorer countries may converge if they develop the appropriate legal, political, and economic institutions. In addition, trade policy is an important factor, which we address in the next section.

15

GROWTH IN AN OPEN ECONOMY

- describe the economic rationale for governments to provide incentives to private investment in technology and knowledge
- describe the expected impact of removing trade barriers on capital investment and profits, employment and wages, and growth in the economies involved

The Solow model discussed earlier assumed a closed economy in which domestic investment equals domestic savings and there is no international trade or capital flows. Opening up the economy to trade and financial flows can significantly affect the rate of growth in an economy for the following reasons:

1. A country can borrow or lend funds in global markets, and domestic investment can be funded by global savings. Thus, investment is not constrained by domestic savings.
2. Countries can shift resources into industries in which they have a comparative advantage and away from industries in which they are relatively inefficient, thereby increasing overall productivity.
3. Companies have access to a larger, global market for their products, allowing them to better exploit any economies of scale and increasing the potential reward for successful innovation.
4. Countries can import technology, thus increasing the rate of technological progress.
5. Global trade increases competition in the domestic market, forcing companies to produce better products, improve productivity, and keep costs low.

According to the neoclassical model, convergence should occur more quickly if economies are open and there is free trade and international borrowing and lending. Opening up the economy should increase the rate at which countries' capital-to-labor ratios converge. The dynamic adjustment process can be described as follows:

1. Developing countries have less capital per worker, and as a result, the marginal product of capital is higher. Thus, the rate of return on investments should be higher in countries with low capital-to-labor ratios and lower in countries with high capital-to-labor ratios.
2. Global savers, seeking higher returns on investments, will invest in the capital-poor countries. In an open economy, capital should flow from countries with high capital-to-labor ratios to those that are capital poor.

3. Because of the capital inflows, the physical capital stock in the developing countries should grow more rapidly than in rich countries even if the saving rate is low in the poorer countries. Faster capital growth will result in higher productivity growth, causing per capita incomes to converge.
4. Because capital flows must be matched by offsetting trade flows, capital-poor countries will tend to run a trade deficit as they borrow globally to finance domestic investment. In contrast, the developed countries will tend to run trade surpluses as they export capital.
5. During the transition to the new steady state, the inflows of capital will temporarily raise the rate of growth in the capital-poor country above the steady-state rate of growth. At the same time, growth in the capital-exporting countries will be below the steady state.
6. Over time, the physical capital stock will rise in the capital-poor country, reducing the return on investments. As a result, the rate of investment and size of the country's trade deficit will decline. Growth will slow and approach the steady-state rate of growth. If investment falls below the level of domestic savings, the country will eventually shift from a trade deficit to a trade surplus and become an exporter of capital.
7. In the Solow model, after the reallocation of world savings, there is no permanent increase in the rate of growth in an economy. Both the developed and developing countries grow at the steady-state rate of growth.

In contrast to the neoclassical model, endogenous growth models predict that a more open trade policy will permanently raise the rate of economic growth. In these models, international trade increases global output through the following:

1. A selection effect, whereby increased competition from foreign companies forces less efficient domestic companies to exit and more efficient ones to innovate and raises the efficiency of the overall national economy.
2. A scale effect that allows producers to more fully exploit economies of scale by selling to a larger market.
3. A backwardness effect arising from less advanced countries or sectors of an economy catching up with the more advanced countries or sectors through knowledge spillovers.

Open trade also affects the innovation process by encouraging higher levels of spending on R&D and on human capital as companies invest to take advantage of access to larger markets and the greater flow of ideas and knowledge among countries. The rate of return to new investment increases, as does the rate of economic growth. In general, most countries gain from open trade, with the scale effect benefiting smaller countries and the backwardness effect benefiting the poorer, less developed countries. But trade can also retard growth in some cases, especially in small countries that lag behind the technology leaders. Opening these countries to trade may discourage domestic innovation because companies will recognize that, even if they innovate, they may lose out to more efficient foreign companies.

EXAMPLE 13

The Entry of China and India into the Global Economy

China and India effectively entered the global economy in the 1980s as they shifted toward more market-oriented policies and opened up to global trade. Their impact on global growth was significant. In 2018, according to the IMF, China and India accounted for 20% and 8% of world GDP (based on PPP), respectively, whereas the two countries combined for only 4.2% of global output in 1980. The

entry of these two countries significantly increased the global supply of skilled and unskilled labor receiving relatively lower wages. As a result of the surge in available labor, global potential GDP increased sharply. Economic theory suggests that the supply-side increase in the global capacity to produce goods and services would increase global output and put downward pressure on prices.

The neoclassical model of growth can provide us with some further insights into the impact of China and India entering the global economy. At the time, China and India had relatively lower wages and capital compared with the United States and Europe. One would expect that the rate of return on capital would be higher in China and India and that capital would flow from the developed countries to China and India. Hence, both China and India would be expected to run trade deficits. This has been the case for India but, contrary to the model's prediction, China has run trade surpluses. These surpluses stem mainly from China's very high domestic saving rate.

Nonetheless, China has experienced large foreign direct investment (see Exhibit 18) inflows, which have reinforced its already high private investment rate. As China and India accumulate capital, their capital-to-labor ratios, real wage levels, and per capita income should converge toward those of the advanced economies. Depending on global aggregate demand conditions, wages might even have to fall in the developed countries in the process of shifting wealth and income to the developing economies. Because of the surge in the global supply of labor, the overall share of labor in global income should decline relative to capital. In addition, global productivity should rise as China and India account for a rising share of global output. In sum, over the long run, the growing share of global GDP going to China and India will benefit the global economy as more efficient utilization of resources allows global potential GDP to grow more rapidly for an extended period.

Although both the neoclassical and the endogenous models of growth show the benefits of open markets, over the last 50 years developing countries have pursued two contrasting strategies for economic development:

- *Inward-oriented policies* attempt to develop domestic industries by restricting imports. Instead of importing goods and services, these policies encourage the production of domestic substitutes, despite the fact that it may be more costly to do so. These policies are also called import substitution policies.
- *Outward-oriented policies* attempt to integrate domestic industries with those of the global economy through trade and make exports a key driver of growth.

Many African and Latin American countries pursued inward-oriented policies from the 1950s to the 1980s that resulted in poor GDP growth and inefficient industries producing low-quality goods. In contrast, many East Asian countries, such as Singapore and South Korea, pursued outward-oriented policies during this same period, which resulted in high rates of GDP growth and convergence with developed countries. These countries also benefited from the positive effects of foreign direct investment, which suggests that more open and trade-oriented economies will grow at a faster rate. The evidence strongly supports this case.

In Example 1, we compared the economic performance of Argentina and Venezuela with that of Japan, South Korea, and Singapore. In 1950, the per capita GDP of the two Latin American countries was well above that of the three East Asian countries. By 2010, however, the per capita GDPs of the three Asian countries were well above those of Argentina and Venezuela. The difference in the growth rates between Argentina

and Venezuela and the three Asian countries is explained largely by the openness of their economies. Argentina and Venezuela were relatively closed economies, whereas the Asian countries relied on foreign investment and open markets to fuel growth.

Many African and Latin American countries have removed trade barriers and are pursuing more outward-oriented policies, and they experienced better growth. Brazil is a good example. Exports of goods and services increased from \$64.6 billion in 2000 to \$218 billion in 2018, an increase of more than 237%. As shown in Exhibit 18, exports as a share of GDP rose from 10.2% to 14.8% over this period.

Exhibit 18: Exports and Foreign Direct Investment of Selected Countries

	1980	1990	2000	2018
Brazil				
Exports as a percentage of GDP	9.1%	8.2%	10.2%	14.8%
Inflows of foreign direct investment (\$ billions)	NA	NA	\$32.8	\$61.2
China				
Exports as a percentage of GDP	5.9%	13.6%	20.9%	19.5%
Inflows of foreign direct investment (\$ billions)	NA	NA	\$38.4	\$203.5
India				
Exports as a percentage of GDP	6.1%	7.1%	13.0%	19.7%
Inflows of foreign direct investment (\$ billions)	NA	NA	\$3.6	\$42.1
Ireland				
Exports as a percentage of GDP	44.3%	54.6%	94.5%	122.3%
Inflows of foreign direct investment (\$ billions)	NA	NA	\$25.8	\$28.1
Mexico				
Exports as a percentage of GDP	10.1%	18.7%	25.4%	39.2%
Inflows of foreign direct investment (\$ billions)	NA	NA	\$18.0	\$32.7
South Africa				
Exports as a percentage of GDP	34.3%	23.5%	27.2%	30.1%
Inflows of foreign direct investment (\$ billions)	NA	NA	\$0.9	\$5.3
South Korea				
Exports as a percentage of GDP	28.5%	25.3%	35.1%	44.0%
Inflows of foreign direct investment (\$ billions)	NA	NA	\$9.3	\$14.5
United States				

	1980	1990	2000	2018
Exports as a percentage of GDP	9.8%	9.3%	10.7%	12.2%
Inflows of foreign direct investment (\$ billions)	NA	NA	\$159.2	\$268.4

Source: OECD (2019).

EXAMPLE 14

Why Some Countries Converge and Others Do Not

As evident from the high rates of growth between 1950 and 2018 shown in Exhibit 18, China and South Korea are converging toward the income levels of the advanced economies. In contrast, the economies of Mexico and South Africa have not converged.

1. Using the data in Exhibit 18, give some reasons why this has occurred.

Solution

Two reasons largely account for the difference. First, growth in the Chinese and South Korean economies has been driven by high rates of business investment. As shown in Exhibit 9, investment as a share of GDP in 2018 was 44% in China, almost double the rate of 23.0% in Mexico and more than double the rate of 18% in South Africa. Although investment as a share of GDP in South Korea is lower than in China, it is well above that of Mexico and South Africa.

Second, both China and South Korea have pursued an aggressive export-driven, outward-oriented policy focusing on manufactured goods. In 2018, exports were 44% of GDP for South Korea and 19.5% of GDP for China (Exhibit 18). In addition, foreign direct investment is a major factor underlying growth in China.

On the other hand, South Africa's more inward-oriented economy attracted only \$5.3 billion in foreign direct investment in 2018, significantly less than that of Ireland—a smaller but much wealthier and very open country—and the \$203 billion inflow of foreign investment into China. These trends are changing, however, as many African and Latin American countries are increasingly relying on growing exports and foreign investment to increase GDP growth.

EXAMPLE 15

Investment Prospects in Spain: Estimating the Sustainable Growth Rate

You are a financial analyst at Global Invest Inc., an investment management firm that runs a number of global mutual funds with a significant exposure to Spain. The IBEX 35 Index, which reached a crisis-induced low of 6,065 in May 2012, remains far below its October 2007 peak of almost 16,000. The members of the investment policy committee at the firm believe the equity market in Spain is attractive and is currently being depressed by temporary problems in the banking and real estate markets of Spain, which they feel are overstated.

They believe that higher profits will ultimately drive the market higher but are concerned about the long-term prospects and the sustainable rate of growth for Spain. One of the research assistants at the firm gathers the data shown in Exhibit 19 from the OECD and the Conference Board.

Exhibit 19: Growth Data for Spain

	GDP in Billions of USD Adjusted for PPP	Gross Capital Spending as Percentage of GDP	Consumption of Fixed Capital (percent of GDP)	Labor Cost as Percentage of Total Factor Cost	Total Hours Worked (millions)	Output per Hour Worked in 2011 USD Adjusted for PPP	Growth in Total Factor Productivity (%)
2006	1,390	31.3	14.9	61.4	35,358	48	-0.5
2007	1,481	31.3	15.1	60.5	36,259	48	-0.4
2008	1,527	29.6	15.6	60.2	36,519	48	-1.6
2009	1,484	24.6	16.4	60.5	34,371	50	-1.7
2010	1,501	23.5	16.8	59.1	33,591	51	-0.1
2011	1,517	21.9	17.4	59.1	32,788	51	-0.8
2012	1,501	20.0	18.0	57.3	31,204	52	-1.2
2013	1,501	18.7	17.8	56.5	30,250	53	-1.0
2014	1,551	19.5	17.8	56.1	30,569	53	-0.3
2015	1,625	20.4	17.5	56.4	31,527	54	-0.9

Sources: OECD Stat Extracts and the Conference Board Total Economy Database.

According to the Conference Board website, the physical capital stock for Spain was estimated at \$1,808 billion (adjusted for purchasing power parity) in 2005. The research analyst calculated the physical capital stock (K) for Spain for the years 2006–2015 using the following equation:

$$K_t = K_{t-1} + I - D,$$

where I is gross investment or gross capital spending and D is the depreciation or the consumption of fixed capital. So for 2006 and 2007, the physical capital stock is calculated as follows:

$$K_{2006} = \$1,808 + \$1,390 (0.313 - 0.149) = \$2,036 \text{ billion}$$

$$K_{2007} = \$2,036 + \$1,481 (0.313 - 0.151) = \$2,276 \text{ billion}$$

The physical capital stock for the remaining years is calculated in the same way and given by Exhibit 20.

Exhibit 20: Estimated Physical Capital Stock (USD billions)

2006	\$2,036
2007	2,276
2008	2,490
2009	2,611
2010	2,713
2011	2,782
2012	2,812
2013	2,826

2014	2,851
2015	2,898

The investment policy committee asks you to use the preceding data to address the following:

1. Calculate the potential growth rate of the Spanish economy using the production function or growth accounting method (Equation 4), and determine the amount of growth attributed to each source.

Solution

The production function or growth accounting method estimates the growth in GDP using Equation 4:

$$\text{Growth in potential GDP} = \alpha\Delta K/K + (1 - \alpha)\Delta L/L + \Delta A/A$$

The annual growth rate in capital is calculated from Exhibit 20 as

$$(2,898/2,036)^{1/9} - 1 = 4.0\%.$$

The labor input is measured by the growth rate in total hours worked in the economy (Exhibit 19) and given by

$$(31,527/35,358)^{1/9} - 1 = -1.27\%.$$

The growth rate in total factor productivity (Exhibit 19) is calculated by using a geometric average of the growth rates for 2006–2015 and is equal to -0.85% . Finally, the labor share of output is given by the average of the labor cost as a percentage of total factor cost, which is 58.7% for 2006–2015 (Exhibit 19). Thus, the share of capital (α) is $1 - 0.587 = 41.3\%$.

Using these numbers, the growth in potential GDP is

$$\begin{aligned}\text{Growth in potential GDP} &= \alpha\Delta K/K + (1 - \alpha)\Delta L/L + \Delta A/A \\ &= (0.413)0.04 + (0.587)(-0.0127) + (-0.0085) \\ &= 0.06\%\end{aligned}$$

Sources of growth for Spain over the period 2006–2015 were as follows:

Capital	$(0.413) \times (0.04) = 1.65\%$
Labor	$(0.587) \times (-0.0127) = -0.75\%$
TFP	$= -0.85\%$

2. Calculate the potential growth rate of the Spanish economy using the labor productivity method (Equation 5).

Solution

The labor productivity method estimates the growth in GDP using Equation 5:

Growth rate in potential GDP = Long-term growth rate of labor force + Long-term growth rate in labor productivity

As before, we use the growth in total hours worked to measure the growth in the labor force. The growth in labor productivity per hour worked is as follows:

$$(54/48)^{1/9} - 1 = 1.32\%$$

$$\text{Growth in potential GDP} = -1.27\% + 1.32\% = 0.05\%$$

Note that the estimate of potential GDP growth using the labor productivity approach is broadly similar to that obtained from the growth accounting method. In general, the two methods are likely to give somewhat different estimates because they rely on different data inputs. The growth accounting method requires measurements of the physical capital stock and TFP. As discussed earlier, TFP is estimated using various time-series or econometric models of the component of growth that is not accounted for by the explicit factors of production. As a result, the estimate of TFP reflects the average (or "smoothed") behavior of the growth accounting residual. The labor productivity approach is simpler, and it avoids the need to estimate the capital input and TFP. In contrast to the estimated value of TFP, labor productivity is measured as a pure residual; that is, it is the part of GDP growth that is not explained by the labor input (and only the labor input). The cost of the simplification is that the labor productivity approach does not allow a detailed analysis of the drivers of productivity growth.

3. How significant are capital deepening and technology in explaining growth for Spain?

Solution

Capital deepening occurs in an economy when there is an increase in the capital-to-labor ratio. The labor input for Spain is measured in terms of total hours worked in the economy. Thus, the capital-to-labor ratio for Spain is calculated by dividing the physical capital stock in Exhibit 20 by total hours worked in Exhibit 19. The results, shown in Exhibit 21, indicate that capital deepening was very significant in Spain: The amount of capital per hour worked increased from \$57.6 in 2006 to \$91.9 in 2015. In terms of the growth rate, the capital-to-labor ratio increased at an annual rate of 5.3%. The contribution of TFP is measured by the growth in total factor productivity. In contrast to capital deepening, TFP made a negative contribution to growth; the average rate of growth for TFP from 2006 to 2015 was -0.85%. However, TFP is estimated using various statistical techniques, and given the uncertainty around these estimates, it should be viewed with some caution.

**Exhibit 21: Estimated Capital-to-Labor Ratio
(\$/hour worked)**

2006	\$57.6
2007	62.8
2008	68.2
2009	76.0
2010	80.8
2011	84.8
2012	90.1
2013	93.4
2014	93.3
2015	91.9

4. What is the steady-state growth rate for Spain according to the neoclassical model?

Solution

The steady-state growth rate in the neoclassical model is estimated by the following (see Equation 8):

$$\Delta Y/Y = (\theta)/(1 - \alpha) + n$$

= Growth rate of TFP scaled by labor factor share + Growth rate in the labor force

$$\text{Steady-state growth rate} = -0.85\%/(1 - 0.413) + (-1.27\%) = -2.7\%$$

As expected, the growth rate in potential GDP (calculated as in the solutions to 1 and 2) is above the steady-state growth rate. The reason for this is that Spain's economy is still in the process of converging to the higher income levels of the United States and the major economies in Europe. The physical capital stock is below the steady state, and capital deepening is a significant factor increasing productivity growth and the growth in potential GDP.

Steady-state growth may be somewhat underestimated in our analysis given that TFP growth is likely to revert to the 1% annual rate of increase exhibited in other major developed economies. This shift is likely to be offset by a lower growth rate in the labor input (see Example 6). It should also be noted that the negative growth in the labor force used in the calculation is based on a period whose start coincides with high level of hours worked and ends in a year when the hours worked were particularly low. The hours worked actually rose subsequent to the 2006–2015 period.

5. Assess the implications of the growth analysis for future economic growth and equity prices in Spain.

Solution

The results suggest that potential GDP growth in Spain is close to 0%. As we saw in Exhibit 1, the growth rate of actual GDP since early 2000 has been 0.91% per year, close to the previous estimate of potential but well above the steady state. The problem is that all the growth in potential GDP results from the increase in the labor and capital inputs, with capital deepening being very significant as the capital-to-labor ratio is increasing at a 5.3% annual rate. The neoclassical model suggests that the impact of capital deepening will decline over time and the economy will move toward a steady-state rate of growth. Thus, growth based on capital deepening should not be sustainable over time.

The other major question raised is whether the labor input can continue to decline at an annual rate of 1.3%. We examined this question in Example 6. In sum, potential GDP growth is likely to be negatively influenced over time by Spain's reliance on capital deepening. A positive impact may come from increasing labor input. The reversion of TFP growth to levels more typical of other European economies should also be a positive factor. Even if TFP does rebound, relatively slow growth in potential GDP in Spain will likely restrain future stock price increases.

SUMMARY

This reading focuses on the factors that determine the long-term growth trend in the economy. As part of the development of global portfolio equity and fixed-income strategies, investors must be able to determine both the near-term and the sustainable rates of growth within a country. Doing so requires identifying and forecasting the factors that determine the level of GDP and that determine long-term sustainable trends in economic growth.

- The sustainable rate of economic growth is measured by the rate of increase in the economy's productive capacity or potential GDP.
- Growth in real GDP measures how rapidly the total economy is expanding. Per capita GDP, defined as real GDP divided by population, measures the standard of living in each country.
- The growth rate of real GDP and the level of per capita real GDP vary widely among countries. As a result, investment opportunities differ by country.
- Equity markets respond to anticipated growth in earnings. Higher sustainable economic growth should lead to higher earnings growth and equity market valuation ratios, all other things being equal.
- In the long run, the growth rate of earnings cannot exceed the growth in potential GDP. Labor productivity is critical because it affects the level of the upper limit. A permanent increase in productivity growth will raise the upper limit on earnings growth and should translate into faster long-run earnings growth and a corresponding increase in stock price appreciation.
- For global fixed-income investors, a critical macroeconomic variable is the rate of inflation. One of the best indicators of short- to intermediate-term inflation trends is the difference between the growth rate of actual and potential GDP.
- Capital deepening, an increase in the capital-to-labor ratio, occurs when the growth rate of capital (net investment) exceeds the growth rate of labor. In a graph of output per capita versus the capital-to-labor ratio, it is reflected by a move along the curve (i.e., the production function).
- An increase in total factor productivity causes a proportional upward shift in the entire production function.
- One method of measuring sustainable growth uses the production function and the growth accounting framework developed by Solow. It arrives at the growth rate of potential GDP by estimating the growth rates of the economy's capital and labor inputs plus an estimate of total factor productivity.
- An alternative method measures potential growth as the long-term growth rate of the labor force plus the long-term growth rate of labor productivity.
- The forces driving economic growth include the quantity and quality of labor and the supply of non-ICT and ICT capital, public capital, raw materials, and technological knowledge.
- The labor supply is determined by population growth, the labor force participation rate, and net immigration. The physical capital stock in a country increases with net investment. The correlation between long-run economic growth and the rate of investment is high.
- Technological advances are discoveries that make it possible to produce more or higher-quality goods and services with the same resources or inputs. Technology is a major factor determining TFP. TFP is the main factor affecting long-term, sustainable economic growth rates in developed

countries and also includes the cumulative effects of scientific advances, applied research and development, improvements in management methods, and ways of organizing production that raise the productive capacity of factories and offices.

- Total factor productivity, estimated using a growth accounting equation, is the residual component of growth after accounting for the weighted contributions of all explicit factors (e.g., labor and capital).
- Labor productivity is defined as output per worker or per hour worked. Growth in labor productivity depends on capital deepening and technological progress.
- The academic growth literature is divided into three theories —the classical view, the neoclassical model, and the new endogenous growth view.
- In the classical model, growth in per capita income is only temporary because an exploding population with limited resources brings per capita income growth to an end.
- In the neoclassical model, a sustained increase in investment increases the economy's growth rate only in the short run. Capital is subject to diminishing marginal returns, so long-run growth depends solely on population growth, progress in TFP, and labor's share of income.
- The neoclassical model assumes that the production function exhibits diminishing marginal productivity with respect to any individual input.
- The point at which capital per worker and output per worker are growing at equal, sustainable rates is called the steady state or balanced growth path for the economy. In the steady state, total output grows at the rate of labor force growth plus the rate of growth of TFP divided by the elasticity of output with respect to labor input.
- The following parameters affect the steady-state values for the capital-to-labor ratio and output per worker: saving rate, labor force growth, growth in TFP, depreciation rate, and elasticity of output with respect to capital.
- The main criticism of the neoclassical model is that it provides no quantifiable prediction of the rate or form of TFP change. TFP progress is regarded as exogenous to the model.
- Endogenous growth theory explains technological progress within the model rather than treating it as exogenous. As a result, self-sustaining growth emerges as a natural consequence of the model and the economy does not converge to a steady-state rate of growth that is independent of saving/investment decisions.
- Unlike the neoclassical model, where increasing capital will result in diminishing marginal returns, the endogenous growth model allows for the possibility of constant or even increasing returns to capital in the aggregate economy.
- In the endogenous growth model, expenditures made on R&D and for human capital may have large positive externalities or spillover effects. Private spending by companies on knowledge capital generates benefits to the economy as a whole that exceed the private benefit to the company.
- The convergence hypothesis predicts that the rates of growth of productivity and GDP should be higher in the developing countries. Those higher growth rates imply that the per capita GDP gap between developing and developed economies should narrow over time. The evidence on convergence is mixed.

- Countries fail to converge because of low rates of investment and savings, lack of property rights, political instability, poor education and health, restrictions on trade, and tax and regulatory policies that discourage work and investing.
- Opening an economy to financial and trade flows has a major impact on economic growth. The evidence suggests that more open and trade-oriented economies will grow at a faster rate.

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PRACTICE PROBLEMS

The following information relates to questions 1-9

Victor Klymchuk, the chief economist at ECONO Consulting (EC), is reviewing the long-term GDP growth of three countries. Klymchuk is interested in forecasting the long-term change in stock market value for each country. Exhibit 1 presents current country characteristics and historical information on select economic variables for the three countries.

Exhibit 1: Select Country Factors and Historical Economic Data

Country Factors	2009–2019				
	Growth in Hours Worked (%)	Growth in Labor Productivity (%)	Growth in TFP (%)	Growth in GDP (%)	
Country A	<ul style="list-style-type: none">▪ High level of savings and investment▪ Highly educated workforce▪ Low tariffs on foreign imports▪ Limited natural resources	0.9	2.4	0.6	3.3
Country B	<ul style="list-style-type: none">▪ Developed financial markets▪ Moderate levels of disposable income▪ Significant foreign direct and indirect investments▪ Significant natural resources	-0.3	1.6	0.8	1.3
Country C	<ul style="list-style-type: none">▪ Politically unstable▪ Limited property rights▪ Poor public education and health▪ Significant natural resources	1.8	0.8	-0.3	2.6

Klymchuk instructs an associate economist at EC to assist him in forecasting the change in stock market value for each country. Klymchuk reminds the associate of the following:

Statement 1: “Over short time horizons, percentage changes in GDP, the ratio

of earnings to GDP, and the price-to-earnings ratio are important factors for describing the relationship between economic growth and stock prices. However, I am interested in a long-term stock market forecast."

A client is considering investing in the sovereign debt of Country A and Country B and asks Klymchuk his opinion of each country's credit risk. Klymchuk tells the client the following:

Statement 2: "Over the next 10 years, I forecast higher potential GDP growth for Country A and lower potential GDP growth for Country B. The capital per worker is similar and very high for both countries, but per capita output is greater for Country A."

The client tells Klymchuk that Country A will offer 50-year bonds and that he believes the bonds could be a good long-term investment given the higher potential GDP growth. Klymchuk responds to the client as follows:

Statement 3: "After the next 10 years, I think the sustainable rate of economic growth for Country A will be affected by a growing share of its population over the age of 65, a declining percentage under age 16, and minimal immigration."

The client is surprised to learn that Country C, a wealthy, oil-rich country with significant reserves, is experiencing sluggish economic growth and asks Klymchuk for an explanation. Klymchuk responds by stating:

Statement 4: "Although countries with greater access to natural resources are often wealthier, the relationship between resource abundance and economic growth is not clear. My analysis shows that the presence of a dominant natural resource (oil) in Country C is constraining growth. Interestingly, Country A has few natural resources but is experiencing a strong rate of increase in per capita GDP growth."

Klymchuk knows that growth in per capita income cannot be sustained by pure capital deepening. He asks the associate economist to determine how important capital deepening is as a source of economic growth for each country. Klymchuk instructs the associate to use the data provided in Exhibit 1.

Klymchuk and his associate debate the concept of convergence. The associate economist believes that developing countries, irrespective of their particular characteristics, will eventually equal developed countries in per capita output. Klymchuk responds as follows:

Statement 5: "Poor countries will only converge to the income levels of the richest countries if they make appropriate institutional changes."

1. Based on the country factors provided in Exhibit 1, the country *most likely* to be considered a developing country is:
 - A. Country A.
 - B. Country B.
 - C. Country C.
2. Based on Exhibit 1, capital deepening as a source of growth was *most* important for:
 - A. Country A.
 - B. Country B.
 - C. Country C.
3. Based on Statement 1, over the requested forecast horizon, the factor that will

most likely drive stock market performance is the percentage change in:

- A. GDP.
 - B. the earnings to GDP ratio.
 - C. the price-to-earnings ratio.
4. Based solely on the predictions in Statement 2, over the next decade Country B's sovereign credit risk will *most likely*:
- A. increase.
 - B. decrease.
 - C. not change.
5. Based on Statement 2, the difference in per capita output between Country A and Country B *most likely* results from differences in:
- A. capital deepening.
 - B. capital per worker.
 - C. total factor productivity.
6. Based on Statement 3, after the next 10 years, the growth rate of potential GDP for Country A will *most likely* be:
- A. lower.
 - B. higher.
 - C. unchanged.
7. Based on Statement 4 and Exhibit 1, the sluggish economic growth in Country C is *least likely* to be explained by:
- A. limited labor force growth.
 - B. export driven currency appreciation.
 - C. poorly developed economic institutions.
8. Based on Statement 4, the higher rate of per capita income growth in Country A is *least likely* explained by the:
- A. rate of investment.
 - B. growth of its population.
 - C. application of information technology.
9. The type of convergence described by Klymchuk in Statement 5 is *best* described as:
- A. club convergence.
 - B. absolute convergence.
 - C. conditional convergence.

The following information relates to questions 10-15

At an international finance and economics conference in Bamako, Mali, Jose Amaral of Brazil and Lucinda Mantri of India are discussing how to spur their countries' economic growth. Amaral believes that growth can be bolstered by removing institutional impediments and suggests several possibilities for Brazil: launching a rural literacy program, clarifying property rights laws, and implementing a new dividend tax on foreign investors.

Mantri responds that for India, capital deepening will be more effective, and she has proposed the following ideas: building a group of auto and textile factories in the southern states, developing a north–south and east–west highway network, and sponsoring a patent initiative.

In response, Amaral says to Mantri:

"Based on endogenous growth theory, one of those proposals is more likely to raise total factor productivity than result in pure capital deepening."

Although Mantri recognizes that India lacks the significant natural resources that Brazil has, she states that India can overcome this challenge by bolstering long-term growth through three channels:

- Channel 1 Deepening the capital base
- Channel 2 Making investments in technology
- Channel 3 Maintaining a low rupee exchange rate

Each country's basic economic statistics were presented at the conference. Selected data for Brazil and India are presented in Exhibit 1. Adama Kanté, a fund manager based in Mali, is planning to increase the fund's allocation to international equities and, after some preliminary analysis, has determined the new allocation will be to Brazilian or Indian equities. After reviewing the data in Exhibit 1, Kanté decides that the allocation will be to Indian equities.

Exhibit 1: Economic Statistics for Brazil and India

Economic Statistic	Brazil	India
GDP per capita, 2018	\$14,360	\$6,999
GDP per capita growth, 2000–2018	1.3%	5.8%
GDP growth, 2005–2018	2.0%	7.2%
- Growth resulting from labor productivity component	1.3%	6.3%
- Growth resulting from capital deepening component	1.9%	4.5%

Kanté is concerned about the low standard of living in Mali and its large informal sector. To improve per capita GDP, Kanté is considering five specific strategies:

- Strategy 1 Lower the country's tax rate.
- Strategy 2 Introduce policies that encourage the return of highly educated Malian emigrants.
- Strategy 3 Build daycare centers to increase women's participation in the workforce.

- | | |
|------------|--|
| Strategy 4 | Impose high tariffs on imports to protect the country's nascent industries. |
| Strategy 5 | Use economic development bank loans to improve the country's transport and manufacturing infrastructure. |

10. Which of Amaral's initiatives is *least likely* to achieve his stated growth objective?
 - A. Dividend tax
 - B. Rural literacy
 - C. Property rights

11. Which proposal for India is Amaral *most likely* referring to in his response to Mantri?
 - A. Patent initiative
 - B. Highway network
 - C. Auto and textile factories

12. The channel that is *least likely* to help India overcome its challenge of lacking significant natural resources is:
 - A. Channel 1.
 - B. Channel 2.
 - C. Channel 3.

13. Based on Exhibit 1, which Indian economic statistic *least likely* supports Kanté's international equity allocation preference?
 - A. GDP per capita
 - B. Growth resulting from labor productivity
 - C. Growth resulting from capital deepening

14. The strategy that is *least likely* to improve per capita GDP in Mali is:
 - A. Strategy 1.
 - B. Strategy 2.
 - C. Strategy 3.

15. Which of the following strategies being considered by Kanté is *most likely* to undermine or delay convergence with developed economies?
 - A. Strategy 2
 - B. Strategy 4
 - C. Strategy 5

The following information relates to questions 16-21

Hans Schmidt, CFA, is a portfolio manager with a boutique investment firm that specializes in sovereign credit analysis. Schmidt's supervisor asks him to develop estimates for GDP growth for three countries. Information on the three countries is provided in Exhibit 1.

Exhibit 1: Select Economic Data for Countries A, B, and C

Country	Economy	Capital per Worker
A	Developed	High
B	Developed	High
C	Developing	Low

After gathering additional data on the three countries, Schmidt shares his findings with colleague, Sean O'Leary. After reviewing the data, O'Leary notes the following observations:

Observation 1: The stock market of Country A has appreciated considerably over the past several years. Also, the ratio of corporate profits to GDP for Country A has been trending upward over the past several years and is now well above its historical average.

Observation 2: The government of Country C is working hard to bridge the gap between its standard of living and that of developed countries. Currently, the rate of potential GDP growth in Country C is high.

Schmidt knows that a large part of the analysis of sovereign credit is to develop a thorough understanding of the potential GDP growth rate for a particular country and the region in which the country is located. Schmidt is also doing research on Country D for a client of the firm. Selected economic facts on Country D are provided in Exhibit 2.

Exhibit 2: Select Economic Facts for Country D

- Slow GDP Growth
- Abundant Natural Resources
- Developed Economic Institutions

Prior to wrapping up his research, Schmidt schedules a final meeting with O'Leary to see if he can provide any other pertinent information. O'Leary makes the following statements to Schmidt:

Statement 1: Many countries that have the same population growth rate, savings rate, and production function will have growth rates that converge over time.

Statement 2: Convergence between countries can occur more quickly if economies are open and there is free trade and international borrowing and lending; however, there is no permanent increase in the rate of growth in an economy from a more open trade policy.

16. Based on Exhibit 1, the factor that would *most likely* have the greatest positive

impact on the per capita GDP growth of Country A is:

- A. free trade.
 - B. technology.
 - C. saving and investment.
17. Based on Observation 1, in the long run the ratio of profits to GDP in Country A is *most likely* to:
- A. remain near its current level.
 - B. increase from its current level.
 - C. decrease from its current level.

18. Based on Observation 2, Country C is *most likely* to have:

- A. relatively low real asset returns.
- B. a relatively low real interest rate.
- C. a relatively high real interest rate.

19. Based on Exhibit 2, the *least likely* reason for the current pace of GDP growth in Country D is:

- A. a persistently strong currency.
- B. strong manufacturing exports.
- C. strong natural resource exports.

20. The type of convergence described by O'Leary in Statement 1 is *best* described as:

- A. club convergence.
- B. absolute convergence.
- C. conditional convergence.

21. Which of the following growth models is *most* consistent with O'Leary's Statement 2?

- A. Classical
 - B. Endogenous
 - C. Neoclassical
-

SOLUTIONS

1. C is correct. Country C is the most likely to be a developing economy. Political instability, limited property rights, and poor public education and health are all factors that limit economic growth and thereby contribute to a relatively low standard of living.
2. A is correct. The associate economist can measure the effect of pure capital deepening by measuring the difference of the growth rates of labor productivity and total factor productivity. The larger the difference, the more important capital deepening is as a source of economic growth. From 2000–2010, Country A's labor productivity grew by 2.4% per year, of which 0.6% came from TFP growth and 1.8% from capital deepening ($2.4\% - 0.6\% = 1.8\%$).
3. A is correct. In the long run, the GDP growth rate is the most important driver of stock market performance. Therefore, the associate economist should focus on the drivers of long-run potential GDP growth. The ratio of earnings to GDP cannot increase indefinitely because that would imply that profit would eventually absorb all of GDP. This ratio cannot shrink forever, either, because unprofitable companies will go out of business. Thus, the annualized growth rate of the earnings to GDP ratio must be approximately zero over long time horizons, and this ratio should not be a dominant factor in forecasting long-term stock market performance. Similarly, the price-to-earnings ratio cannot grow or contract at a finite rate forever because investors will not pay an excessive price for each dollar of earnings, nor will they give away earnings for free. Therefore the rate of change in the price-to-earnings ratio must be approximately zero over long time horizons and should not be a dominant factor in the forecast of long-term stock market performance.
4. A is correct. Credit rating agencies consider the growth rate of potential GDP when evaluating the credit risk of sovereign debt. The chief economist's expectation for lower potential GDP growth for Country B over the next decade increases the perceived credit risk of its sovereign bonds.
5. C is correct. The higher per capita output for Country A is most likely the result of differences in the cumulative impact of technological progress embodied in total factor productivity. Technological progress raises a country's productive capacity and causes an upward shift in the entire production function, resulting in higher output per worker for a given level of capital per worker.
6. A is correct. Demographic factors can positively or negatively contribute to a country's sustainable rate of economic growth. After the next 10 years, Country A is expected to experience a growing share of the population over the age of 65 and a declining percentage of the population under the age of 16. All else the same, this implies slower growth of the labor force and hence slower growth of potential GDP. Immigration could offset these demographic challenges. However, Statement 3 indicates that Country A is expected to experience minimal immigration.
7. A is correct. Country C is an example of a country endowed with an abundant natural resource yet experiencing slow economic growth. Although labor force growth is an important source of economic growth, it is the least likely explanation of the sluggish economic growth in Country C. As shown in Exhibit 1, growth in total hours worked has accounted for most of Country C's growth. Furthermore, export driven currency appreciation and poorly developed economic

institutions are both likely causes of sluggish growth in countries with abundant natural resources.

8. B is correct. Population growth can increase the growth rate of the overall economy but does not affect the rate of increase in *per capita* GDP. Therefore, population growth does not explain Country A's higher rate of per capita income growth. An increase in labor force participation could, however, raise the growth rate of per capita GDP.
9. A is correct. Klymchuk is referring to the concept of club convergence. The basic premise is that lower-income members of the club are converging to the income levels of the richest countries. This implies that the countries with the lowest per capita income in the club grow at the fastest rate. Countries outside the club, however, continue to fall behind.
10. A is correct. Amaral's initiative to implement a new dividend tax is likely to impede inflows of equity capital by making equity investment in Brazil less attractive for foreign investors. Capital flows, or lack thereof, have a major impact on economic growth because, in an open economy, world savings can finance domestic investment. As a potential source of funds, foreign investment breaks the vicious cycle of low income, low domestic savings, and low investment.
11. A is correct. Mantri's proposal to sponsor a patent initiative, which is likely to result in technology investment and improvement, is likely to cause a proportional upward shift in the entire production function, allowing the economy to produce higher output per worker for a given level of capital per worker. Technological progress also increases the marginal product of capital relative to its marginal cost.
12. C is correct. Maintaining a low currency exchange rate is a policy aimed at maintaining demand for the country's exports. It would have little direct impact on the potential growth rate of aggregate supply. It might boost long-term capacity growth indirectly, however, by encouraging adoption of leading edge technology. Nonetheless, it would not be expected to be as powerful as capital deepening and/or investment in technology.
13. A is correct. Kante's decision to invest in equities in India is supported by the country's strong economic growth. For global investors, economic growth is important because equity composite valuations depend to a great extent on both the level of economic output (GDP per capita and GDP overall) and the rate of economic growth. Relative to Brazil, India's growth rate in per capita GDP has been much higher, and furthermore, the growth rate in GDP has also been much higher than that of Brazil. In contrast to the growth rate, the relatively low *level* of GDP per capita in India is less likely to indicate attractive equity investment opportunities. Low per capita GDP suggests that India may lack sufficient industrial and financial infrastructure to support some types of industries. It also indicates that domestic purchasing power is relatively limited, decreasing the potential for higher-margin, domestically oriented businesses.
14. A is correct. With Mali's low standard of living (i.e., GDP per capita and large informal workforce), the tax rate is unlikely to be an impediment to growth, so lowering the tax rate is not likely to be a major contributor to growth.
15. B is correct. The strategy for Mali to impose high tariffs (trade restrictions) on imports is likely to undermine rather than enhance growth and therefore is not supportive of convergence with developed economies. Freer trade (fewer trade restrictions) tends to enhance growth by, for example, inducing a shift of resourc-

es into industries in which the country has a comparative thereby increasing overall productivity; forcing less efficient domestic companies to exit and more efficient ones to innovate; allowing domestic producers to more fully exploit economies of scale by selling to a larger market; and enabling less advanced sectors of an economy to catch up with more-advanced countries or sectors through knowledge spillovers.

16. B is correct. Country A is a developed country with a high level of capital per worker. Technological progress and/or more intensive use of existing technology can help developed countries increase productivity and thereby increase per capita GDP. Most developed countries have reasonably low trade barriers; thus, somewhat freer trade is likely to have only an incremental, and probably transitory, impact on per capita GDP growth. Also, because the country already has a high capital-to-labor ratio, increased saving/investment is unlikely to increase the growth rate substantially unless it embodies improved technology.
17. C is correct. The ratio of profits to GDP for Country A has been trending upward over the past several years and is now well above its historical average. The ratio of profits to GDP cannot rise forever. At some point, stagnant labor income would make workers unwilling to work without an increase in wages and would also undermine demand, making further expansion of profit margins unsustainable. Thus, the ratio of profits to GDP will likely decline in the long run toward its historical average.
18. C is correct. A high growth rate of potential GDP would cause real incomes to rise more rapidly and also translate into higher real interest rates and higher expected/required real asset returns. The real interest rate is essentially the real return that consumers/savers demand in exchange for postponing consumption. Faster growth in potential GDP means that consumers expect their real income to rise more rapidly. This implies that an extra unit of future income/consumption is less valuable than it would be if income were expected to grow more slowly. All else the same, the real interest rate will have to be relatively high in order to induce the savings required to fund required/desired capital accumulation.
19. B is correct. Country D is a country with abundant resources and has developed the economic institutions necessary for growth, yet the country is experiencing slow economic growth. It is likely that Country D is experiencing the Dutch Disease, whereby currency appreciation driven by strong export demand for natural resources makes other segments of the economy, in particular manufacturing, globally uncompetitive. Strong manufacturing exports indicate that Country D is globally competitive and likely to have adopted leading edge technology. Thus, it is unlikely that the slow growth reflects inability to maintain productivity growth. Similarly, strong exports suggest adequate demand for its products. Thus, strong exports are unlikely to be the cause of slow growth.
20. C is correct. Conditional convergence means that convergence is conditional on the countries having the same savings rate, population growth rate, and production function. If these conditions hold, the neoclassical model implies convergence to the same *level* of per capita output as well as the same steady-state growth rate.
21. C is correct. According to the neoclassical model, convergence should occur more quickly if economies are open and there is free trade and international borrowing and lending. Opening up the economy should increase the rate at which the capital-to-labor ratio converges among countries. In the neoclassical Solow model, however, after the reallocation of world savings, there is no permanent increase in the rate of growth in an economy. Both the developed and developing

countries eventually grow at the same steady-state rate.

