ECON 1550 Course Notes

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Chapter I

Models in Economics

1 Models in Economics

"Economists do it with models"

Old Keynesian proverb

A model is a set of equations with economic meaning attached to them. It is important to realize that all models are wrong. Because models are not reality itself, any model we write down will always omit some aspect of reality. Once an element of reality is omitted, it is always possible to find predictions of the model that are at odds with the real world, which means that every model is wrong. Indeed, economic models omit *most* elements of reality, so they are often demonstrably at odds with many empirical observations.

Even though all models are wrong, some models are useful. Models have many uses, including differentiating causal from non-causal effects, allowing counterfactual analysis, rationalizing past economic outcomes, providing forecasts, evaluating the social welfare costs and benefits of policy, clarifying assumptions behind economic statements, and giving insight into specific mechanisms otherwise obscured by confounding effects. Many (perhaps most) economists evaluate models based on their usefulness rather than their correctness or accuracy. The choice of what elements from the real world to omit in a model is just as important as the elements that are included. A substantial source of disagreement among economists is, at its core, a disagreement about whether elements of the real world that were omitted by a model are important for the question under consideration and should instead be included.

Takeaway
All models are wrong, some models are useful.

1.1 Types of Equations

The models that we study in this course have three types of equations:

- **Identities** hold by definition or construction. For example, disposable income is defined by $Y_D \equiv Y - T$ where Y is income and T represents taxes. When an equation defines a variable, we use the symbol "$\equiv$" rather than a regular equal sign. Another kind of identity is an accounting identity, an equality that must be true regardless of the value of its variables by virtue of how the variables are defined or constructed. The national income identity

  $$\text{GDP} = \text{consumption} + \text{investment} + \text{government spending} + \text{exports} - \text{imports},$$

  is an accounting identity. Although none of the variables are defined by the accounting identity, the identity always holds (the equality is always true) because of the way in which all the variables are defined. When consumption increases by \$1 and investment, government spending, exports, and imports remain the same, then GDP will always also be measured as having increased by \$1. Another accounting identity is the balance sheet relation that

  $$\text{assets} = \text{liabilities} + \text{equity}.$$

- **Behavioral equations** are assumptions that capture some aspect of behavior that we include in a model. For example, a model can postulate that consumers behave so that aggregate consumption is one-half of disposable income. The behavioral equation that captures this behavior is $C = 0.5Y_D$. Behavioral equations hold by assumption and are the equations that distinguish one model from the next.

- **Equilibrium conditions** describe the relationship that must hold between variables in a model when economic forces are balanced. The main equilibrium condition that we will encounter is the condition that supply equals demand. For example, if money demand is assumed to be a function $L(\cdot)$ of the nominal interest rate i, and money supply is assumed to be equal to a constant level M^s, the equilibrium condition that money supply equals money demand is $L(i) = M^s$.

1.2 Types of Variables

All models in economics have two types of variables:

- **Endogenous variables** are variables explained within the model.
- **Exogenous variables** are variables that are taken as given. The behavior and value of exogenous variables are not explained by the model.

Exogenous variables are the inputs that we provide to the model, while endogenous variables are the outputs produced by the model.

The way we use models is by looking at how endogenous variables change when we decide to change the value of one or more exogenous variables. We are not allowed to decide on the value of endogenous variables, or to change their value "by hand" or "by assumption". Only the equations of the model can determine the value of endogenous variables.

Given a set of equations that comprise a model, it is not possible to tell just by looking at the equations which variables are endogenous and which variables are exogenous. A model must include, together with its equations, a list of which variables are endogenous and which variables are exogenous. Whether a variable is endogenous or exogenous is part of the "economic meaning we attach to equations" that was mentioned in the very first sentence of Section 1.

To **solve a model** is to write all endogenous variables only in terms of exogenous variables. To **solve for an endogenous variable** means writing that particular endogenous variable in terms of exogenous variables.

Parameters

We sometimes call certain exogenous variables **structural parameters**, or simply **parameters**. Parameters are exogenous variables that are **policy-independent** or **policy-invariant**, that is, do not change when government policy changes[1]. The exact meaning of policy-invariant can depend on the context or the model. For example, a variable that captures the overall productivity of the workforce is usually considered policy-independent in models of business cycles, but not in models of long-run growth.

Just as for endogenous and exogenous variables, there is no way to know just by looking at the equations of a model which of the exogenous variables are parameters. If a model has parameters, they must be identified separately. Specifying whether a variable is a parameter is not always relevant for the task at hand, in which case we don't need to waste time listing which of the variables are parameters.

Example 1.1. We build a simple model of consumption. The model has five variables: consumption denoted by C, taxes denoted by T, income denoted by Y, disposable income denoted by Y_D, and the marginal propensity to consume denoted by c_1. Taxes, income, and the marginal propensity to consume are exogenous. In addition to being exogenous, the marginal propensity to consume is assumed to be a parameter, whereas income and taxes are not. Consumption and disposable income are endogenous. We assume all variables are strictly positive and, in addition, that $c_1 < 1$. The model has two equations:

$$Y_D \equiv Y - T, \tag{1.1}$$

$$C = c_1 Y_D. \tag{1.2}$$

The first equation is an identity that defines Y_D. The second equation is a behavioral equation that describes consumer behavior. Consumers are assumed to consume a fixed fraction c_1 of their disposable income. This model has no equilibrium conditions.

[1]Economists – myself included! – sometimes consider parameters as a third type of variable (neither exogenous nor endogenous) but I am not sure I can explain why.

Let's now use the model to understand the effect of taxes on consumption. When taxes go up, disposable income goes down by definition. When consumers have a lower disposable income, they reduce consumption.

We cannot use this model to study the effect of consumption on taxes, since consumption is an endogenous variable. It does not make sense to start by saying "consider an increase in consumption" and then trace how the increase in consumption changes taxes. The reason is that taxes, being exogenous, cannot be explained within the model. Any changes in T must be postulated by us; T can only be changed for reasons outside the model. In addition, we cannot simply postulate that consumption increases as consumption is endogenous. If consumption increases, it must be because some change in exogenous variables induced the change.

Now we solve the model, that is, write the two endogenous variables, C and Y_D, only in terms of the exogenous variables Y, T, and c_1. Equation (1.1) already expresses Y_D only in terms of Y and T, so solving for Y_D is immediate. Plugging equation (1.1) into equation (1.2) gives C only in terms of Y, T, and c_1. Therefore, the model's solution is:

$$
\begin{aligned}
Y_D &= Y - T, \\
C &= c_1(Y - T).
\end{aligned}
$$

□

Example 1.2. Consider now a different model that has the same equations as the model in the previous example (equations (1.1) and (1.2)), the same five variables (C, T, Y, Y_D, c_1), but a different set of exogenous and endogenous variables. The exogenous variables of this new model are consumption, income, and the marginal propensity to consume. The endogenous variables are taxes and disposable income.

In this model, it *is* possible to study the effect of consumption on taxes, since consumption is exogenous and taxes are endogenous. Consider then an increase in consumption. Equation (1.2) then implies that the higher consumption leads to higher disposable income. In turn, equation (1.1) shows that, by definition, the higher disposable income is associated with lower taxes.

Let's think about this for a second. This model claims that an increase in consumption leads to an increase in disposable income. Wouldn't that be nice! Of course, this model makes no sense, which is the point: Even though this model has the exact same equations and variables as the model in the previous example, the economic interpretation is completely different because the choice of exogenous variables was different.

One implication is that if in the real world we observe that C and T always go up and down together, two economists using two different models can have a very different interpretation of what is going on in the economy. And they can disagree even if their two models have the exact same equations! □

Shocks

Many times, economists use the word shock to describe changes in exogenous variables. Usually, the term shock is reserved for changes that are unforeseen, unforeseeable, or random, but this is not always the case.

A more formal definition of **shocks** is that they are economically interpretable primitive exogenous forces that satisfy three characteristics:[2]

- They are not explained by past and present endogenous variables.
- They are uncorrelated with other shocks.
- They represent either unanticipated movements in other exogenous variables or news about future movements in exogenous variables.

A technology shock may be the sudden discovery of the steam engine. A tax shock might represent the passing of legislation resulting from a change in political power. The outbreak of COVID-19 can be considered a health shock.

[2]The definition is adapted from: Ramey, Valerie A. "Macroeconomic shocks and their propagation." Handbook of macroeconomics 2 (2016): 71-162.

Takeaway

Models include three types of equations

- Identities hold by construction
- Behavioral equations capture assumptions
- Equilibrium conditions balance economic forces as in supply equals demand

and two types of variables

- Endogenous variables are explained within the model
- Exogenous variables are what the model takes as given
  - Parameters are policy-invariant exogenous variables
  - Shocks are economically interpretable, unanticipated, exogenous variables

1.3 Dynamic Models

A model is **static** when it only characterizes endogenous variables at a given point in time. When a model specifies the evolution of endogenous variables over time, we say that it is **dynamic**.

The list of values that a variable takes over time is called a **path**. We use subscripts to index time. When we use **discrete time**, periods are indexed by non-negative integers $(0, 1, 2, ...)$. For example, if Y_t is output in period t, then $\{Y_0, Y_1, Y_2\}$ is the path of Y in a three-period model. One period can correspond to a day, a month, a quarter, a year, etc. Suppose GDP in three consecutive years is \$1 trillion, \$1.2 trillion, and \$1.4 trillion. The path of GDP is $\{1, 1.2, 1.4\}$.

We can also use **continuous time** and index time by a positive real number. For example, if time t is a real number in $[0, T]$, then a path for output is the collection of values of Y_t for all $t \in [0, T]$, sometimes also written as $\{Y_t\}_{t\in[0,T]}$ or $\{Y_t\}_{t=0}^{T}$. Just as we had to pick what one period means in discrete time, we have to pick units for continuous time. For example, if one unit of time is a year, our model with $t \in [0, T]$ and $T = 3$ encompasses three years. The value $Y_{0.5}$ is output after six months have passed.

When we specify the values of exogenous variables, we must now specify an entire path for each exogenous variable (one value for each time period) rather than a single value as we did before. Similarly, when we solve the model, we must solve for the entire path of each endogenous variable in terms of the paths of exogenous variables.

Takeaway

- Static models consider variables at a single point in time
- Dynamic models consider variables that evolve over time
  - The collection of values of a variable over time is called a path
  - Time can be discrete $t = 0, 1, 2, ...$ or continuous $t \in [0, T]$
  - When we solve a dynamic model, we write the paths of endogenous variables in terms of the paths of exogenous variables

Chapter II

Financial Assets

1 Financial Assets

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

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

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

  - *"pay one dollar a day until the end of this year"*,
  - *"pay one dollar a day until the end of this year if, and only if, the stock market went up the previous day"*,
  - *"on the day Greece defaults on its debt, pay one dollar, and pay nothing otherwise"*.

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

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

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

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

   - late by a single day, or
   - short by a single dollar.

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

A **financial liability** is a contractual obligation to deliver the payments associated with a financial asset. In the situation considered above, the seller has a financial liability corresponding to the legal obligation to make the payments promised by the financial asset it created.

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

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

Payoffs can be cash payments in dollars or in other foreign currencies, deliveries of commodities such as gold, oil, or soybean, and even transfers of other financial assets. Therefore, when talking about financial assets, we often use the word **payoffs** rather than **payments** to highlight this generality, though both terms are largely interchangeable. When all payments are in dollars, they are usually referred to as **cash flows**.

Takeaway

- Financial assets are legal contracts defined by their payoffs.

1.1 Bonds

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

What distinguishes bonds from other types of financial assets—what makes a bond a *bond*—is that the amount and timing of the promised payoffs are fixed at issuance. Absent default, the sizes and dates of the payoffs are thus known with certainty from the moment the bond is issued, and they never change throughout the bond's lifetime.

Zero-coupon bonds

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

Coupon bonds

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

In the bond of Figure 1.1(b), the first coupon is paid six months after issuance, and the

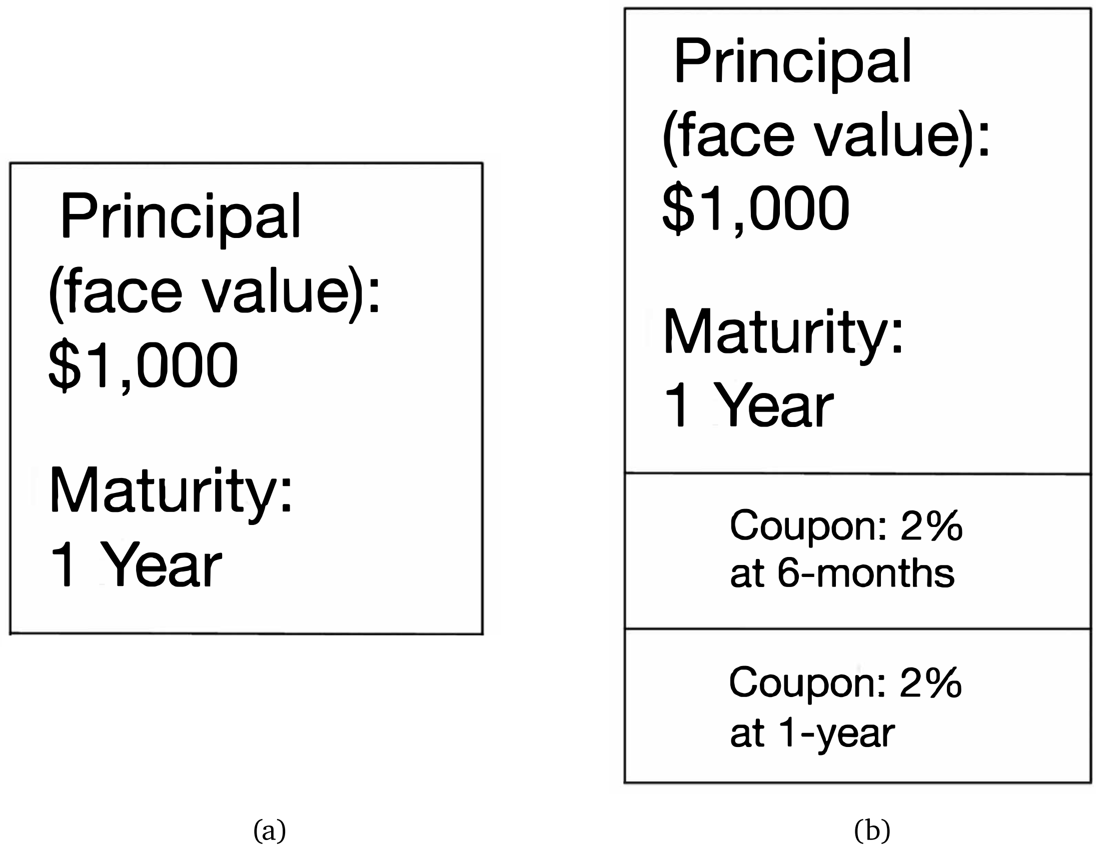

Figure 1.1: Panel (a) shows a one-year-maturity zero coupon bond with a principal of $1,000. This bond has a single fixed payment of $1,000 that occurs one year after the bond is issued.

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

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

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

Takeaway

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

Bond Prices

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

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

Bond Yields

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

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

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

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

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

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

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

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

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

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

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

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

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

It is always possible to translate interest rates that are annualized using continuous compounding to interest rates that are annualized by using period-by-period compounding. Both measure the same economic quantity in different units. Annualized yields using continuous and period-by-period compounding are numerically close to each other—and hence essentially interchangeable without converting units—when $R_t^{\text{annualized}}$ is not too big (say, 10%-15% or less). In these notes, we use continuous compounding because calculations are easier.

Takeaway

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

Risk-free bonds

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

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

Price Risk

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

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

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

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

at $t+2$. The number 2 in front of R_{2t} is there because R_{2t} is expressed in annualized terms.

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

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

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

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

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

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

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

Takeaway

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

Bond Risk Premia

Equilibrium in Bond Markets Determines Risk Premia Investors do not like risk. If buying the two-year bond and rolling over the one-year bond twice had the same expected payoffs, investors would always prefer to buy the two-year bond. No one would want to hold the existing supply of one-year-maturity bonds, preventing the market for one-year bonds from being in equilibrium.

For the bond market to be in equilibrium, rolling over the one-year bond twice must have a

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

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

Mathematically, equilibrium in the bond market requires that

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

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

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

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

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

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

or

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

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

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

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

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

Takeaway

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

Nominal and Real Interest Rates

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

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

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

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

The real yield is the yield on a **real bond**, which has payments specified not in terms of dollars but in terms of the representative basket of goods and services of the economy. Investing an amount equal to one basket of goods in zero-coupon real bonds with maturity m at time t has a promised payoff of $(1+r_{mt})$ baskets of goods at $t+m$.

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

$$\begin{aligned} R_{mt} &= \frac{1}{m}\Big[(r_{1t}+\pi^e_{1t}) + (r^e_{1,t+1}+\pi^e_{1,t+1}) + \ldots + (r^e_{1,t+m-1}+\pi^e_{1,t+m-1}) + x_m\Big] \\ &= \frac{1}{m}\Big[(r_{1t}+r^e_{1,t+1}+\ldots+r^e_{1,t+m-1}) + (\pi^e_{1t}+\pi^e_{1,t+1}+\ldots+\pi^e_{1,t+m-1}) + x_m\Big]. \end{aligned}$$

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

1.2 Stocks

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

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

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

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

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

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Chapter III

Review of Intermediate Macro

1 A Closed Economy Model[1]

1.1 National Income Accounts

The measure of aggregate output in the national income accounts is **gross domestic product**, or GDP. We can measure GDP in three different but equivalent ways:

1. From the production side: GDP equals the value of the final goods and services produced in the economy during a given period. The important word here is final. We want to count only the production of final goods, not intermediate goods.

2. Also from the production side: GDP is the sum of value added in the economy during a given period. The value added by a firm is defined as the value of its production minus the value of the intermediate goods used in production.

3. From the income side: GDP is the sum of incomes in the economy during a given period.

The three ways to measure GDP give the same number.[2] We use Y to refer to GDP. Depending on the context, we refer to Y as output, production, value added, or income.

[1] This document based on Blanchard (2024).
[2] We ignore measurement error.

1.2 The Market for Goods and Services

Goods and Services

The economy produces many goods and services. We are only interested in aggregate production, so we construct a representative basket of goods and services and treat that basket as the single aggregate good in the economy. Output Y is the number of baskets of goods produced.

The Price Level

The price in dollars of one basket of goods is denoted by P. We refer to P as **the price level**.

Equilibrium in the Goods Market

Demand is given by:

$$Z \equiv C + I + G, \tag{1.1}$$

where Z is demand; C is aggregate consumption; I is investment in physical capital; and G is government spending.

Consumption C is an increasing function of **disposable income** $Y_D \equiv Y - T$:

$$C = C(\underset{(+)}{Y_D}), \tag{1.2}$$

where Y is income and T are taxes. The plus sign below Y_D signifies that the function $C(Y_D)$ is increasing in Y_D. We note that we have abused notation in equation (3.8): the symbol C on the left-hand side is a number while the symbol C on the right-hand side is a function. We will use the same abuse of notation throughout.

Investment I is a decreasing function of the **real interest rate,** r and an increasing function of income Y:

$$I = I(\underset{(-)}{r}, \underset{(+)}{Y}).$$

From now on, we ignore the dependence of investment on Y and simply write:

$$I = I(\underset{(-)}{r}).$$

We highlight that investment I is *not* investment in financial assets. It is investment in *physical capital* such as machines and buildings. Similarly, when we use the word capital in this context, we always mean *physical* capital, not *financial* capital (money invested in some financial assets).

Using $C = C(Y - T)$ and $I = I(r)$ in equation (1.1) gives:

$$Z = C(Y - T) + I(r) + G, \tag{1.3}$$

so Z is an increasing function of Y and G and a decreasing function of T and r.

The **supply of goods** is simply domestic production Y.

The equilibrium condition in the goods market is that the supply goods Y equals the demand for goods Z. We can write this as:

$$\underbrace{Y}_{\text{supply}} = \underbrace{C(Y - T) + I(r) + G}_{\text{demand}}. \tag{1.4}$$

We think of this equation as determining the equilibrium level of Y given T and r and G.

Table 1.1 lists the exogenous variables of the model in alphabetical order. Table 1.2 lists the endogenous variables in alphabetical order, together with the equations that determine them.

Goods market: exogenous variables

Variable	Description
G	government spending
r	real interest rate
T	taxes

Table 1.1

Goods market: endogenous variables and equations

Variable	Description	Equation	Type of equation
C	consumption	$C = C(\underset{(+)}{Y_D})$	Behavioral
I	investment	$I = I(\underset{(-)}{r})$	Behavioral
Y	income, production	$Y = C + I + G$	Equilibrium condition
Y_D	disposable income	$Y_D \equiv Y - T$	Identity
Z	demand for goods	$Z \equiv C + I + G$	Identity

Table 1.2

Example 1.1. We use the following functions:

$$C(Y - T) = 1 + \frac{1}{2}(Y - T), \tag{1.5}$$

$$I(r) = 2 - r. \tag{1.6}$$

Our goal is to solve the model, that is, express all endogenous variables in terms of exogenous variables only.

Plugging equations (1.5) and (1.6) into equation (3.3) gives:

$$Y = \underbrace{1 + \frac{1}{2}(Y - T)}_{C(Y-T)} + \underbrace{2 - r}_{I(r)} + G.$$

Solving for Y gives Y in terms of exogenous variables:

$$Y = \frac{1}{1 - \frac{1}{2}}\left(1 + 2 - \frac{1}{2}T - r + G\right) = 2\left(3 - \frac{1}{2}T - r + G\right). \tag{1.7}$$

The rest of the endogenous variables can be found by plugging in equation (1.7) into the equations from Table 1.2. □

Saving

Private saving, denoted by S^p is defined as the part of disposable income that is saved rather than consumed:

$$S^p \equiv Y_D - C.$$

Government saving, denoted S^g is defined similarly to private saving. The government's "income" is its tax revenue, T while its "consumption" is government spending:

$$S^g \equiv T - G.$$

National saving, sometimes called aggregate saving or just **saving**, is denoted by S and defined by:

$$S \equiv S^p + S^g.$$

The two types of saving we have defined, private and government, add up to national saving, denoted by S

$$S = S^p + S^g.$$

Using equation (3.3) and the equations for saving above, we get

$$I = S. \tag{1.8}$$

In a closed economy investment is always equal to saving. Equation (1.8) is where the name "IS" of the IS curve comes from.

The government's **budget deficit** is defined as $G - T$ which also equals the negative of government saving $G - T = -S^g$. Using the equations for saving given above, equation (1.8) can be written as:

$$S^p = I + (G - T). \tag{1.9}$$

Equation (1.9) states that private saving can take one of two forms: investment in physical capital I and purchases of government debt $G - T$. Investing in physical capital is saving because it involves foregoing some consumption today (equal to the amount invested) in order to have more consumption in the future (equal to the additional consumption that can be produced in the future with the additional physical capital).

When the budget deficit is positive the government is spending more than its income because $G > T$. Where does it get the difference? It gets it by borrowing from the private sector using government bonds. The private sector purchases the government bonds today, and the government repays bondholders in the future. Thus, budget deficits act as saving for the private sector, who consumes less today in order to have resources to buy government bonds, in exchange for higher future consumption when bonds pay out.

1.3 The Money Market

Real money demand is denoted by M^d/P. We assume the real money demand is given by:

$$\frac{M^d}{P} = \mathcal{L}(\underset{(-)}{i}, \underset{(+)}{Y}),$$

where $\mathcal{L}$ is a function that is decreasing in the **nominal interest rate** i (indicated by the minus sign below the i), and increasing in income Y (indicated by the plus sign under the Y). The **real money supply** is denoted by M^s/P.

The equilibrium level of real money, also called the **real money stock**, or the **real money balance**, is denoted by M/P. The real money stock is determined by the equilibrium condition in the money market that real money supply is equal to real money demand, $M^s/P = M^d/P$:

$$\frac{M^s}{P} = \mathcal{L}(i, Y). \tag{1.10}$$

Two models for the money market

We consider two different models for the money market. The money demand function $M^d/P = \mathcal{L}(i, Y)$ and the equilibrium condition $M^s/P = M^d/P$ are the same in both models. What differs is how the central bank behaves. Table 1.3 summarizes the two models, which are presented in more detail next.

Money market: two models

Model	Exogenous variable	Endogenous variable	Money market equilibrium
1	M^s	i	$M^s/P = \mathcal{L}(i,Y)$ determines i
2	i	M^s	$M^s/P = \mathcal{L}(i,Y)$ determines M^s/P

Table 1.3

Model 1: Exogenous money supply In this model, we assume that the real money supply M^s/P is exogenous while the nominal interest rate i is endogenous. We interpret this model as the central bank picking the money supply. The equilibrium condition $M^s/P = M^d/P$ determines the endogenous money demand and the behavioral equation $M^d/P = \mathcal{L}(i,Y)$ then determines the nominal interest rate.

This model is sometimes called the "old LM" or "classical LM" model. The idea is that the central bank's defining property is the ability to "print money". When the central bank prints money and uses it to buy bonds, money supply increases. In equilibrium, money demand must equal money supply, so money demand must increase. For money demand to increase, the nominal interest rate must go down so that people find bonds less attractive, prompting them to sell bonds in exchange for money. In the new equilibrium, the central bank holds more bonds, and the private sector holds more money.

Table 1.4 lists the exogenous variables for model 1. Table 1.5 lists the endogenous variables for model 1, together with the equations that determine them.

Money market Model 1: exogenous variables

Variable	Description
M^s/P	real money supply
Y	income

Table 1.4

Money market Model 1: endogenous variables and equations

Variable	Description	Equation	Type of equation
M^d/P	real money demand	$M^d/P = \mathcal{L}(\underset{(-)}{i}, \underset{(+)}{Y})$	Behavioral
i	nominal interest rate	$M^s/P = M^d/P$	Equilibrium condition

Table 1.5

Model 2: Exogenous nominal interest rate This model assumes that the nominal interest rate i is the exogenous variable, while the real money supply is determined endogenously. Now, instead of picking the real money supply, the central bank picks the nominal interest. Given the exogenous nominal interest rate i and the exogenous level of income Y; the real money demand is determined by $M^d/P = \mathcal{L}(i, Y)$. The real money supply is then determined by the equilibrium condition $M^s/P = M^d/P$.

This model is sometimes called the "new LM" model. Just as in Model 1, this model also takes into account the central bank's ability to print money. However, it also recognizes that the central bank has a monopoly on money creation, which allows it to pick not only the quantity of money (the money supply) but also the price of money (the nominal interest rate). Operationally, the way that the central bank "picks" the nominal interest rate is by allowing people to deposit money in central bank accounts—in the same way that you deposit money in your own checking account at your bank—that earn the interest rate chosen by the central bank. The central bank can pay any interest it chooses, since it can always print any amount of money needed to do so.

Table 1.6 lists the exogenous variables for model 2. Table 1.7 lists the endogenous variables for model 2, together with the equations that determine them.

Example 1.2. We use the following function for $\mathcal{L}$:

$$\mathcal{L}(i, Y) = 2 + Y - 0.2i. \tag{1.11}$$

The goal is to solve both money market models, that is, to express all the endogenous

Money market Model 2: exogenous variables

Variable	Description
i	nominal interest rate
P	price level
Y	income

Table 1.6

Money market Model 2: endogenous variables and equations

Variable	Description	Equation	Type of equation
M^d/P	real money demand	$M^d/P = \mathcal{L}(\underset{(-)}{i}, \underset{(+)}{Y})$	Behavioral
M^s/P	real money supply	$M^s/P = M^d/P$	Equilibrium condition

Table 1.7

variables in terms of exogenous variables only.

Model 1 The equilibrium condition for the money market is that real money demand M^d/P equals real money supply M^s/P. Since real money supply is exogenous, and $M^d/P = M^s/P$ already expresses money demand only as a function of exogenous variables.

Now we find i in terms of exogenous variables. Plugging equation (1.11) into equation (1.10) gives:

$$\frac{M^s}{P} = 2 + Y - 0.2i.$$

Solving for i gives:

$$i = 10 - 5\frac{M^s}{P} + 5Y. \tag{1.12}$$

Model 2 Now the nominal interest rate is exogenous. Real money demand in terms of exogenous variables is immediately given by $M^d/P = \mathcal{L}(i, Y) = 2 + Y - 0.2i$. Equating this real money demand to real money supply gives

$$\frac{M^s}{P} = 2 + Y - 0.2i,$$

which expresses the real money supply as a function of exogenous variables only. □

1.4 The IS-LM Model

The Expected Price Level

The **expected price level** denoted by P^e is the price level that we expect will prevail in some future period. You can think of it as our best guess of what the actual price level will be once we get to that future period. For example, let's use t to denote the current period (the present). In the current period, the price level is P_t. This current price level P_t is known at time t since we construct it by looking at currently available prices. The next period $t + 1$ is in the future. The actual or **realized** price level P_{t+1} that will prevail at $t + 1$ is not known at t. The future price level P_{t+1} will only be known at $t + 1$. However, in the present (at time t), we do have some expectations of what P_{t+1} will be, which is the expected price level P^e_{t+1}. We form these expectations at time t. Therefore, unlike the realized future price level P_{t+1}; the future expected price level is known in the present, at time t.

1.5 Inflation

Inflation denoted by π is the percentage change in the price level P over some period:

$$\pi_t \equiv \frac{P_t}{P_{t-1}} - 1. \tag{1.13}$$

For example, if the period t is the year 2025 and the period $t-1$ is the year 2024; π_t is the inflation rate in 2025, the percentage change in the price level between 2024 and 2025.

Expected inflation denoted by π^e is the expected percentage change in the price level over some period that is, at least in part, in the future. For example, if t is the current period, expected inflation for the period $t+1$ is:

$$\pi^e_{t+1} = \frac{P^e_{t+1}}{P_t} - 1, \tag{1.14}$$

and expected inflation for $t+2$ is:

$$\pi^e_{t+2} = \frac{P^e_{t+2}}{P^e_{t+1}} - 1.$$

We follow the convention that whenever we omit the time index subscript for a variable, then that variable corresponds to the current period. For example, if t is the current period, then π and π_t both denote inflation in the current period. We also follow the convention that whenever we omit the time index subscript for the expectation of a variable, the expectation is about the value of the variable in the next period. For example, if t is the current period, then π^e is the same as π^e_{t+1}. When necessary, we disambiguate by just stating in words what period is the current one, and what future period expectations refer to.

The Fisher Equation

The real interest rate r and the nominal interest rate i are related by:

$$r = i - \pi^e, \tag{1.15}$$

where π^e is expected inflation. Equation (1.15) is called the **Fisher equation**.

The IS Curve

Plugging the Fisher equation (1.15) into the equilibrium condition for the goods market in equation (3.3) gives the **IS relation**:

$$Y = C(Y - T) + I(i - \pi^e) + G. \tag{1.16}$$

The **IS curve** is the set of points (Y, i) that satisfy equation (1.16) when we plot them with values of Y in the horizontal axis and values of i in the vertical axis. Figure 1.1 shows a generic IS curve. The IS curve is always downward sloping. Despite its name, the IS curve is not necessarily curve and can certainly be a (downward sloping) straight line.

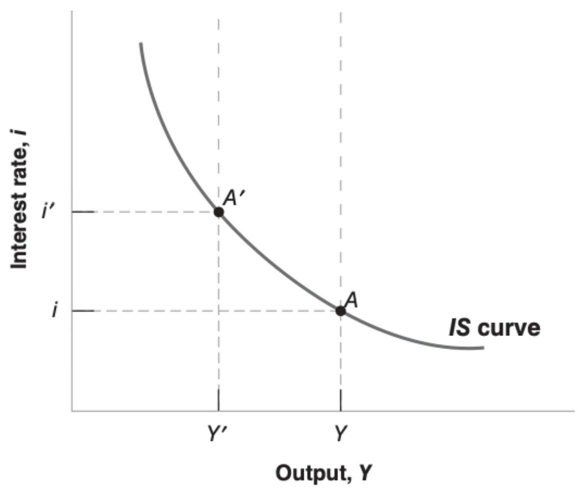


Figure 1.1: The IS curve

Example 1.3. The goal is to derive the IS curve. Using equation (1.7) and the Fisher equation, we get:

$$Y = 2\left(3 - \frac{1}{2}T - i + \pi^e + G\right).$$

Solving for i gives:

$$i = \underbrace{3 - \frac{1}{2}T + \pi^e + G}_{\text{intercept}} + \underbrace{\left(-\frac{1}{2}\right)}_{\text{slope}} Y, \tag{1.17}$$

which we recognize as the equation for a line with intercept $3 - \frac{1}{2}T + \pi^e + G$ and slope $-1/2$. The slope of this line is negative. We note that the only reason to solve for i explicitly is to make plotting the IS curve easier. We still think of the IS as determining Y for given values of i and of all other exogenous variables. When T or π^e or G change, the intercept of the IS changes. In this case, we say the IS shifts. If the intercept goes down, the IS shifts to the left; if the intercept goes up, the IS shifts to the right. We say the IS shifts left and right, rather than up and down, because we are thinking of how Y changes for given values of i (and a given value of i is a horizontal line, so higher or lower Y for that given value of i is the same as moving left or right along that horizontal line). $\square$

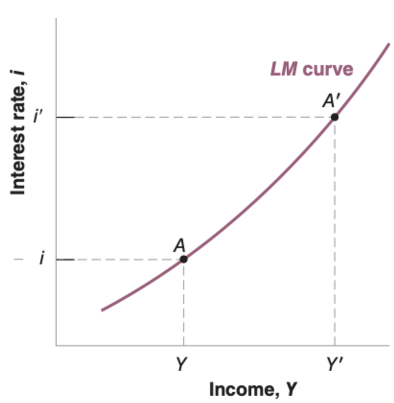
The LM Curve

Equation (1.10) is called the **LM relation** (where the L is for "liquidity" and the M is for "money").

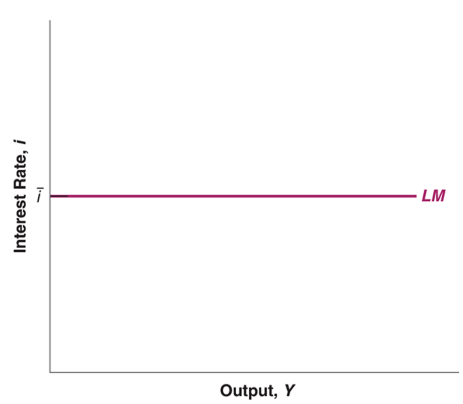
The **LM curve** is the set of points (Y, i) that satisfy equation (1.10) when we plot them with values of Y in the horizontal axis and values of i in the vertical axis. Despite its name, the LM curve is not necessarily curve and can certainly be a straight line.

In model 1, the LM curve is upward sloping because an increase in Y increases money demand and, with M^s exogenous, equilibrium requires a higher i. Figure 1.2(a) shows a generic upward sloping model 1 LM curve.

In model 2, the LM curve is a horizontal line because i is exogenous, and hence does not change with Y. Figure 1.2(b) shows a model 2 flat LM curve.



(a) Model 1: Upward sloping



(b) Model 2: Flat

Figure 1.2: The LM curve

Example 1.4. The goal is to derive the LM curve.

Model 1 If we use the function L from equation (1.11), we already found in the last section that:

$$i = \underbrace{10 - 5\frac{M^s}{P}}_{\text{intercept}} + \underbrace{5}_{\text{slope}} Y, \tag{1.18}$$

which we recognize as the equation for a line with intercept $(10 - 5M^s/P)$ and slope 5. When any of M^s or P change, the intercept of the LM changes. In this case, we say the LM shifts. If the intercept goes up, the LM shifts up; if the intercept goes down, the LM shifts down. We say the LM shifts up and down, rather than left and right, because we are thinking of how i changes for given values of Y.

Model 2 The equation for the LM curve is

$$i = \bar{\imath}, \tag{1.19}$$

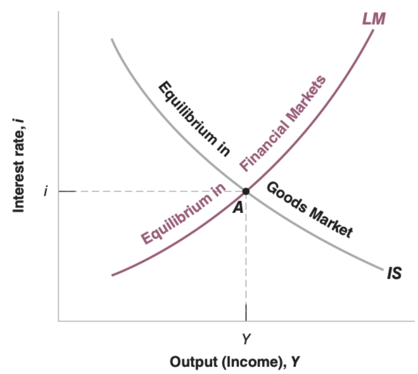
where $\bar{\imath}$ is the exogenous level of the nominal interest rate. □

Combining IS and LM

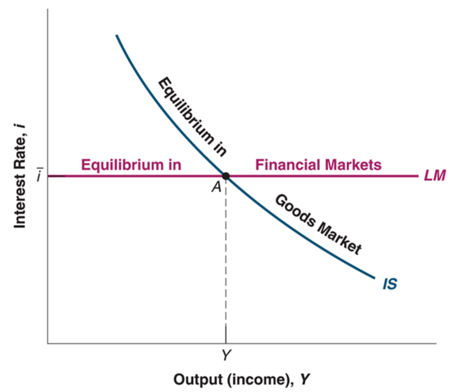
Points in the IS curve are combinations of Y and i that are consistent with equilibrium in the goods market. Points in the LM curve are combinations of Y and i that are consistent with equilibrium in the money market. The unique pair (Y, i) at the intersection of the IS and LM curves are therefore the values of Y and i that are consistent with equilibria in both the goods and money markets. Figure 1.3(a) shows the IS and LM curves together in one graph for model 1, and Figure 1.3(b) shows the same for model 2.

Just as we thought of the IS as determining Y given i and of the LM as determining i given Y. We now think of Y and i as being jointly determined by the IS and the LM—that is, by equilibrium in both the goods and money markets.

Table 1.8 lists the exogenous variables of the IS-LM model for model 1 in Table 1.3. Table 1.9 lists the endogenous variables for model 1, together with the equations that determine them.



(a) Model 1



(b) Model 2

Figure 1.3: IS-LM equilibrium

Tables 1.10 and 1.11 show the same but for model 2.

IS-LM Model 1: exogenous variables

Variable	Description
G	government spending
M^s/P	real money supply
T	taxes
π^e	expected inflation

Table 1.8

Example 1.5. **Model 1.** We start with the IS from equation (1.17) and the LM from equation (1.18):

$$\text{IS curve: } i = 3 - \frac{1}{2}T + \pi^e + G - \frac{1}{2}Y, \tag{1.20}$$

$$\text{LM curve: } i = 10 - 5\frac{M^s}{P} + 5Y. \tag{1.21}$$

We now find the equilibrium values of i and Y: that is, the values of i and Y at the intersection of the IS and the LM curves. First, equate the right-hand side of equation (1.20) to the right

IS-LM Model 1: endogenous variables and equations

Variable	Description	Equation	Type of equation
C	consumption	$C = C(\underset{(+)}{Y - T})$	Behavioral
i	nominal interest rate	$M^s/P = M^d/P$	Equilibrium condition
I	investment	$I = I(\underset{(-)}{i - \pi^e})$	Behavioral
M^d/P	real money demand	$M^d/P = \mathcal{L}(\underset{(-)}{i}, \underset{(+)}{Y})$	Behavioral
r	real interest rate	$r = i - \pi^e$	Identity
Y	income, production	$Y = C + I + G$	Equilibrium condition

Table 1.9

IS-LM Model 2: exogenous variables

Variable	Description
G	government spending
M^s/P	real money supply
T	taxes
π^e	expected inflation

Table 1.10

IS-LM Model 2: endogenous variables and equations

Variable	Description	Equation	Type of equation
C	consumption	$C = C(\underset{(+)}{Y - T})$	Behavioral
i	nominal interest rate	$M^s/P = M^d/P$	Equilibrium condition
I	investment	$I = I(\underset{(-)}{i - \pi^e})$	Behavioral
M^d/P	real money demand	$M^d/P = \mathcal{L}(\underset{(-)}{i}, \underset{(+)}{Y})$	Behavioral
r	real interest rate	$r = i - \pi^e$	Identity
Y	income, production	$Y = C + I + G$	Equilibrium condition

Table 1.11

hand side of equation (1.21):

$$3 - \frac{1}{2}T + \pi^e + G - \frac{1}{2}Y = 10 - 5\frac{M^s}{P} + 5Y.$$

Second, solve for Y to get:

$$Y = -\frac{14}{11} + \frac{10}{11}\frac{M^s}{P} - \frac{1}{11}T + \frac{2}{11}\pi^e + \frac{2}{11}G. \tag{1.22}$$

Last, plug Y into equation (1.20) or equation (1.21) and re-arrange to get the equilibrium value of i:

$$i = \frac{5}{11}\left(8 - \frac{M^s}{P} - T + 2\pi^e + 2G\right). \tag{1.23}$$

Model 2. The IS is the same as in model 1. The LM given in equation (1.19):

$$\text{IS curve: } i = 3 - \frac{1}{2}T + \pi^e + G - \frac{1}{2}Y, \tag{1.24}$$

$$\text{LM curve: } i = \bar{\imath}. \tag{1.25}$$

The equilibrium nominal interest rate is already expressed in terms of the exogenous variable $\bar{\imath}$. Plugging $i = \bar{\imath}$ into the IS curve and solving for Y gives Y in terms of exogenous variables only:

$$Y = 6 - T + 2\pi^e + 2G - 2i.$$

□

1.6 The Labor Market

Unemployment

Let L be the economy's **workforce** or **labor force** and N be the number of people in the workforce who are employed. Then the **unemployment rate** is defined by:

$$u \equiv \frac{L - N}{L}. \tag{1.26}$$

Production Function

The only factor of production is labor[3]. The aggregate **production function** is:

$$Y = N. \tag{1.27}$$

Price-setting

Since the only factor of production is labor, the nominal marginal cost for firms producing goods and services is the **nominal wage** W. If markets were perfectly competitive, firms would set the price P equal to marginal cost W and make zero profits. In the real world, there is market power and firms tend to set prices above marginal cost. We capture this idea by the following **price-setting relation**:

$$P = (1 + m)W, \tag{1.28}$$

where m is the **markup**. This price setting relation says that firms set the price of the goods that they sell to always get a profit rate of m. To see that the markup m is equal to the

[3]This is not as restrictive as it sounds: we are assuming that labor is the only factor of production that adjusts within the time horizons we are considering and ignoring the other factors because they remain unchanged.

profit rate, start by defining the profit rate by

$$\frac{\text{profit}}{\text{cost of production}}.$$

Each unit sold costs W to produce and sells for P. The profit per unit is $P - W$. Hence the profit rate for one unit is

$$\frac{P-W}{W} = \frac{(1+m)W - W}{W} = m.$$

Selling more units raises profits (the numerator) and costs of production (the denominator) proportionally, leaving the profit *rate* unchanged.

There are many factors that can affect the markup, including:

- The cost of production. If the cost of production increases, producers may pass some or all of the cost increase to consumers in the form of higher markups. An important example is the price of oil. When the price of oil increases, costs of production increase even keeping the nominal wage constant.
- Monopoly power. If a firm's monopoly power increases, it can increase the price even keeping labor and other production costs unchanged. Many different channels can influence the degree of monopoly power. For example, making it more difficult for new firms to enter markets increases the monopoly power of incumbent firms. More stringent anti-trust regulation, in contrast, should reduce monopoly power.

Wage-setting

Wages are set according to the following **wage-setting relation**:

$$W = P^e F(\underset{(-)}{u}, \underset{(+)}{z}). \tag{1.29}$$

In this wage setting relation the variable P^e is the expected price level (the price level we expect to hold in the future). The variable u is the unemployment rate. The variable z is a catch-all variable that captures all other elements that influence wages other than P^e and u. The function F is decreasing in u and increasing in z. That the function F is increasing in z is just a convention. There are therefore three elements that determine the wage are

P^e and u and z. We briefly explain why they matter for wages:

- Expected price level. The expected price level P^e is an important determinant of the nominal wage because what people and firms really care about is not the nominal wage but the real wage. Workers value money because of the goods and services they can buy with it, not for its own sake. If my nominal wage is $1,000,000 but the price of one apple is $10,000,000, I am not so happy with my gigantic nominal wage. We use P^e rather than P because after wages are set, they usually remain fixed (or close to fixed) for some time, with wage contracts renegotiated only infrequently. So the relevant price level is the one that will prevail between now and the future time when the wage is renegotiated rather than just the current price level. goods and services that one can afford after W is set are better captured by W/P^e.

- Unemployment. The wage setting equation says that when unemployment is high, wages are low. The reasoning is that when unemployment is high, employers have more bargaining power, since someone seeking a job must compete with a larger pool of unemployed workers. Conversely, when the unemployment rate is low, it is workers who have higher bargaining power, as many firms have to compete to hire among the smaller pool of unemployed people. A conceptual weakness of the unemployment rate as an indicator of the relative bargaining power of workers and firms is that it is based solely on information about the status of workers (employed or unemployed) and does not directly incorporate information on the hiring needs of employers. But the labor market involves costly search by employers for workers as well as by workers for jobs. In principle at least, a given unemployment rate could be consistent with either a strong labor market, with upward pressure on wages, or a weak labor market and low wage pressure, depending on whether job openings are plentiful or scarce. An alternative indicator of bargaining power that takes into account the state of workers and of firms is the ratio of the **vacancy rate** (job listings reported by employers divided by the labor force) denoted by v to the unemployment rate u. The ratio v/u is called **labor market tightness**. However, the notion of labor market tightness is more general. In periods when firms want to hire a lot of workers, unemployment is relatively low, there is upward pressure on wages and many unfilled job vacancies, we say the labor market is **tight**. Conversely, when there are a lot of people looking for jobs, firms are not looking to hire as much, vacancies are filled quickly, and there is a downward pressure on wages, we say that the labor market is **slack**. Thus, conceptually, what we would really like to include in the wage-setting equation (1.2) is a good measure of overall labor market tightness rather than simply unemployment. Using v/u is one good option.

- Other factors. The other factors are defined so that the convention that F is increasing in z applies. Examples of factors that enter z are:
  - Unemployment insurance, the payment of unemployment benefits to workers who lose their jobs. If u and P^e are given then higher unemployment benefits make unemployment less painful, so employers must offer a higher wage to attract workers (in this case higher unemployment benefits are associated with a higher z).
  - The minimum wage. An increase in the minimum wage may increase not only the minimum wage itself, but also wages just above the minimum wage, leading to an increase in the economy-wide average wage W at a given unemployment rate.
  - Employment protection laws, which makes it more expensive for firms to lay off workers. Such a change is likely to increase the bargaining power of workers covered by this protection (laying them off and hiring other workers is now more costly for firms), increasing the wage for a given unemployment rate.
  - Worker's productivity. If workers can produce more output in the same amount of time, their labor is more valuable, which allows them to bid for higher wages.

Table 1.12 lists the exogenous variables of the labor market model. Table 1.13 lists the endogenous variables together with the equations that determine them.

Labor market: exogenous variables

Variable	Description
L	labor force
m	markup
P^e	expected price level
Y	production
z	catch-all variable for factors that affect the nominal wage

Table 1.12

Labor market: endogenous variables and equations

Variable	Description	Equation	Type of equation
N	employment	$Y = N$	Behavioral
P	price level	$P = (1+m)W$	Behavioral
u	unemployment rate	$u = \frac{L-N}{L}$	Identity
W	nominal wage	$W = P^e F(\underset{(-)}{u}, \underset{(+)}{z})$	Behavioral

Table 1.13

Example 1.6. One example for the function F is:

$$F(u,z) = 1 - \frac{1}{4}u + z. \tag{1.30}$$

The goal is to solve the model.

The production function (1.27) immediately gives N as a function of the exogenous Y. Combining equations (1.1) and (1.27) gives u in terms of exogenous variables only:

$$u = \frac{L-N}{L} = 1 - \frac{N}{L} = 1 - \frac{Y}{L}. \tag{1.31}$$

Plugging equation (1.31) into (1.30) gives:

$$F(Y,z) = 1 - \frac{1}{4}\left(1 - \frac{Y}{L}\right) + z. \tag{1.32}$$

Plugging equation (1.32) into equation (1.2) gives:

$$\frac{W}{P^e} = \frac{3}{4} + \frac{1}{4}\frac{Y}{L} + z.$$

Solving for W we get W in terms of exogenous variables only:

$$W = \left(\frac{3}{4} + \frac{1}{4}\frac{Y}{L} + z\right)P^e.$$

Last, plugging into equation (1.1) gives P in terms of exogenous variables only:

$$P = (1+m)\left(\frac{3}{4} + \frac{1}{4}\frac{Y}{L} + z\right)P^e.$$

□

1.7 The Phillips Curve

Aggregate Supply

Combining (1.1) and (1.2) gives:

$$P = (1+m)P^e F(u,z). \tag{1.33}$$

We can re-write equation (1.3) as a relation between P and Y instead of P and u. As in the last example, combining equations (1.1) and (1.27) gives equation (1.31). Equation (1.31) says that lower unemployment is associated with higher output because it takes more employed people to produce more output. Using (1.31) in (1.3) gives:

$$P = (1+m)P^e F\left(1 - \frac{Y}{L}, z\right). \tag{1.34}$$

Equation (1.34) is called the **aggregate supply relation**, or AS relation for short. We think of the AS relation as determining the price level P for a given value of Y.

Figure 1.4 shows a generic AS curve. Just like all the other "curves", the AS curve can be a straight line. The AS curve is always upward sloping. Changes in the markup m and the expected price level P^e and the labor force L and the catch-all variable z shift the AS curve up and down.

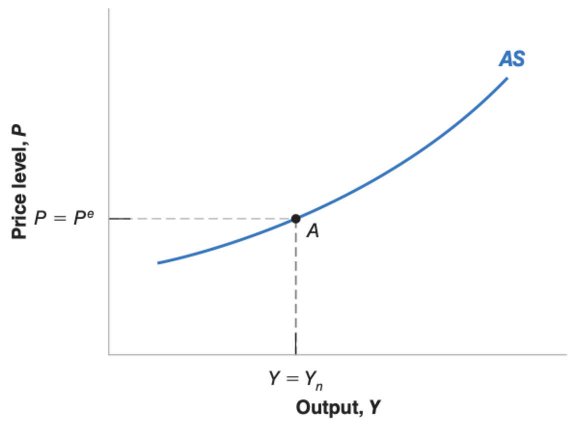


Figure 1.4: The AS curve

From now on, we assume a specific functional form for the function F:

$$F(u, z) = 1 - \alpha u + z, \tag{1.35}$$

where α is a positive parameter (a positive number taken as given). Plugging equation (1.31) into (1.35) gives:

$$F\left(1 - \frac{Y}{L}, z\right) = 1 - \alpha\left(1 - \frac{Y}{L}\right) + z. \tag{1.36}$$

Using equation (1.36) in equation (1.34) and re-arranging gives the AS curve:

$$P = \underbrace{(1+m)P^e(1 - \alpha + z)}_{\text{intercept}} + \underbrace{\frac{(1+m)P^e\alpha}{L}}_{\text{slope}} Y, \tag{1.37}$$

which we recognize as the equation of a line with intercept $(1+m)P^e(1-\alpha+z)$ and slope $(1+m)P^e\alpha/L$. When any of m or P^e or α or z change, the intercept of the AS curve changes and the AS shifts up and down.

Linearization

The definitions of inflation and expected inflation in equations (1.13) and (1.14) imply that

$$P_t = (1+\pi_t)P_{t-1},$$
$$P_t^e = (1+\pi_t^e)P_{t-1}.$$

Adding time subscripts to equation (1.37) and plugging in the last two equations gives:

$$1+\pi_t = (1+m)(1+\pi_t^e)\left(1+z-\alpha+\frac{\alpha}{L}Y_t\right). \tag{1.38}$$

Distributing the product and subtracting 1 from both sides, we get

$$\pi_t = \pi_t^e + m + z - \alpha\left(1-\frac{Y_t}{L}\right) + \text{second order terms}, \tag{1.39}$$

where the second order terms are terms with cross-products of π_t^e and m and $u_t = 1-Y_t/L$. Since π_t^e and m and u_t are relatively small numbers (say, between 0 and 0.2), their cross products are small enough to be ignored and still get a good approximation. Ignoring these second order terms gives the **Phillips curve**:

$$\pi_t = \pi_t^e + m + z - \alpha + \frac{\alpha}{L}Y_t. \tag{1.40}$$

Figure 1.5 shows a generic Phillips curve (PC for short), where the vertical axis plots $\pi_t - \pi_t^e$ and the horizontal axis plots Y_t. Just like all the other "curves", the PC curve can be a straight line. The PC curve is always upward sloping. The variables π_t^e and m and z and α shift the PC up and down, while α and L change the slope of the PC.

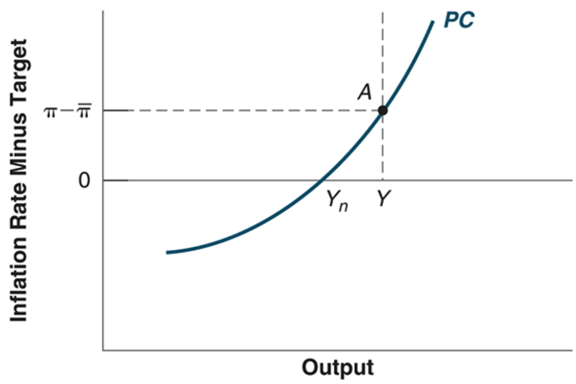


Figure 1.5: The Phillips curve

1.8 IS-LM-PC Model

The IS-LM-PC model combines equilibrium in the goods market (the IS relation), equilibrium in the money market (the LM relation), and equilibrium in the labor market (the Phillips curve, PC).

<u>The model</u>

Adding time subscripts, the IS relation in (1.16) becomes

$$Y_t = C(Y_t - T_t) + I(i_t - \pi_t^e) + G_t, \tag{1.41}$$

where we have used the Fisher equation (1.15) to write the real interest rate as $r_t = i_t - \pi_t^e$.

The LM relation in (1.10) with time subscripts becomes

$$\frac{M_t^s}{P_t} = \mathcal{L}(i_t, Y_t). \tag{1.42}$$

The PC in (1.40) remains unchanged.

Together with the definition of inflation in (1.13), equations (1.41), (1.42), and (1.40) determine the joint behavior of output Y_t and the nominal interest rate i_t and inflation π_t over time. Given an initial price level, the path of inflation can be used to infer the path of the price level P_t.

The natural rate of unemployment and potential output

The **natural rate of unemployment** denoted u^n is defined as the unemployment rate when inflation equals expected inflation, $\pi_t = \pi_t^e$. From (1.40) with $\pi_t = \pi_t^e$ we get

$$u^n \equiv \frac{m+z}{\alpha}. \tag{1.43}$$

The level of output when $\pi_t = \pi_t^e$ is called **potential output**, and is given by

$$Y^n \equiv L(1-u^n) = L\left(1 - \frac{m+z}{\alpha}\right). \tag{1.44}$$

The difference $u_t - u^n$ is called the **unemployment gap** and $Y_t - Y^n$ is called the **output gap**.

Using equations (1.43) and (1.44), we can rewrite the Phillips curve in gap form:

$$\pi_t - \pi_t^e = -\alpha(u_t - u^n), \tag{1.45}$$

or, using the output gap,

$$\pi_t - \pi_t^e = \frac{\alpha}{L}(Y_t - Y^n). \tag{1.46}$$

Equations (1.45) and (1.46) say that unemployment below its natural level and output above potential are associated with inflation above expected inflation.

Expected inflation

Thus far, expected inflation has been taken as exogenous. A behavioral equation that makes expected inflation endogenous—a model of expected inflation—is

$$\pi_t^e = (1-\theta)\bar{\pi} + \theta\pi_{t-1}, \tag{1.47}$$

where θ is a parameter between 0 and 1, and $\bar{\pi}$ is another parameter that we refer to as the **inflation target**. We say that inflation expectations are **anchored** when $\theta = 0$ and **deanchored** when $\theta = 1$.

When $\theta = 1$ the Phillips curve (1.46) is called the "accelerationist" Phillips curve:

$$\pi_t - \pi_{t-1} = \frac{\alpha}{L}(Y_t - Y^n). \tag{1.48}$$

Equation (1.48) implies that whenever output is above its natural level, inflation increases over time, and whenever output is below its natural level, inflation decreases over time. In contrast, when $\theta = 0$ the Phillips curve is

$$\pi_t - \bar{\pi} = \frac{\alpha}{L}(Y_t - Y^n),$$

and inflation increases when the output gap $Y_t - Y^n$ increases, and decreases when the output gap decreases.

The difference between anchored and deanchored inflation expectations is of first-order importance for monetary policy. Consider a scenario in which the economy is in a boom, with unemployment below its natural rate and output above potential. The PC implies that, in this case, inflation is above expected inflation. Imagine monetary policy increases the interest rate over time and stops when unemployment is equal to its natural rate and output is equal to potential. With anchored expectations, the increasing interest rate makes inflation decrease over time as the output gap goes down. When output reaches potential, inflation equals the inflation target $\pi = \bar{\pi}$ so inflation ends up below its initial level. With deanchored expectations, inflation *increases* over time as output goes down, since the output gap is always positive along the path. When output reaches potential, inflation stops increasing. In contrast to the case of anchored expectations, inflation ends up above its initial level.

1.9 Sticky Prices

In the real world, **prices are sticky**: we do not see the price of individual goods changing instantaneously in response to evolving economic conditions, with prices of many individual goods unchanged for months at a time despite fluctuations in economic conditions. In addition, not all prices change at the same time. The stickiness of prices and the lack of synchronization in price changes across firms imply that the aggregate price level changes slowly over time.

Why are prices sticky? One reason is that changing prices is costly. The physical costs of changing prices are called **menu costs**, (think of a restaurant that has to print new menus when it changes prices). There are other reasons why prices are sticky: computing the new price and deciding to change prices can be time-consuming, especially in large companies; the necessary information about economic conditions may take time to get to firms and be digested; even when economic conditions change, if a firm's competitor does not change prices, it may be better to not change prices to remain competitive, etc.

1.10 The Short Run, the Medium Run, and the Long Run

We now want to think about how the economy evolves over time. It is useful to make the conceptual distinction between the short run, the medium run, and the long run.

- **The short run**: What happens to the economy from year to year. Movements in output are primarily driven by "movements in demand", that is, by equilibrium in the goods market. Firms are willing to supply any quantity at the given prevailing price.
- **The medium run**: What happens to the economy over a decade or so. In the medium run, the economy tends to return to the level of output determined by structural "supply factors", that is, by equilibrium in the labor market. Firms supply an amount of output equal to potential, and prices adjust to make the goods market be in equilibrium.
- **The long run**: What happens to the economy over a half century or longer. In the long run, what dominates is not fluctuations, but growth. Long-term growth is determined, among other things, by the growth rate of productivity, the education system, the saving rate, demographics, the rule of law, and the quality of institutions.

The short run, medium run, and long run can also be characterized by how prices behave:

- In the short run the price level P is fixed. In other words, P can be treated as exogenous in the short run. We can think of the short-run price level as being inherited from past decisions, and the short run as the time horizon over which changes in the sticky price level are small enough that they can be ignored.
- The medium run can be thought of as the amount of time it takes for all price changes to occur or, equivalently, for prices to behave as if they were not sticky at all. If prices

are not changing, then the price level must equal the expected price level and inflation must equal expected inflation. Therefore, the conditions $P = P^e$ and $\pi = \pi^e$ can be taken as the *definition* of the medium run.

- In the long run, we have **neutrality of money**: only real variables (rather than nominal ones) determine economic outcomes. The price level P and inflation π are irrelevant in the long run.

Medium-run adjustment

The Phillips curve (1.45) describes how inflation responds to the output gap. Suppose output is above its natural level $Y_t > Y^n$. Then (1.45) implies $\pi_t > \pi_t^e$ so the price level rises faster than expected. A higher price level reduces real money balances M_t^s / P_t; shifting the LM curve up in subsequent periods. This raises the nominal interest rate and lowers output, pushing output back toward Y^n.

Conversely, if output is below its natural level $Y_t < Y^n$ inflation is lower than expected. As the price level rises more slowly (or falls), real money balances increase, shifting the LM curve down and pushing output up toward Y^n.

In the medium run, once the economy reaches a situation in which output equals its natural level $Y_t = Y^n$; the Phillips curve implies that inflation equals expected inflation $\pi_t = \pi_t^e$. In that case, there is no systematic pressure for inflation to accelerate or decelerate.

References

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

Chapter IV

The II-XX Model

1 Internal and External Balance[1]

Section 8.1 of Chapter 8 in the textbook has a good discussion of internal vs external balance. If you have not yet read that section, you may want to do so before reading the rest of this note (even though this note is self-contained and should be understandable without having read Chapter 8).

Our initial understanding of internal vs external balance will require very few assumptions. In some sense, that is great: the fewer the assumptions, the more general we hope our model can be. On the other hand, we will be able to understand fewer things than if we had a more comprehensive model. After this first pass that requires few assumptions, we will return to the AA-DD and use it to reach sharper conclusions that have the same overall message.

Therefore, we now work under the following assumptions:

- There is a long-run level of output that coincides with the full-employment level Y^f. This means that, absent any changes, output Y will approach its full-employment level Y^f. Government policy can make the convergence of Y toward Y^f faster or slower,

[1]This chapter is based on: Roberto Rigobon, "15.014 Applied Macro- and International Economics II", Spring 2016. License: Creative Commons BY-NC-SA.

but it cannot change Y^f. In addition, given that Y^f is the "full-employment level" (whatever that means!), any deviations of Y from Y^f are undesirable for the people who live in this economy.

- There is a long-run level of the current account that is "sustainable", which we denote by XX^b. Sustainable means that, absent any changes, the current account CA:
  - will approach XX^b over time,
  - remains at XX^b once it gets there, and
  - has XX^b as a desirable value for reasons that we leave unspecified; perhaps sustainability itself is a worthy goal, or perhaps there is a good economic reason why people may prefer XX^b to other levels.

Given these three assumptions, an economy that has $Y = Y^f$ and $CA = XX^b$ is in its happy place. Our next task is to understand what combinations of output and exchange rates (Y, E) are compatible with $Y = Y^f$ and $CA = XX^b$ in the short run, that is, when the price level P is fixed.

1.1 The II Curve

In this section, we introduce the II curve. The II curve is the set of points (Y, E) that are consistent with full employment in the short run, i.e., the set of points that have $Y = Y^f$ and any E. As Figure 1.1 shows, the II curve is vertical.

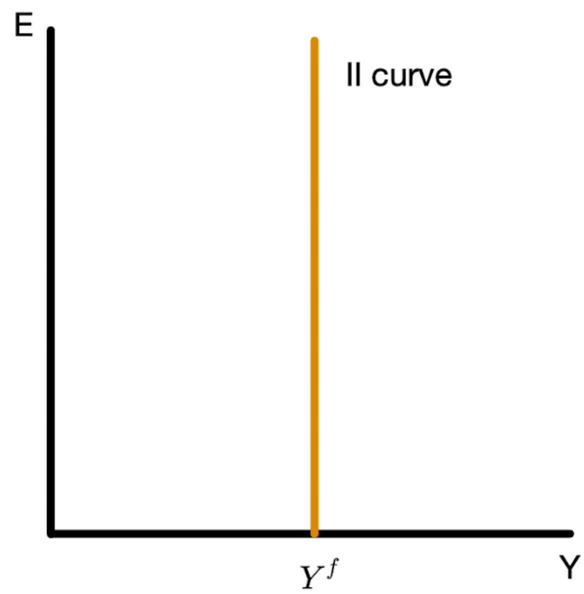


Figure 1.1:

1.2 Internal Balance

When the economy is at $Y = Y^f$, we say it is in "internal balance". At $Y = Y^f$, there is no reason for a policymaker to try to stimulate or cool down the economy in the short run. We have been referring to Y^f as the full-employment level, but there are closely related terms that describe the same idea: the "natural level of output", the "non-accelerating-inflation level of output", the "potential level of output". At $Y = Y^f$, the economy is operating at an efficient and non-inflationary level. Associated with this full-employment level of output is a "natural rate of unemployment", u^n, defined as the rate of unemployment that is consistent with $Y = Y^f$ and a constant price level P^f. Let L be the economy's workforce and N be the number of people in the workforce that are employed. Then the unemployment rate is defined by

$$u = \frac{L - N}{L}. \tag{1.1}$$

If we assume that the only factor of production is labor[2] and that the economy's aggregate production function is

$$Y = N,$$

then the natural rate of unemployment and the "full-employment" level of output are related by

$$u^n = 1 - \frac{Y^f}{L}.$$

Figure 1.2 shows a representation of the adjustment dynamics for the economy as time goes by. The arrows point toward the II line to signify that there is an economic force (as of now unspecified) that tends to move the economy toward Y^f.

When $Y > Y^f$, we describe the situation as one of "overheating". Compared to the more desirable state in which $Y = Y^f$, people are working overtime, inflation is too high, and other resources are being used "above capacity", which can result in higher overall output but with lower productivity and faster capital depreciation.

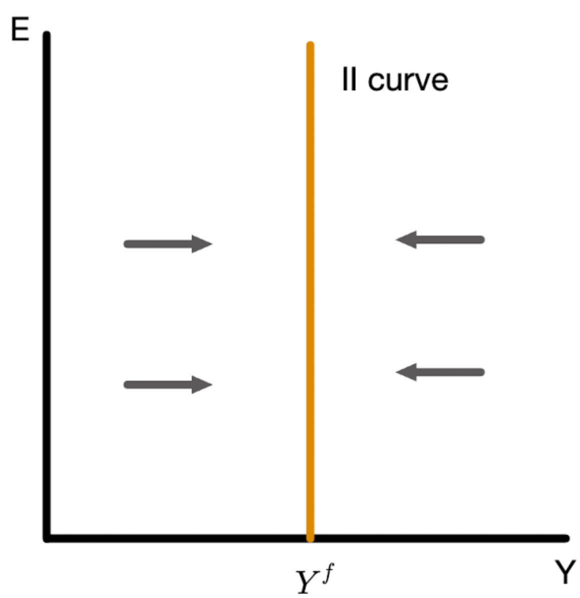


Figure 1.2:

[2]This is not as restrictive as it sounds: we are assuming that labor is the only factor of production that adjusts within the time horizons we are considering and ignoring the other factors because they remain unchanged.

When $Y < Y^f$, we describe the situation as "unemployment". People would like to work more, there is idle capacity or underutilization of resources, and inflation is too low.

1.3 The XX Curve

The XX curve is the set of points (Y, E) that keep the current account constant and equal to a given value XX in the short run (with P fixed):

$$XX = CA\left(\frac{EP^*}{P}, Y, Y^*\right) \tag{1.2}$$

We already encountered the XX curve in the context of the AA-DD model. When plotted in a diagram with Y in the horizontal axis and E on the vertical axis, it is increasing. We know it is increasing because CA is increasing in E and decreasing in Y (keeping P, P^*, Y^* constant).

We now want to have deeper economic understanding of why the XX is increasing. Figure 1.3 shows an arbitrary starting point (Y_0, E_0).

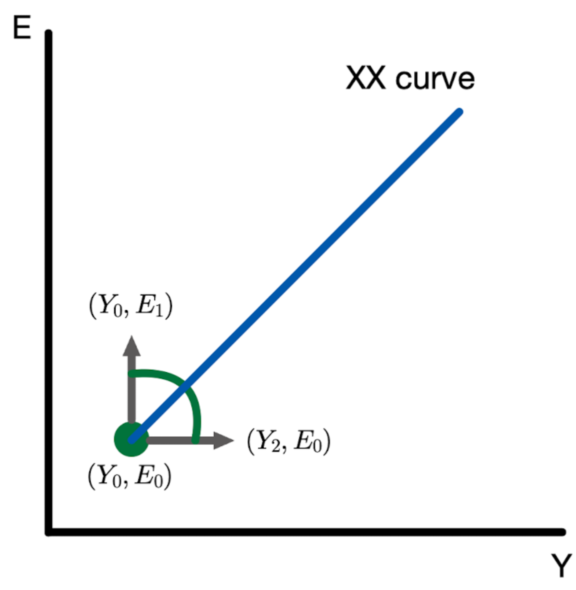


Figure 1.3:

The value of CA at that point is XX_0, so we have that:

$$XX_0 = CA\left(\frac{E_0P^*}{P}, Y_0, Y^*\right)$$

Imagine that there is a nominal depreciation that keeps output fixed: from (Y_0, E_0) we move to (Y_0, E_1) with $E_1 > E_0$. In the short run, P and P^* are fixed, so the nominal depreciation is also a real depreciation. Domestic goods have become cheaper relative to foreign goods. Imports go down, exports go up, and the current account improves (goes up). So when we start at (Y_0, E_0) and move north in the Figure 1.3, CA goes up.

Now imagine a different change that keeps the exchange rate fixed but increases output: from (Y_0, E_0) we move to (Y_2, E_0) with $Y_2 > Y_0$. Higher Y implies that there is a higher demand for foreign goods. Imports go up and the current account deteriorates (goes down). So when we start at (Y_0, E_0) and move east in Figure 1.3, CA goes down.

Going north we have a situation of higher CA, while going east leads to a lower CA. If we move from the point (Y_0, E_1) to the point (Y_2, E_0), we must cross a point of zero change in CA. Said differently, you can always find a combination of movements to the north and to the east that lead to no change in CA. This point of no change in CA to the northeast of (Y_0, E_0) must therefore be on the same XX curve as (Y_0, E_0), which in this case is the one that has $CA = XX_0$.

If we connect all the points that give us a zero change in CA, we trace the entire XX curve. We have found that movements along the XX curve keep CA unchanged because the improvement in CA due to a real depreciation (the movement to the north) is exactly offset by a deterioration in CA due to increased imports that were caused by higher income[3].

1.4 External Balance

We define external balance as the situation in which the current account is at its sustainable level XX^b. Figure 1.4 depicts the dynamics of convergence toward XX^b. First, the figure shows the XX curve with an associated value of the current account equal to XX^b. For any combination of points (Y, E) above this XX^b, the current account is higher than XX^b. In this case, the figure shows arrows that point down and toward the curve to signify dynamics that, over time, make the current account decrease toward XX^b. Similarly, for points below

[3]Remember that Y is both aggregate output and aggregate income. That aggregate output equals aggregate income is an accounting identity. If you don't recall this relation, go back to your notes from intermediate macro or our quick review of this issue in the lecture slides on National Accounts.

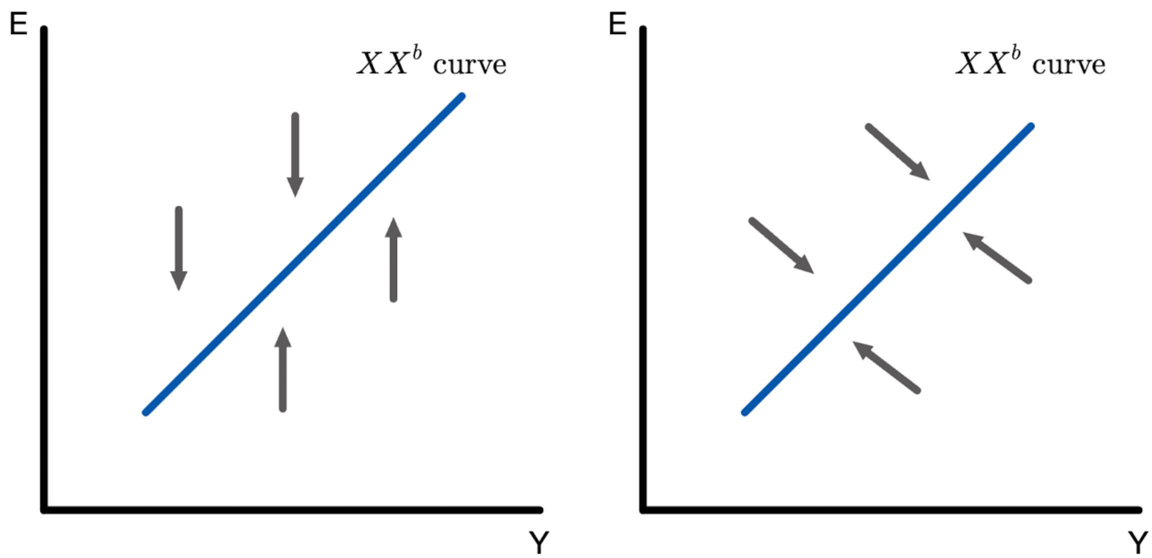


Figure 1.4:

the XX^b curve that have a current account lower than XX^b, the left panel of the figure shows arrows pointing up and toward the curve, to signify dynamics that make the current account increase toward XX^b. Arrows that point straight up and straight down are not the only possibility. Indeed, the adjustment toward XX^b does not have to occur only through the exchange rate and can occur through combinations of E and Y. The right panel of Figure 1.4 shows an example in which E and Y are both changing as the adjustment takes place. The arrows point toward the XX^b curve at some angle rather than vertically up and down, as in the right panel of the figure.

The lack of specificity about how the adjustment toward XX^b is one of the drawbacks of this simple model vis-a-vis a model with more structure such as the AA-DD.

When the current account is above XX^b, we say that the economy is in a situation of "surplus", while when the current account is lower than XX^b, we say that the economy is in a situation of "deficit". Here the word deficit refers to a *current account* deficit (relative to the level XX^b) and not a *fiscal* deficit. A fiscal deficit is characterized by government purchases larger than taxes, $G > T$, while the current account deficit is characterized by $CA < XX^b$. While current account and fiscal deficits are not the same thing, we do see in the real world that persistent domestic fiscal deficits are often sustained, at least in part, by borrowing from the rest of the world, which brings the current account down.[4]

1.5 The Four Zones of Economic Discomfort

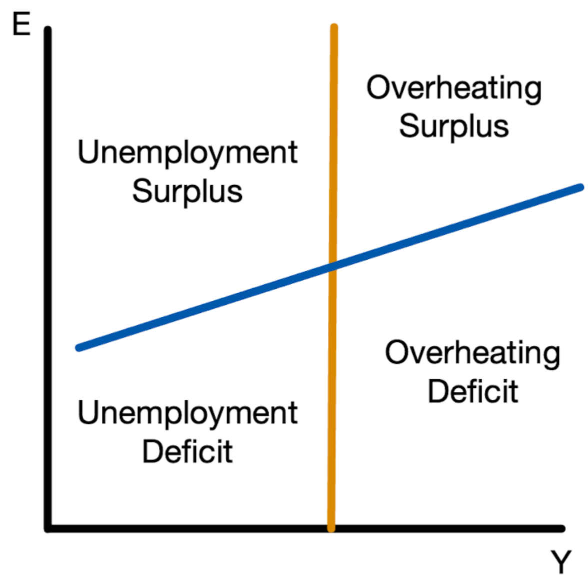


Figure 1.5:

Figure 1.5 shows the result of putting Figures 1.2 and 1.4 together. We can use this figure to diagnose the state of the economy belonging to one of the four "zones of economic discomfort". In each of these zones, we have an absence of internal of external balance of a different kind. For example, the south-east zone represents an overheating economy with current account deficits, while the north-east zone has overheating and surplus.

We can also combine the dynamics from Figures 1.2 and 1.4, as is done in Figure 1.6. An important question is how long it takes for an economy to trace the whole path in the real world.

Without any policy intervention, the answer is that it can take many years. Policy intervention, if appropriate, can speed up the convergence toward the long-run equilibrium. However, the effects of policy also take time to be felt in the economy. In the United States, monetary policy actions usually start to have an effect on output and the current account

[4]Recall that if S^p is private saving, $S^g \equiv T - G$ is public saving, and I is investment, then $S^p + S^g = I + CA$. For given S^p and I, higher public saving (equivalently, lower public deficit) is associated with a lower current account.

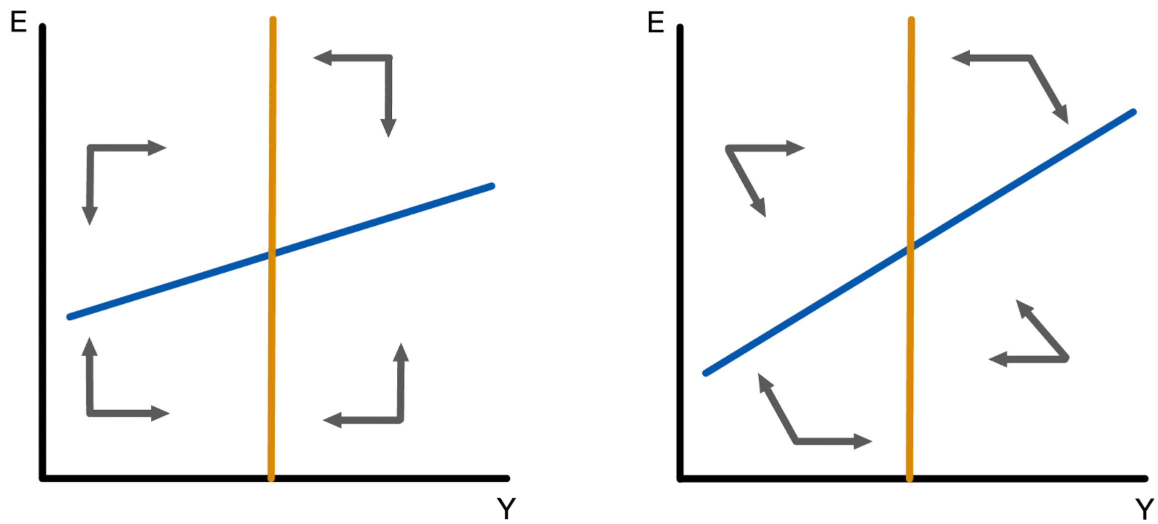


Figure 1.6:

after a few months, and have their largest effect between one and two years after the actions are taken. Fiscal policy can be faster or slower, depending on the nature of the policy. For example, one would expect that mailing stimulus checks to households would have a faster effect than increasing spending on education. The *nominal* exchange rate usually adjusts more rapidly. In the context of the AA-DD model, the convergence to the long-run was assumed to happen "monotonically", that is, with Y and E always moving in one direction between the short run and the long run. With a slower adjustment along the Y or the E directions, or with different ways to converge to XX^b, the resulting dynamics can be very different. Figure 2.1 shows three possible cases. On the left panel, we have the type of monotonic adjustment that was commonplace in the AA-DD framework. The middle panel shows a transition from overheating to unemployment, and the right panel shows a transition from deficit to surplus.

2 The Latin Triangle

We can extend our framework to include social constraints. We will model these social constraints by assuming that there is a level of the real wage above which there is "social peace" and below which there is "social unrest". When there is social peace, there is little social pressure exerted on the government to enact reform or significantly change course.

Social unrest, on the other hand, is a situation in which people's standard of living is not acceptable, prompting society to make demands on the government. There are many levels of social unrest: from just complaining, to demonstrations, to riots, to revolution. Our way to capture social constraints is, of course, an extreme simplification of much more multidimensional and complicated issues. But even with its simplicity, we will gain what I think is valuable insight.

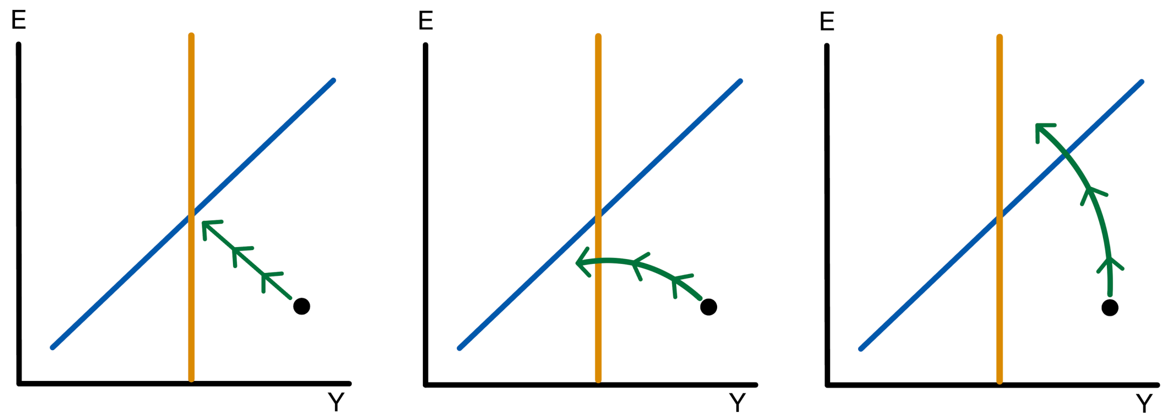


Figure 2.1:

2.1 Social Peace Line

Figure 2.2 plots the social peace curve SP as a function of output Y and the real exchange rate q. To interpret this SP curve, we first note that the real wage and the real exchange rate are inversely related[5], so moving north in the figure implies lower real wages. Social peace occurs when the economy is below the SP curve, and social unrest when the economy is above the SP curve. If social peace is achieved at a high enough real wage independent of the level of Y, the SP curve is flat.

In general, however, we can easily imagine an upward sloping SP curve. It is reasonable to assume that people may be equally happy with a lower real wage if Y is higher. For example, people may be equally happy if they have a lower real wage but the government provides better healthcare (which makes Y go up through higher G). Of course, there is a question about how to finance such change, but the social peace line is not about financing; that

[5]Technically, the *expected* real wage is inversely proportional to the real exchange rate. See Appendix 1 for details.

is what the XX is for. Here we are mostly interested in happiness. Another reason for an increasing SP curve is that people dislike to live in an economy with higher unemployment (which in our framework means low Y) for a given level of the real wage. Nevertheless, a flat SP curve suffices to make the points we want to make, and makes everything simple, so we assume the SP is flat. In addition, any aspects that we have explicitly omitted can be incorporated as "shifters" of the SP curve. Therefore, even though the schedule only depends on real wages, changes in inequality, quality of democracy, legitimacy of the government, corruption, crime, freedom of speech, etc., can be analyzed by shifting the SP curve.

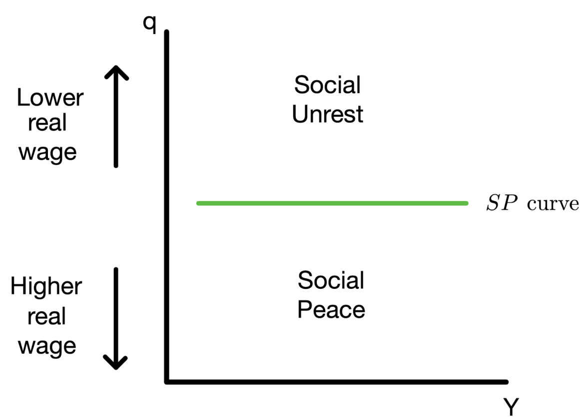


Figure 2.2:

The next step is to put the SP curve together with the II-XX framework. Where does the SP curve lie? Above, below, or through the intersection of the II and XX curves? Nothing forces the SP curve to cross at exactly the same point at which II and XX intersect.

The most interesting case is when the SP curve is below the long-run equilibrium. In Figure 2.3, we show the three curves together. Although we now have q rather than E on the vertical axis, the shapes of the II and XX curves remain unchanged since we keep P fixed (and P^* is exogenous). There are three points of intersection. At point A, the economy has internal and external balance, but real wages are too low and citizens are rioting. At point B, wages are high enough for social peace, external balance is achieved, but the economy is not in internal balance and has unemployment. Finally, at point C, wages are high enough to achieve social peace, the economy achieves internal balance, but there is external imbalance with a current account deficit.

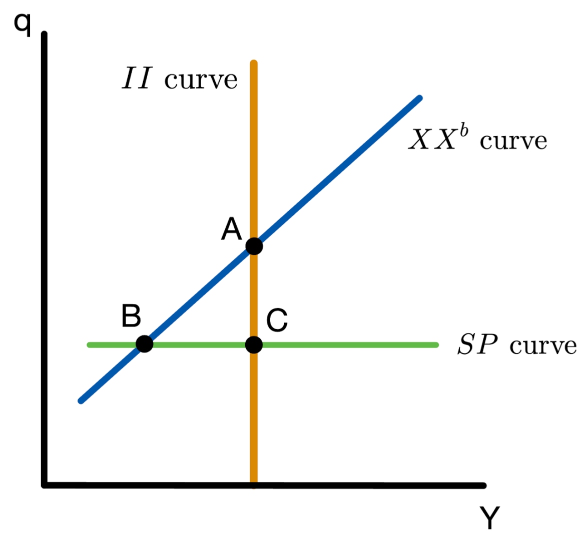


Figure 2.3:

These three points highlight the conflict between social and economic objectives. We can give some more evocative labels to the three points: point A is the *IMF equilibrium*, point B is *Europe*, and point C is *Populism*. Each of the three options has a problem. In the IMF equilibrium, the economic equilibrium has been achieved, but socially and politically, the situation is unsustainable. In Europe, even though salaries are high, standards of living are high, and the current account is in balance, the labor market exhibits significant unemployment. So, wages are high, but only for the those who actually have a job. Finally, in Populism, wages are high and unemployment is low, but this is at the expense of a significant current account deficit. Borrowing from the rest of the world is needed to keep the economy at this level of demand and exchange rates, and borrowing that much forever is not sustainable.

Because none of these options are sustainable in the long run, the economy cannot stay on any one of the three options forever. Figure 2.4 shows that, instead, the economy cycles over the options.

Assume the economy starts with a relatively conservative government at point A (IMF). Of course wages are low, but everybody is working and the current account is at a sustainable level. The low standards of living slowly lead citizens to some complaints. Later the complaints increase enough to reach levels where public demonstrations and even riots occur. The complaining takes a toll on the political landscape. The government responds by increasing wages. Because the government is relatively conservative, it does not want to increase foreign debt. Or perhaps it cannot borrow more from abroad due to prior agreements with the IMF, or other constraints arising from foreign creditors. To keep the current account at its sustainable level while increasing wages, the economy moves along the XX^b schedule from point A to point B.

As the economy is moving from A to B, unemployment starts to increase. However, at the beginning, the unemployed are few and disorganized. Politically speaking, it is relatively easy to increase wages and make the small yet increasing number of unemployed people pay the cost of the adjustment. However, when the economy reaches point B, the unemployment rate is large enough that workers get organized, and they start applying political pressure. Elections are approaching, so the government decides it is time to respond to people's demands. The government decides to keep salaries high, but implements expansionary fiscal and monetary policy to stimulate the economy and reduce unemployment. Interest rates drop, taxes are cut, highways are built.

The incumbent government moves to C and makes all citizens happy. Of course, the government is financing all the expansion through a massive current account deficit, borrowing internationally. After the elections, the government finds itself with large fiscal and current account deficits. The "country risk" increases as it becomes increasingly obvious that the creditworthiness of the country is becoming questionable. The government cuts spending somewhat, but the reduction in government spending is small relative to the already large interest payments on all the accumulated debt. Refinancing the government's debt is becoming more expensive, as creditors demand higher and higher interest rates in compensation for the increased country risk. Soon, the government starts having difficulty borrowing from abroad at ever-increasing interest rates. Eventually, the country defaults, faces a balance of payments crisis, or becomes unable to borrow a sufficient amount to keep the economy at full employment with high wages. There is a crisis. The country calls the IMF for help. Of course the IMF is willing to help, but the assessment of the situation reveals that the economy is not competitive, that wages are too high, and that the economy needs and adjustment program that reduces fiscal and current account deficits. The economy needs to return to conservativeness. The government cuts expenses drastically, increases taxes, and devalues the currency to stimulate exports and improve the current account. And the cycle starts again.

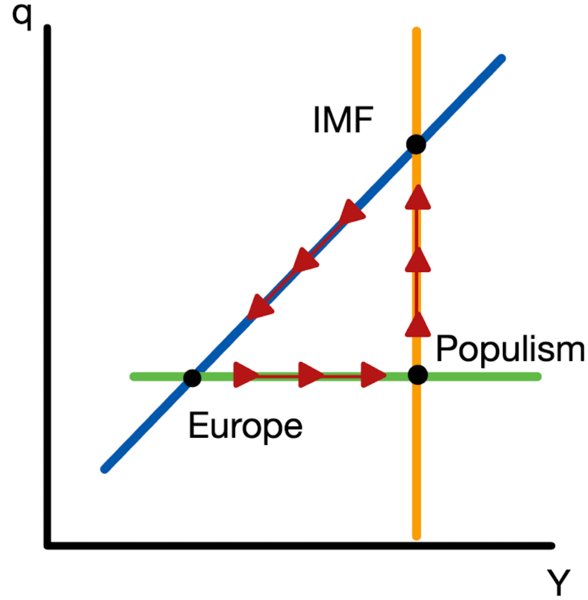


Figure 2.4:

This cycle is remarkably and scarily realistic, especially in many Latin American countries – hence the name "Latin Triangle". We have made some very minimal assumptions thus far, yet captured a deep-rooted cycle that comes from the fact that economic objectives sometimes collide with political and social aspirations. The cycle acknowledges that there are no simple answers and that, over time, there will inevitably be periods of painful adjustment – social, political, economic. It is easy to blame incompetent politicians, greedy foreign institutions, or our corrupt political rivals for these episodes. The Latin Triangle gives us a way to more deeply understand the ultimate forces behind some of the more immediate causes of bad outcomes.

The model can help us conceptualize the social narratives that shape social sentiment in different economic environments. Let's now revisit the cycle from from the perspective of how society sees itself. A country in the populist phase is financing its standard of living with borrowing. Unemployment is at a record low, salaries are high, aggregate demand is booming, and the economy has been doing "well" for quite a while. The only bad indicator in the economy is that it is running a current account deficit. So, yes, the economy is not competitive (since wages are "too high"), but if the future is as bright as the past, this is transitory. This false sense of invincibility, mostly driven by a sequence of previous "good economic times", masks the underlying lack of economic sustainability. This is a time of excess optimism. The future and present are perceived to be much better than what they truly are. Elections take place and the incumbent government wins.

Of course, just after the elections, the continuing borrowing puts pressure on the exchange rate, taking a toll on the central bank balance sheet. Reserves plummet to dangerous levels and the country's currency suffers a balance of payments crisis. How is that possible? How is it possible that such a successful country with only some minor weaknesses is being so unfairly treated? Financial speculation is blamed for the unwarranted attack on the currency and on the central bank. The country has no option but to devalue, cut aggregate demand, and call international institutions to repair the damaged financial situation. In fact, in some cases, the country needs to restructure or outright default on its debt. When this happens, the country is excluded from international financial markets, the interest rate increases to unthinkable levels, and a massive credit drought takes place. The government claims that the unfair adjustment is being imposed by these evil international financial institutions, amplified by speculators and vulture funds. The country has "no other option"; it is almost as if the country has lost part of its sovereignty.

At the IMF equilibrium, economic balance is reestablished, but at the cost of a significant drop in standards of living. On the economic side, the government runs a tight fiscal ship. There is neither a fiscal nor a current account deficit. There is no excess unemployment. On the social side, however, real wages are significantly lower. With depreciation comes domestic inflation. Slowly but surely, the purchasing power of consumers declines. Even though the economics is sound, the social contract is not. Poverty increases, inequality deteriorates, consumers start expressing their discontent privately and, later on, publicly. This is a time in which consumption is depressed. The bright future is now gone. The unrest prompts the government to deal with the low standards of living by compensating workers with salary increases, subsidies, a better social safety net, etc. The outcome is that the cost of the workers goes up, but because the country has been excluded from borrowing they cannot run a current account deficit. Hence, the only option is increase wages by cutting aggregate demand. The expenses by the government are increasing but, at the same time, taxes are increasing as well. The economy is now on its way to the Europe equilibrium.

Wages are high, but unemployment starts to increase. At the IMF equilibrium, everybody was employed but upset at the low wages. As wages start improving, the majority becomes happier. Only a few unemployed are disgruntled but by and large people see an improvement in their standard of living. Politically, this is palatable situation. The problem of rising unemployment can be addressed by a more generous unemployment insurance and a strengthening the social safety net. In the meantime, because the country has been running relatively good economic policy, it can, and does, re-enter international financial markets. After some time, the number of unemployed has increased so much that it is clear that the situation is no longer sustainable.

The more open financial markets and the high unemployment makes political rhetoric shift toward a more populist stance. Impositions by foreigners cannot determine the fate of millions of citizens; it is unfair that a country that was once so successful on its own is now at the mercy of heartless financial speculators. In response, government spending increases, taxes are cut, interest rates are cut, and all is financed with borrowing (mostly from abroad). At the beginning, the borrowing is manageable. The low initial fiscal debt levels allow the government to borrow at a low rate. The situation improves, unemployment declines, and wages start to go up. The government believes it has found the right policy. Why not do more of the same? And they do. The economy is now moving toward populism. The only way to sustain the economy and fulfill campaign promises is to keep borrowing more, increasing aggregate demand, and keeping wages high. Citizens feel better, and their contentment is reflected in the polls. Elections are nearby and there is no incentive to go back to orthodoxy. This is the time to concentrate on what is important: the welfare of our citizens – and their votes. And just like that, we are back to populism, and the cycle repeats itself.

2.2 Dynamics

Figure 2.4 shows a counter-clockwise spiral. If we compare these counter-clockwise dynamics with those in Figure 1.6, we see that the movements from the Europe point to Populism, and from Populism to IMF, are consistent with the "natural" adjustment dynamics of the economy. In other words, even if the government kept policy unchanged, the tendency of the economy to approach internal and external balance is compatible with the Europe-to-Populism-to-IMF dynamics. Of course, our narrative of the Latin Triangle makes clear that governments do change policies along the way, which can speed up, slow down, or change the "natural" dynamics. The point is that on this part of the Triangle, the government will find it generally easier to steer the economy since it is not going against the built-in adjustment mechanisms of the economy.

In contrast, the transition from IMF to Europe does imply an active government policy that goes against (and overcomes) the tendency of the economy to converge toward internal balance.

3 The II-XX with Domestic Demand and Real Exchange Rates

We now put more structure on the model by making stronger assumptions on how the economy adjusts over time toward internal and external balance. As anticipated, the stronger assumptions will allow us to have a sharper characterization of the dynamics that the economy follows.

To incorporate these two adjustment mechanisms into our model, it will be convenient to look at diagrams with domestic demand A and the real exchange rate q in the axes rather than output Y and the nominal exchange rate E as we had done before (we already took some steps in this direction during the Latin Triangle discussion, where we plotted q rather than E on the vertical axis). With A on the horizontal axis and q on the vertical axis, the adjustments toward internal and external balance will be very simple. Internal balance will be achieved through vertical movements (changes in q) while external balance will be achieved through horizontal movements (changes in A). The switch from Y and E to A and q also has the conceptual advantage of separating domestic policy (changes in A) from external policy (changes in q).

Therefore, our first job is to express all the equations we will need as functions of A and q. After that, we study the adjustment dynamics.

3.1 Domestic Demand

Let's recall that demand for domestic goods is not the same as domestic demand, since domestic demand includes demand for all goods, both domestic and foreign. Demand for domestic goods is

$$Z = C + I + G + CA,$$

while domestic demand is

$$A = C + I + G. \tag{3.1}$$

In the present context, domestic demand is sometimes referred to as "domestic *a*bsorption", which is why I have denoted it with an A. The term absorption is supposed to evoke the idea that when demand for domestic goods goes up, some of that demand is "absorbed" by A, while the rest is "lost" to imports. Domestic demand is also referred to as "aggregate demand", since it is the total demand for all goods, foreign and domestic.

As usual, we maintain the assumption that consumption is an increasing function of disposable income: $C = C(Y - T)$. Using $C = C(Y - T)$ in equation (3.1) gives:

$$A = C(Y - T) + I + G \tag{3.2}$$

so A is an increasing function of Y. In addition, since marginal propensity to consume out of disposable income is less than one (consumers on aggregate save at least some part of their income), an increase in Y is associated to a less than one-for-one increase in A.

The current account is also modeled just as before:

$$CA = CA(EP^*/P, Y, Y^*),$$

where CA is a function that is increasing in the real exchange rate EP^*/P, decreasing in domestic income Y, and increasing in foreign demand Y^*.

With a supply of goods given by Y, the equilibrium condition in the market for domestic goods is

$$Y = C + I + G + CA. \tag{3.3}$$

To write our model in terms of A, we combine equations (3.1) and (3.3) to get

$$A = Y - CA(EP^*/P, Y, Y^*)$$

Now use that $q = EP^*/P$ to write

$$A = Y - CA(q, Y, Y^*) \tag{3.4}$$

3.2 The *II* Curve in Terms of *A* and *q*

In this context, we define the II curve as the set of points (A, q) compatible with a goods market equilibrium that has $Y = Y^f$ in the short run (i.e., with P fixed). Using $Y = Y^f$ in equation (3.4) gives the II curve:

$$A = Y^f - CA(q, Y^f, Y^*). \tag{3.5}$$

Figure 3.1 plots the II curve from equation (3.5) with A on the horizontal axis and q on the vertical axis. The II curve gives the combination of domestic demand levels and real exchange rates that, keeping prices fixed, gives a short-run equilibrium in the goods market that has output equal to its full-employment level.

In this model, A and q are both endogenous. We can take q as given and see what happens to A, or we can take A as given and see what happens to q. In the end, the model determines the joint behavior of A and q. Taking q as given, the II curve provides the answer to the following question: For a given value of q, what is the level of domestic demand (or

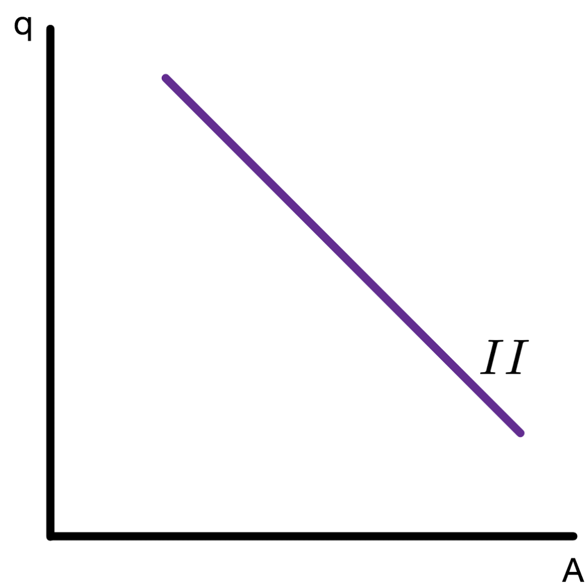


Figure 3.1:

absorption A) required to make output equal to the full-employment level of output? Now let's assume that A is given. First, consider a given A that is much smaller than Y^f. In order for output to equal Y^f, there has to be a large current account surplus. The only way to achieve a large current account surplus is to have a real exchange rate that is sufficiently high (a large enough depreciation). Consider now a given A that is above Y^f. If $CA = 0$, then we must have $Y > Y^f$. In order to have $Y = Y^f$, we need a current account deficit. The only way to achieve a deficit in the short run is if q is low enough (a large enough apreciation).

We note that this II curve is conceptually similar to the II curve that we introduced in Section 1, but not exactly the same. The earlier version of the II curve was defined as the set of points (Y, E) that are consistent with $Y = Y^f$ in the short run. The new II curve in equation (3.5) gives the set of points (A, q) that are consistent with a short-run goods market equilibrium that has $Y = Y^f$. In addition to considering (A, q) instead of (Y, E), the new II introduces the requirement that (A, q) can *support an equilibrium* with $Y = Y^f$. The earlier II curve, in contrast, just required $Y = Y^f$ without any reference to equilibria.

3.3 The *XX* Curve in Terms of *A* and *q*

Let's now write the XX^b curve as a function of A and q. Equation (1.2) with $XX = XX^b$ and $q = EP^*/P$ gives the XX^b curve:

$$XX^b = CA(q, Y, Y^*). \tag{3.6}$$

To write CA as a function of A instead of Y, we solve equation (3.2) for Y to get:

$$Y = C^{-1}(A - I - G) + T, \tag{3.7}$$

where $C^{-1}(\cdot)$ is the inverse function of the increasing function $C(\cdot)$. For example, if

$$C(x) = 1 + \frac{3}{4}x \tag{3.8}$$

then

$$C^{-1}(x) = \frac{4}{3}(x - 1). \tag{3.9}$$

Plugging equation (3.7) into equation (3.6) gives:

$$XX^b = CA\left(q, C^{-1}(A - I - G) + T, Y^*\right).$$

We can write this equation as

$$XX^b = \widetilde{CA}(q, A, Y^*) \tag{3.10}$$

where the function $\widetilde{CA}$ is defined by

$$\widetilde{CA}(q, A, Y^*) \equiv CA\left(q, C^{-1}(A - I - G) + T, Y^*\right).$$

Since $C(\cdot)$ is increasing and $CA(\cdot, \cdot, \cdot)$ is decreasing in its second argument, $\widetilde{CA}$ is also decreasing in its second argument. It is good to keep in mind that sometimes, with some abuse of notation, we write $XX^b = CA(q, A, Y^*)$ instead of the more correct but cumbersome $\widetilde{CA}(q, A, Y^*)$.

Example 3.1. We keep using equation (3.8). We additionally assume that

$$CA(q, Y, Y^*) = 2q - 0.5Y + 0.1Y^*.$$

Using (3.9), we have

$$\begin{aligned}
CA(q,Y,Y^*) &= 2q - 0.5Y + 0.1Y^*, \\
&= 2q - 0.5[C^{-1}(A-I-G)+T] + 0.1Y^*, \\
&= 2q - 0.5\left[\frac{4}{3}(A-I-G-1)+T\right] + 0.1Y^*, \\
&= 2q - \frac{2}{3}A + \frac{2}{3}(I+G+1) - 0.5T + 0.1Y^*.
\end{aligned}$$

So, in this case

$$\widetilde{CA}(q,A,Y^*) = 2q - \frac{2}{3}A + \frac{2}{3}(I+G+1) - 0.5T + 0.1Y^*.$$

□

Figure 3.2 plots the XX^b curve from equation (3.10) with A on the horizontal axis and q on the vertical axis. This is the same curve as the upward sloping curve from Figures 1.3, 1.5 and 1.6, but plotted in a different axis. The XX^b curve is the set of points (A,q) that are consistent with a current account equal to XX^b in the short run. It answers the following question: For a given value of q, what is the level of domestic demand (or absorption A) required to make the current account equal to its sustainable level XX^b? Just as for the II curve, we can also take A as given and ask what happens to q. The XX^b curve therefore also answers the question: For a given value of A, what is the level of q required to make the current account equal to its sustainable level XX^b?

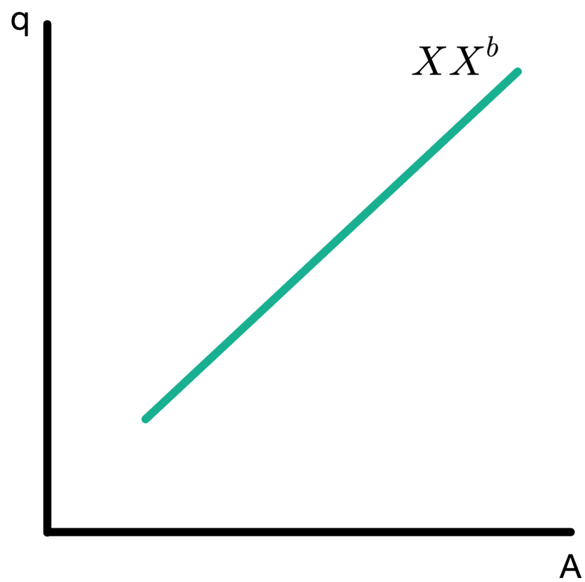


Figure 3.2:

3.4 The Four Zones of Economic Discomfort

The left panel of Figure 3.3 shows the II and XX^b curves in the same plot, with A and q in the axes. Similar to Figure 1.5, we can characterize the four regions of economic discomfort based on the combinations of internal and external imbalances that prevail.

The points above the II curve have $Y > Y^f$ and, conversely, the points below the II curve have $Y < Y^f$.[6] For the XX^b curve, we have that points above it have $CA > XX^b$ while points below it have $CA < XX^b$. Points exactly on II have $Y = Y^f$ and correspond to points in which there is internal balance. Points exactly on XX^b have $CA = XX^b$ and correspond to points in which there is external balance.

[6] To see that $Y > Y^f$ is the same as being above the II curve, use equations (3.5), (3.4), and that domestic demand A is increasing in Y.

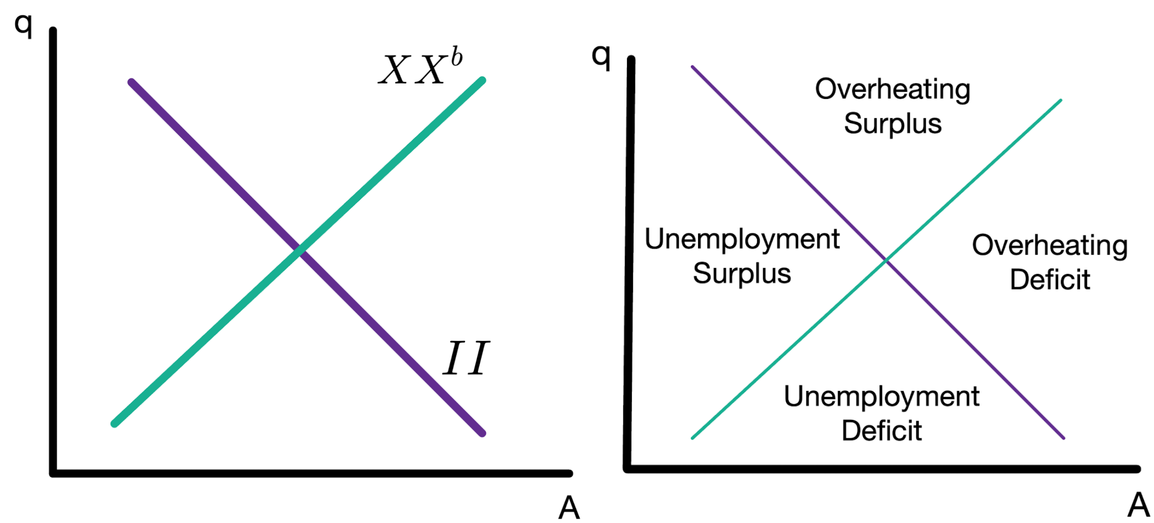


Figure 3.3:

3.5 Adjustment Mechanisms

We are finally ready to make the stronger assumptions regarding how the economy adjusts over time toward internal and external balance.

Adjustment Mechanism Toward Internal Balance

- The economy tends toward internal balance through adjustments in the price level P. When $Y > Y^f$, P is increasing. When $Y < Y^f$, P is decreasing. As time goes by, absent any changes in exogenous variables or parameters, the changes in P will make Y approach Y^f.

What does this adjustment mechanism imply for the dynamics of A and q? The left panel of Figure 3.4 shows the dynamics that arise from adjustments in P. All the points above the II curve have $Y > Y^f$. For these points, P is increasing over time. When P is increasing over time, q is decreasing over time (since $q = EP^*/P$). Conversely, for points below the II curve we have $Y < Y^f$, P decreasing and q increasing. Thus, internal balance is achieved by movements in the real exchange rate q, which are movements in the north-south direction.

In the AA-DD model, we had already encountered an adjustment mechanism driven by changes in P. In fact, for the AA-DD model, it was the *only* endogenous adjustment mechanism. When P changed, it induced shifts in both the AA and the DD. The shifting of the curves stopped when their intersection gave an equilibrium with $Y = Y^f$. Thus, starting from any short-run equilibrium, the adjustments in P pushed the economy toward a long-run equilibrium. One aspect that is different in the current model compared to the AA-DD model is that we now assume that adjustments in P serve as an adjustment mechanism for internal balance only. In the AA-DD, changes in P induced changes in Y, q and E, moving all of them toward their long-run equilibrium levels. As a consequence, changes in P also induced changes in A in the AA-DD model (although we never looked at that directly when we studied the AA-DD). In contrast, in the present II-XX model, changes in P induce changes in q only; neither Y nor E change with P.

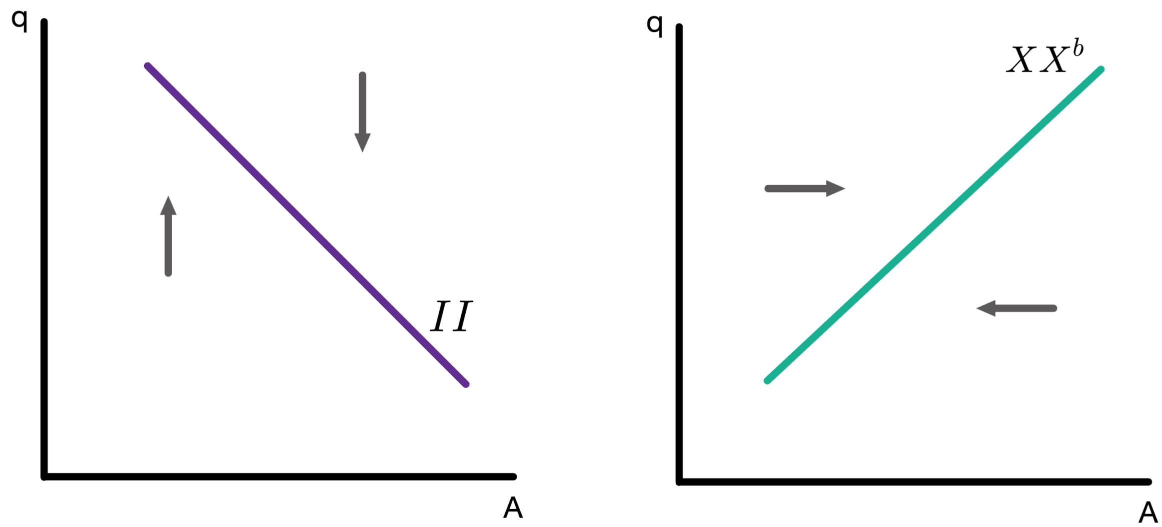


Figure 3.4:

Adjustment Mechanism Toward External Balance

The adjustment mechanism we consider now is a new mechanism that is absent in the AA-DD framework and that we have not encountered (in this course) until now.

- The economy tends toward external balance through adjustments in aggregate consumption C. When the current account is below its sustainable level XX^b, consumption is decreasing over time. Lower consumption leads to lower aggregate demand A, lower output and lower income. Lower income makes imports go down, which makes the current account increase and get closer to XX^b. Conversely, when the current account is above its sustainable level XX^b, consumption, output and income are increasing over time. The current account is deteriorating and moving toward XX^b.

The right panel of Figure 3.4 shows the dynamics that are brought about by this adjustment mechanism.

Let's now understand the economic logic behind it. At the deepest level, the adjustment mechanism of the current account through consumption and aggregate demand comes from two sources. The first is the existence of an aggregate budget constraint for the entire economy that says that we cannot finance too high a level of consumption with ever-increasing borrowing. The second is that people value consumption and will not choose to consume less in every period if it can consume more in every period with the same resources.

The existence of a budget constraint provides the adjustment mechanism of CA toward XX^b when $CA < XX^b$. The preference for higher consumption provides the adjustment mechanism of CA toward XX^b when $CA > XX^b$.

Imagine the economy has an unsustainable current account deficit, which in this context means $CA < XX^b$. In the right panel of Figure 3.4, points with $CA < XX^b$ correspond to points below the XX^b line. When $CA < XX^b$, the country is consuming more than what is sustainable in the long run and financing this consumption by borrowing from the rest of the world. As time goes by, the country's debt to foreigners keeps increasing. The borrowing being unsustainable means that, eventually, the borrowing must go down, and the debt levels must stabilize (or else the budget constraint is violated). When the borrowing goes down, consumption levels cannot be sustained and must go down as well. Lower consumption leads to lower domestic demand. In a goods market equilibrium, lower demand implies lower output. Since aggregate output equals aggregate income[7], aggregate income goes down. Lower aggregate income implies that demand for imports is lower, so equilibrium imports go down. Lower imports make CA go up, which is an adjustment toward XX^b.

[7] See footnote 3.

In the chain of events described in the last paragraph, the unsustainably high borrowing must *eventually* go down. There is in principle no reason why we can't keep an unsustainable deficit, or even increase the deficit, for some time before having to reduce consumption. After all, whether a current account level is sustainable is a long-run issue. Short-run movements away from sustainability may be consistent with long-run sustainability if they are reversed quickly enough. However, in our model we do assume that the adjustment toward long-run sustainability and toward external balance begins immediately. This does not rule out all temporary movements away from sustainability. There can be movements away from sustainability brought about by changes in exogenous variables or parameters. However, it is good to keep in mind that, in the real world, endogenous movements away from sustainability can occur, do occur, and are sometimes quite persistent.

Imagine now that the economy has an unsustainable current account surplus, $CA > XX^b$. When $CA > XX^b$, the country's income is higher than its aggregate demand. The difference between income and demand is lent out to the rest of the world. As time goes by, the domestic economy accumulates wealth in the form of foreign assets – the IOUs that entitle the domestic economy to future repayments from the rest of the world. This accumulation of wealth is a form of saving, as it foregoes consumption today (by lending to foreigners) in exchange for consumption in the future (when we use the IOU repayments to increase consumption). The accumulation of saving becomes unsustainable when it is not desirable for consumers to keep lending forever at the current level, as that would imply that, for all future periods, wealth is being accumulated faster than it is consumed. And if wealth is forever being accumulated faster than it is consumed, it is possible to consume some of the wealth today and also keep all future consumption unchanged. Therefore, when the current account surplus becomes unsustainable, it is optimal for consumers to consume more and lend less. The reduced lending to the rest of the world lowers the current account toward its sustainable level, while the higher consumption increases domestic demand.

In sum, countries cannot borrow at an unsustainable level forever, and do not want to save at an unsustainable level forever. In either case, the external imbalances are corrected over time by changes in aggregate demand A. In the right panel of Figure 3.4, this corresponds to movements in the east-west direction. When the external imbalance is in the form of a surplus, the economy is above the XX^b line and the adjustment toward external balance happens by increasing A over time. When the external imbalance is in the form of deficits, the economy is below the XX^b line and the adjustment toward external balance happens by lowering A over time.

3.6 Adjustment Dynamics

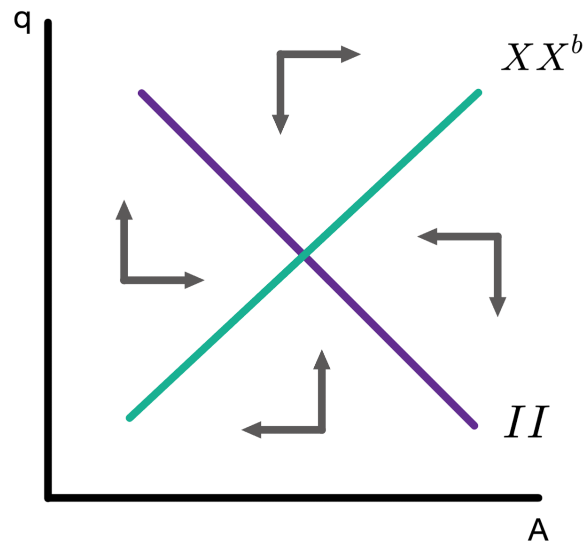


Figure 3.5:

Combining the dynamics from the two panels of Figure 3.4 gives Figure 3.5. Each of the four zones of economic discomfort have their own dynamics. For example, the top quadrant has overheating and surplus. Because it has overheating, the price level is increasing, which pushes q down. Because it has surpluses, consumption is increasing, which pushes A to the right (toward higher values).

Figure 3.6 places the economy at a starting point in the top quadrant and traces the path that results from following the adjustment dynamics from Figure 3.5. The result is a clockwise spiral.

We can get some further insight by looking at the strength of each of the two adjustment mechanisms for different combinations of A and q. Figure 3.7 illustrates the strength of the adjustment mechanisms with arrows attached to the path traversed by the economy

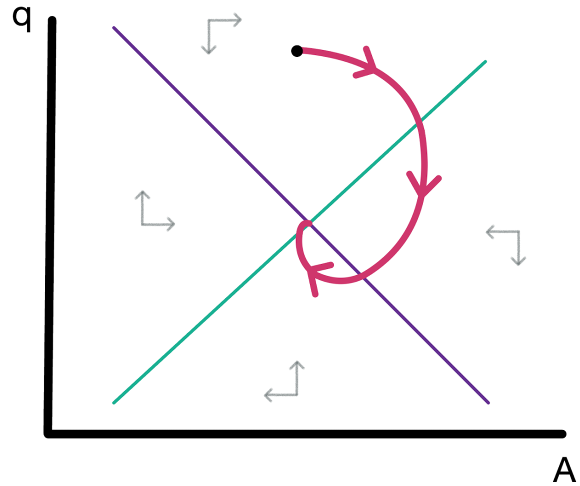


Figure 3.6:

over time. Longer arrows denote a “stronger” adjustment. We equate stronger adjustments with faster adjustments; we can think of the length of an arrow as indicating the speed at which the economy is moving in the direction of the arrow. The arrows pointing up or down correspond to adjustments in q that move the economy toward internal balance while the arrows pointing east or west correspond to adjustments in A that move the economy toward external balance. A natural assumption, which we make from now on, is to have adjustments be faster when the economy is far away from balance, and slower when the economy is closer to balance.

In Figure 3.7 the red path starts with two arrows that are relatively large and of similar size. The arrows are large because the economy is far from the lines. The arrows are of similar size because the distance to the purple II curve is similar to the distance to the green XX^b curve. We expect the economy to move down and to the right at approximately similar speeds. As the economy moves down and to the right, it gets closer to the green XX^b curve of external balance. As it gets closer to XX^b, the arrow pointing to the right becomes shorter. For example, the arrow pointing to the right at the midpoint of the red path is shorter than the arrow pointing to the right at the beginning of the red path.

At the midpoint of the red path, we also see that the arrow pointing to the right is shorter than the arrow pointing down. The arrow pointing right is shorter because the economy is closer to the green external balance XX^b curve than to the purple internal balance II

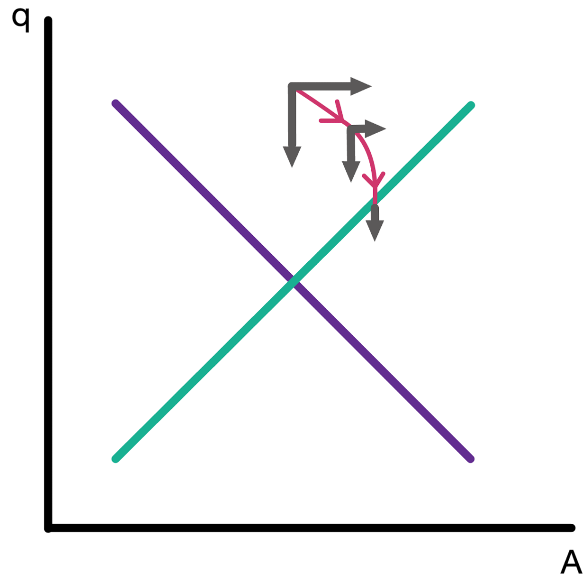


Figure 3.7:

curve. Adjustment toward external balance (moving to the right) is happening at a slower pace than the adjustment toward internal balance (moving down).

When the economy is at the end of the red path, it is on the green XX^b line, so it is in external balance. When the economy is in external balance, there is no force pushing the economy toward higher or lower A, which is why there is no horizontal arrow at that point (equivalently, the arrow has zero length). On the other hand, there still is internal imbalance in the form of overheating, which pushes q down. The economy is therefore moving straight down. The length of the arrow pointing down at the end of the red path is smaller than the two other arrows pointing down in the red path because the economy is closer to internal balance at the end of the red path than at any other point in the path.

The same reasoning applies when the economy finds itself on the purple II line. In this case, there would be no north-south adjustment and the economy would be moving only in the east-west direction toward the green XX^b line. You can try starting the economy in different places and trace the path it follows. The result will always be adjustment dynamics that trace a clockwise spiral path that converges toward the intersection of the II and XX^b curves.

4 Environmental Sustainability

We now look at how to incorporate environmental concerns to the framework. As usual, we simplify the problem, not with the intention of trivializing it, but to have a manageable model that, despite its simplicity, is still useful.

With environmental concerns, we do not see cycles like the ones that arise in the Latin Triangle. The reason is that the environment moves much slower than economic and social events. The slow-moving nature of the environment makes some of the tensions between environmental sustainability and all other goals more dangerous. If the environment were already deteriorating at a fast enough pace, we probably would have taken corrective actions already. Instead, social choices are more focused on the economic and social cycles.

At the end of this section, we discuss the type of technological progress that can help resolve the tension between economic and environmental goals.

4.1 Environment Schedule

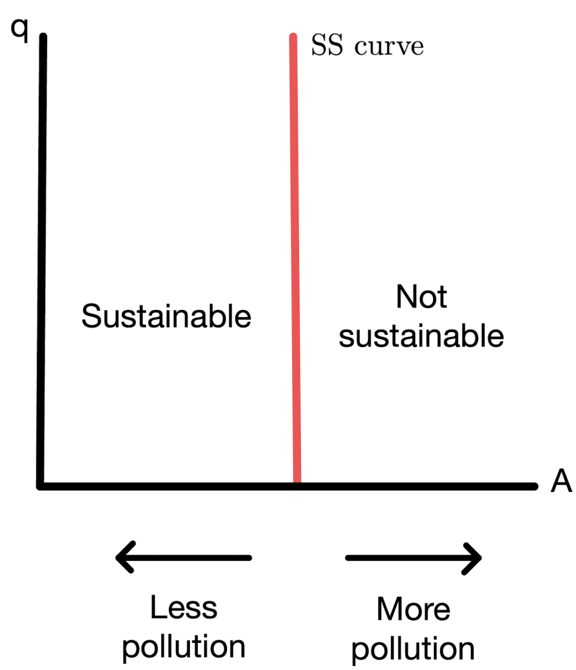


Figure 4.1:

We assume that there exists a level of aggregate demand A below which the impact on the environment is sustainable. This assumption is meant to capture that some of the environmental problems of excessive consumption of natural resources (renewables or not), excessive production and pollution, congestion, and many others, require a large enough level of consumption and investment. We do not assume that sustainability depends on exchange rates – which sounds like a reasonable assumption, especially in the long run. Figure 4.1 shows a diagram that represents the idea of an aggregate level of A below which we have environmental sustainability. We refer to the vertical line that determines this cut-off level of A as the SS curve. To the right of SS, the environment suffers. The more to the right, the more it suffers. To the left of the SS curve, the environment is protected and consumption is sustainable. We have once again simplified and labeled the complex effects that lead to a less sustainable environment as "more pollution", and those that improve the environmental sustainability as "less pollution".

4.2 Kyoto's Triangle

Given the slow-moving nature of the environment, the uncertainty in the speed and type of future technological progress, the scientific disagreements in long-run environmental predictions, and the likelihood and variety of potential policies that may or may not be implemented, it is difficult to know where to place the SS relative to the other curves we have been studying. We will look at the case in which the level of consumption implied by having internal and external balance (the IMF equilibrium) is already too high to be consistent with a sustainable environment. Even if other placements of the SS curve are possible and interesting, the case we look at presents a number of challenges that, to me, seem relevant in today's world and will become even more relevant as time goes by.

Figure 4.2 adds the SS curve to Figure 2.3, with the SS to the left of the IMF equilibrium. The SS goes exactly through the Europe point, but this is not so important. If we move the SS slightly to the left or to the right, other points of intersection would arise among the curves. However, not much would change in terms of the insights we are interested in.

In Figure 4.2, the intersection of the red environmental sustainability SS curve with the purple internal balance II curve is labeled "Kyoto". Now we have four locations to think

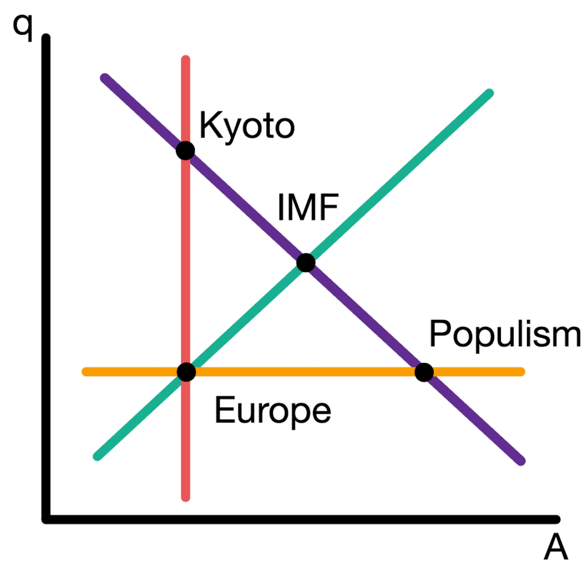


Figure 4.2:

about, each of which has its own challenges. Table 4.1 summarizes them.

At the IMF equilibrium, the economy is in internal and external balance, but it exhibits social tensions and the demand implies the environmental sustainability – polluting, for simplicity – is not attained. In other words, we have economic balance, but neither social nor environmental balance. Even though there is full employment and there are no current account pressures, the economy is unsustainable.

In the point labeled Europe, the country has external balance, the standard of living is relatively high – given the high real wage – and the demand is low enough that the impact in the environment is low enough for sustainability. The only problem is that the country has a relatively large level of unemployment. So, even though the economy is sustainable along the social, environmental, and external balance dimensions, labor markets are in significant disarray. This is sustainable for a while, but the social safety net required to keep the unemployed content is a large burden for the economy.

At the point labeled Populism, political and social concerns are minimal. Real wages are high and employment is at the natural rate. People are very happy regarding economic matters. However, the country is running an unsustainable current account deficit that requires borrowing from foreigners – the equivalent of running down savings. In addition, aggregate demand is so high that the environmental impact is the worse out of the five options we are considering. This is clearly an unsustainable situation. In general, however, the escape valve is the current account. In most cases, a sharp reduction in (or outright shutdown of) foreign lending is what forces the economy to adjust – not the environmental impact.

Finally, the point labeled Kyoto is in many ways similar to Europe. Aggregate demand is low enough that the environmental impact is sustainable. However, instead of workers having to suffer from unemployment, it is real wages that are too low. At the Kyoto point, because wages are depressed, the costs of production are low by international standards, the export sector is very competitive and the current account has a large surplus. The label "Kyoto" is evocative not only of Japan, which is arguably in a low-demand, depressed-wage situation (or used to be until recently), but also of the Kyoto Protocol, one of the first international treaties to reduce greenhouse gas emissions. Saying that wages in Japan are depressed does not mean that wages in Japan are lower than their counterpart in other less developed countries. Wages in Japan are depressed relative to the wages that would prevail at the IMF equilibrium. In other words, wages are below the level required to achieve external balance. Because wages are low, the economy has a current account surplus. This is also an unsustainable situation. First, there is tension in the political system. Second, not all countries in the world can run surpluses – by definition, every surplus must be balanced by a deficit.

	Internal Balance	External Balance	Social Peace	Environment
IMF	✓	✓	Conflict	Pollution
Europe	Unemployment	✓	✓	✓
Populism	✓	Deficit	✓	High Pollution
Kyoto	✓	Surplus	Conflict	✓

Table 4.1:

4.3 Productivity Improvements

Technological improvements can increase production without increasing the use of resources. This is one of the "solutions" to environmental sustainability issues that has received a lot of attention in the public discussion. However, technological improvements have two implications. First, if production increases without using additional resources, the SS shifts to the right, which allows the economy to sustain a larger demand with a smaller impact on the environment. Second, if technological improvements come with an increase in productivity, the full-employment level of output Y^f also increases – the same labor force can now produce more output. Changes in Y^f shift the II curve.

The overall effect of technological improvements depends crucially on how much the SS and II curves shift. Figure 4.3 shows three possibilities. On the left panel, the technological improvement has a relatively large impact on production and a relatively small impact on environmental sustainability. In this case, the IMF equilibrium has higher demand and a lower wage than before, making social unrest more severe. If the change in SS is small enough, even the original IMF equilibrium (at the intersection of the dashed purple initial II curve and the green XX^b) remains unsustainable.

The center panel of Figure 4.3 shows a productivity increase that makes both the SS and the II shift more than in the left panel. If the II did not shift, then the IMF equilibrium would be sustainable. However, the technological improvements have made much more production feasible. The new IMF equilibrium can support a level of demand that is too high to be environmentally sustainable, even after the large shift in the SS.

Last, the right panel of Figure 4.3 shows the kind of technological progress that solves the environmental problems. This kind of "green" technology increases the level of production that is environmentally sustainable without simultaneously increasing demand beyond that new environmentally sustainable point.

The bad news is that social unrest remains in all panels of Figure 4.3. To address social peace and environmental sustainability together, we must consider shifts in the XX^b curve.

Figure 4.4 shows three possibilities when the XX^b curve shifts. These shifts can come from

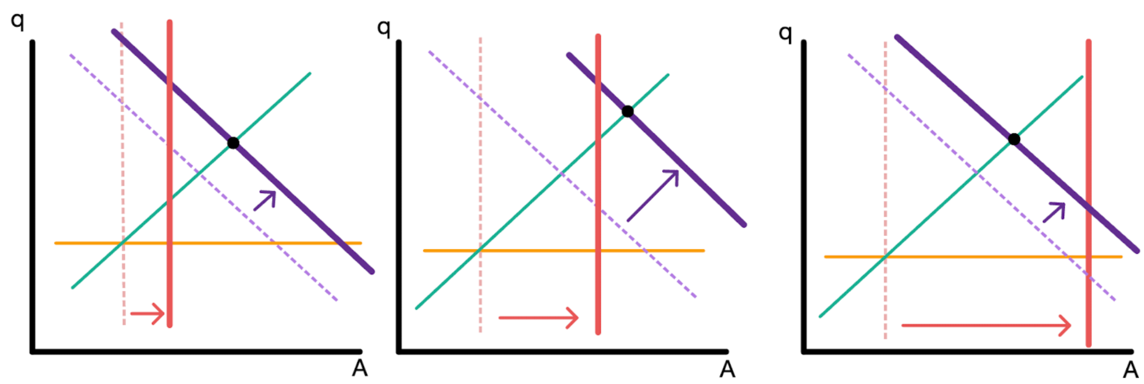


Figure 4.3:

many sources. Here we still consider technological changes, which can induce changes in the level XX^b that is sustainable for the current account, or in foreign demand Y^* if technology diffuses globally.

On the left panel, the technological improvement has a large impact on the XX^b curve but a small impact on environmental sustainability. In this case, the IMF equilibrium implies a much higher standard of living, a higher demand, and, if the improvements are large enough, social peace. On the other hand, the environmental impact, measured by the horizontal distance between the SS curve and the IMF equilibrium, is now larger.

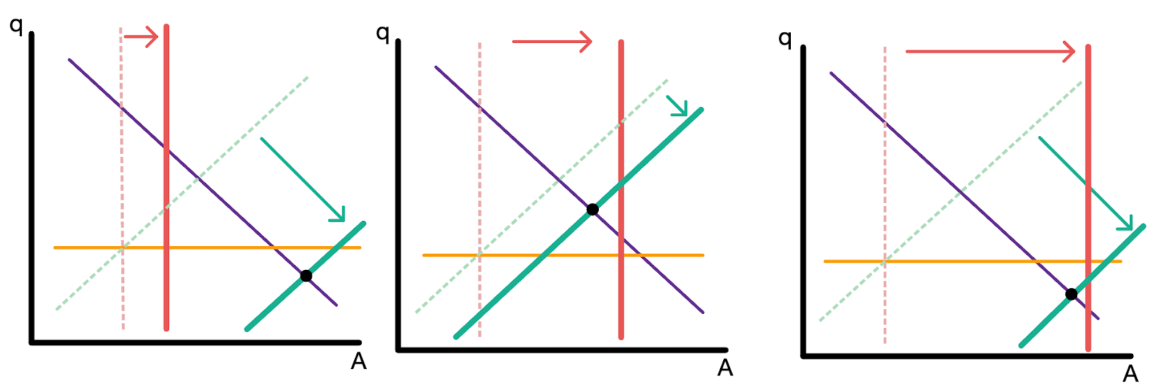


Figure 4.4:

The center panel of Figure 4.4 shows a technological change that makes the SS shift significantly, and the XX^b shift little. The improvement in environmental sustainability is so large that the IMF equilibrium is to the left of the SS. There is no negative environmental outcome associated with this type of technological progress. On the other hand, the Latin

Triangle and its implied cycles are a concern. Even though the environment is sustainable, the economy and the politics are not.

Last, the right panel of Figure 4.4 shows the kind of technological progress that solves both the Latin Triangle and the environmental problems.

1 Appendix

1.1 Labor Market

In this Appendix, we develop a small model of the labor market, taken straight from intermediate macro. You do not need to know this model of the labor market, I will not ask you about it in exams.

In our labor market model, labor is the only factor of production and $Y = N$, as we had assumed above. Since the only factor of production is labor, the marginal cost for firms producing goods and services is the wage W. If markets were perfectly competitive, firms would set the price P equal to marginal cost W and make zero profits. In the real world, there is market power and firms tend to set prices above marginal cost. We capture this idea by the following price-setting relation:

$$P = (1 + m)W. \tag{1.1}$$

where m is the markup. This price setting relation says that firms set the price of their goods based with a markup above their marginal cost W.

Wages are set according to the following wage setting relation:

$$W = P^e F(\underset{(-)}{u}, \underset{(+)}{z}). \tag{1.2}$$

In this wage setting relation, P^e is the expected price level (the price level we expect to hold in the future), u is the unemployment rate, z is a catch-all variable that captures all other elements that influence wages, and F is a function that is decreasing in u and increasing in z (as represented by the plus and minus signs in the formula). There are therefore three elements that determine the wage: P^e, u and z. We briefly explain why they matter for wages:

- Expected price level. The expected price level P^e is an important determinant of the nominal wage because what people and firms really care about is not the nominal wage but the real wage. Workers value money because of the goods and services they can buy with it, not for its own sake. If my nominal wage is $1,000,000 but the price of one apple is $10,000,000, I am not so happy with my gigantic nominal wage. We use P^e rather than P because after wages are set, they usually remain fixed (or closed to fixed) for some time, with wage contracts renegotiated only infrequently. So the relevant price level is the one that will prevail between now and the future time when the wage is renegotiated rather than just the current price level. goods and services that one can afford after W is set are better captured by W/P^e.
- Unemployment. The wage setting equation says that when unemployment is high, wages are low. The reasoning is that when unemployment is high, employers have more bargaining power, since someone seeking a job must compete with a larger pool of unemployed workers. Conversely, when the unemployment rate is low, it is workers who have higher bargaining power, as many firms have to compete to hire among the smaller pool of unemployed people.
- Other factors. The other factors are defined so that when z goes up, wages go up. That F is increasing in z is arbitrary, we could have just as well assumed the opposite and change the meaning of z. One example of a factor that enters z are unemployment benefits. For given u and P^e, higher unemployment benefits make unemployment less painful, so employers must offer a higher wage to attract workers (in this case higher unemployment benefits were associated with a higher z).

Combining (1.1) and (1.2) gives

$$P = (1+m)P^e F(u, z). \tag{1.3}$$

In the long-run, $P = P^e$. Using $P = P^e$ in (1.3) defines the natural rate of unemployment

u^n:

$$1 = (1+m)F(u^n, z).$$

Given u^n, we can find the full-employment level of output Y^f using equation (1.1).

Equation (1.1) implies that the expected real wage is:

$$\frac{W}{P^e} = \frac{1}{1+m}\frac{P}{P^e} \tag{1.4}$$
$$= \frac{1}{(1+m)(1+\pi^e)} \tag{1.5}$$

where I have used the definition of expected inflation $\pi^e \equiv P^e/P - 1$.

1.2 Real uncovered interest parity

Using the definitions of the real exchange rate

$$q \equiv EP^*/P \tag{1.6}$$

and of expected inflation

$$\pi^e \equiv P^e/P - 1, \tag{1.7}$$

we have that

$$\begin{aligned}
\frac{E^e}{E} &= \frac{q^e \frac{P^e}{P^{*e}}}{q \frac{P}{P^*}} \\
&= \frac{q^e}{q}\frac{1}{P^{*e}/P^*}\frac{P^e}{P} \\
&= \frac{q^e}{q}\frac{(1+\pi^e)}{(1+\pi^{e*})} \\
&= \left(1 + \left[\frac{q^e}{q} - 1\right]\right)\frac{(1+\pi^e)}{(1+\pi^{e*})}
\end{aligned}$$

A linear approximation gives

$$\frac{E^e}{E} \approx 1 + \left(\frac{q^e}{q} - 1\right) + \pi^e - \pi^{e*}$$

Using this linear approximation in the uncovered interest parity condition

$$R - R^* = \frac{E^e}{E} - 1$$

gives

$$R - R^* = \left(\frac{q^e}{q} - 1\right) + \pi^e - \pi^{e*}$$

Using the definition of the real interest rate

$$r^e = R - \pi^e, \tag{1.8}$$

we get the real uncovered interest parity condition

$$r^e - r^{e*} = \left(\frac{q^e}{q} - 1\right) \tag{1.9}$$

1.3 Real Wages and Real Exchange Rates

Using (1.8) and (1.9) in (1.5) gives

$$\begin{aligned}\frac{W}{P^e} &= \frac{1}{(1+m)(1+\pi^e)} \\ &= \frac{1}{(1+m)(1+R-r^e)} \\ &= \frac{1}{(1+m)\left(1+R-r^{e*}-\left[\frac{q^e}{q}-1\right]\right)}\end{aligned}$$

A linear approximation gives

$$\begin{aligned}\frac{W}{P^e} &\approx 1 - m - \left(R - r^{e*} - \left[\frac{q^e}{q} - 1\right]\right) \\ &= 1 - m + r^{e*} - R + \left(\frac{q^e}{q} - 1\right)\end{aligned}$$

which shows that, for a given domestic interest rate R, the expected real wage W/P^e is proportional to real expected depreciation $q^e/q - 1$. In turn, for a given expected real exchange rate q^e, real expected depreciation is inversely related to the current real exchange rate q. It follows that, for given R and q^e, the expected real wage W/P^e and the real exchange rate q are inversely related.

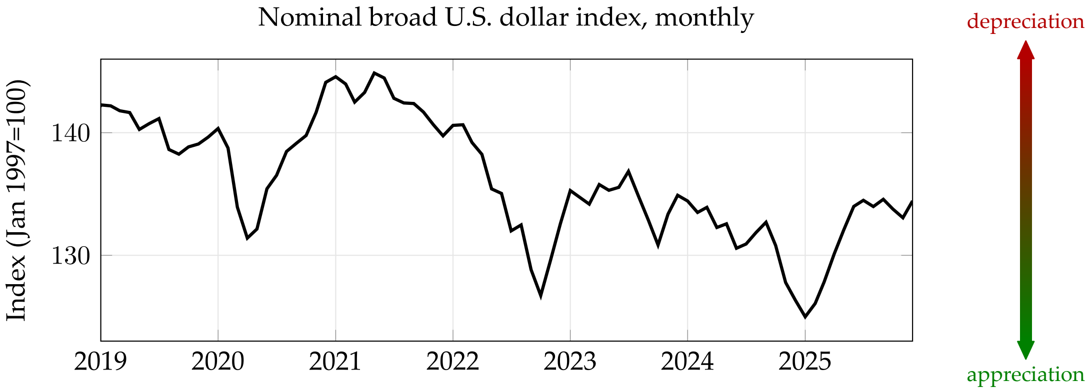
ECON 1550: International Finance

A Tour of the Class

What is International Finance?

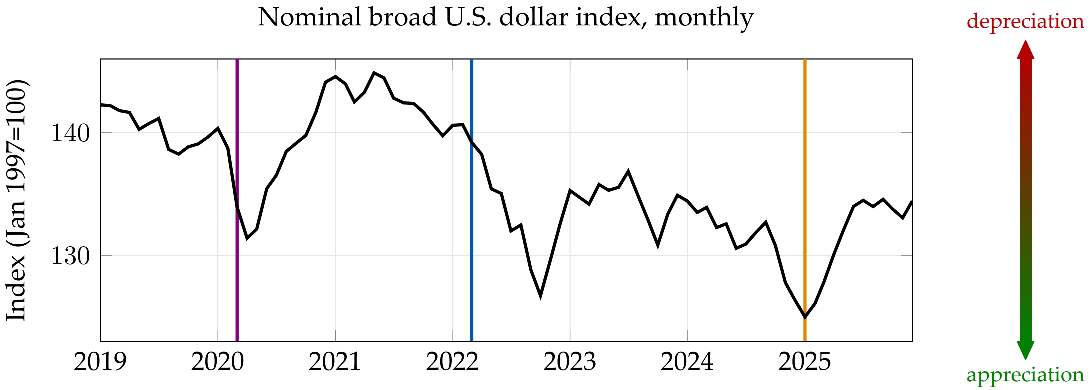
- Extension of Intermediate Macro to open economies
- Open economies:
  - Imports and Exports
  - $Y = C + I + G$ becomes $Y = C + I + G + EX - IM$
- Why finance?
  - Exports and imports must be paid for!
  - If a country imports more than it exports, it must issue IOUs
  - IOUs are *financial assets*
  - $EX - IM$ = change in net foreign wealth

Dollar Exchange Rate: 2019–present



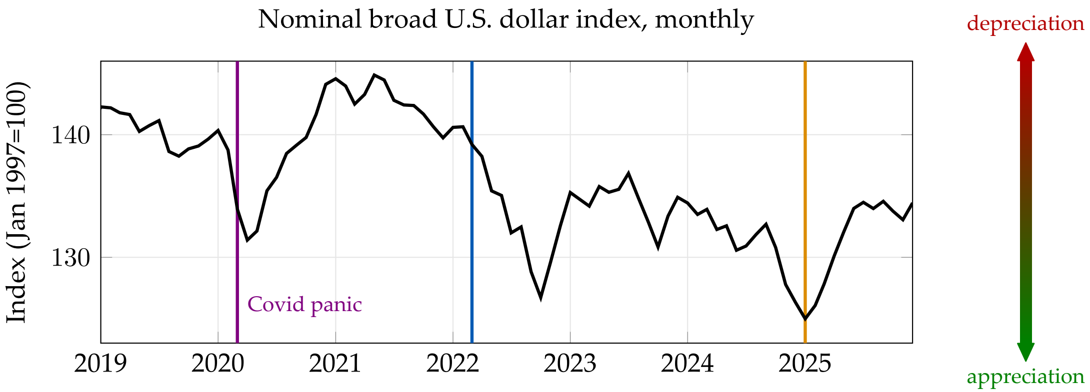
Source: Board of Governors of the Federal Reserve System (US) via FRED (TWEXBMTH and TWEXBGSMTH, spliced).

Dollar Exchange Rate: 2019–present



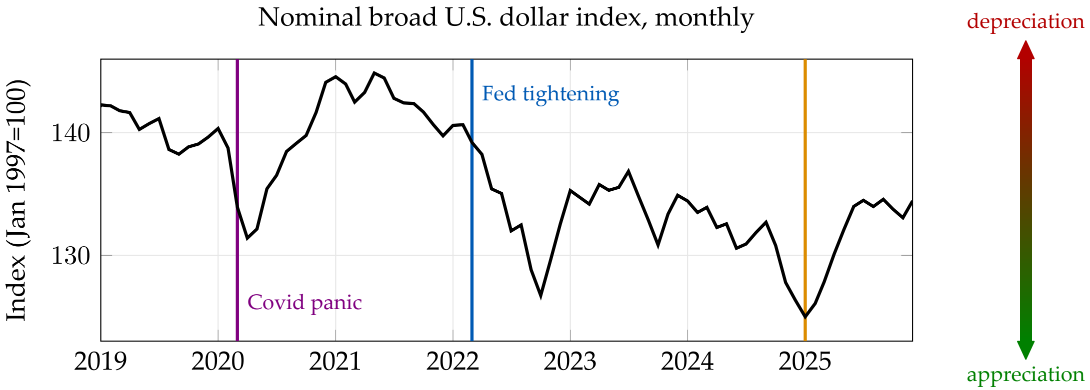
Source: Board of Governors of the Federal Reserve System (US) via FRED (TWEXBMTH and TWEXBGSMTH, spliced).

Dollar Exchange Rate: 2019–present



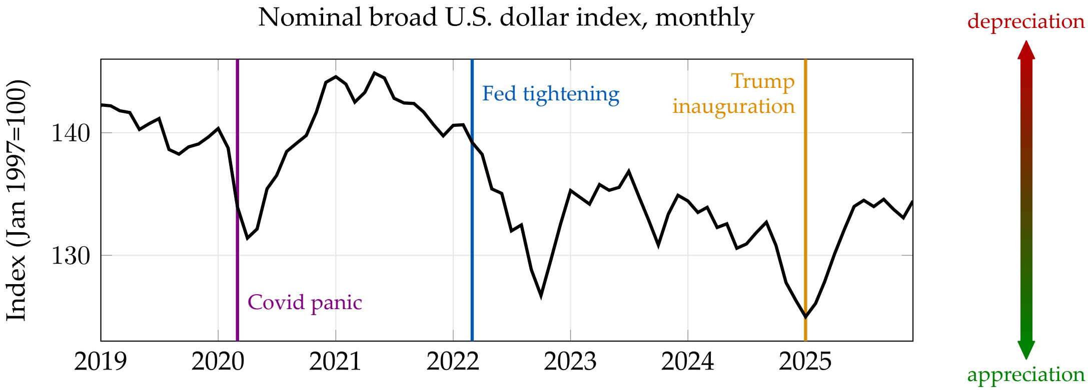
Source: Board of Governors of the Federal Reserve System (US) via FRED (TWEXBMTH and TWEXBGSMTH, spliced).

Dollar Exchange Rate: 2019–present



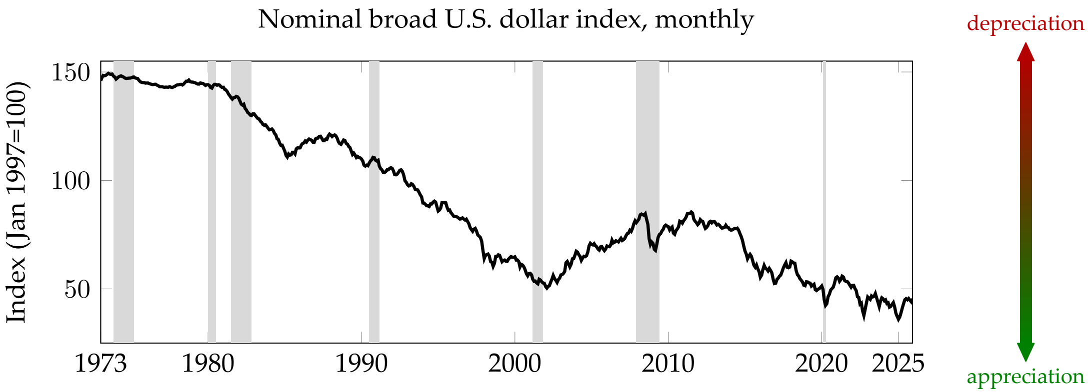
Source: Board of Governors of the Federal Reserve System (US) via FRED (TWEXBMTH and TWEXBGSMTH, spliced).

Dollar Exchange Rate: 2019–present



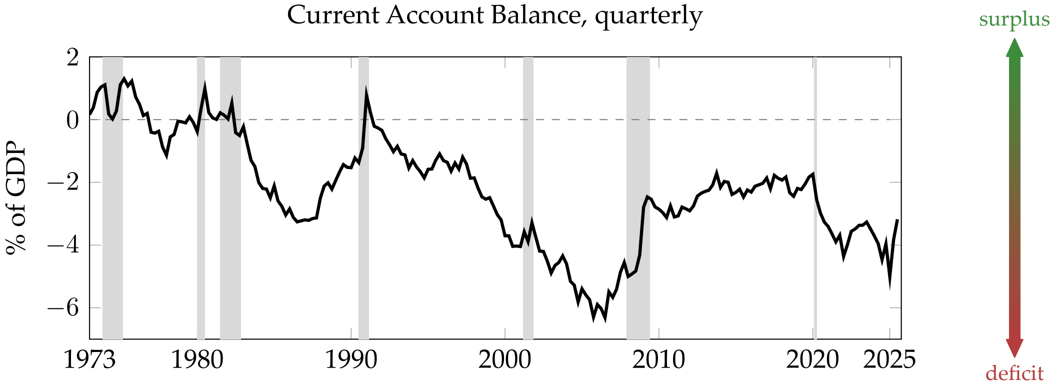
Source: Board of Governors of the Federal Reserve System (US) via FRED (TWEXBMTH and TWEXBGSMTH, spliced).

Dollar Exchange Rate: 1973–present

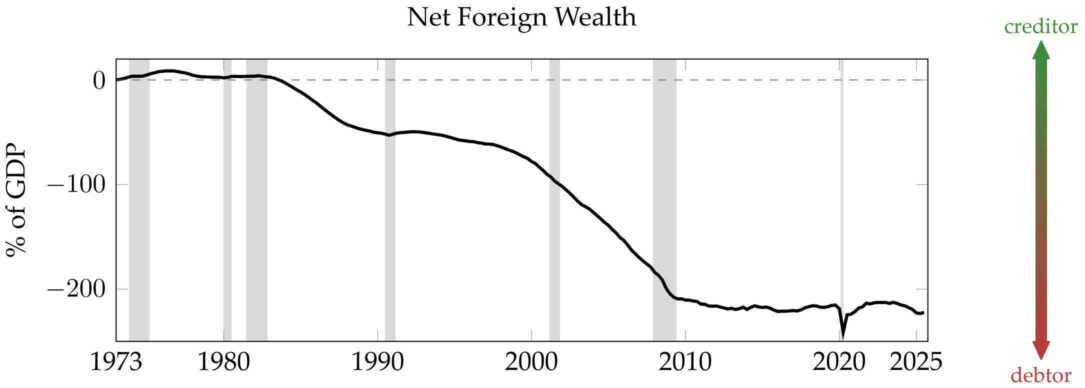


Source: Board of Governors of the Federal Reserve System (US) via FRED (TWEXBMTH and TWEXBGSMTH, spliced).

U.S. Current Account Balance: 1973–present

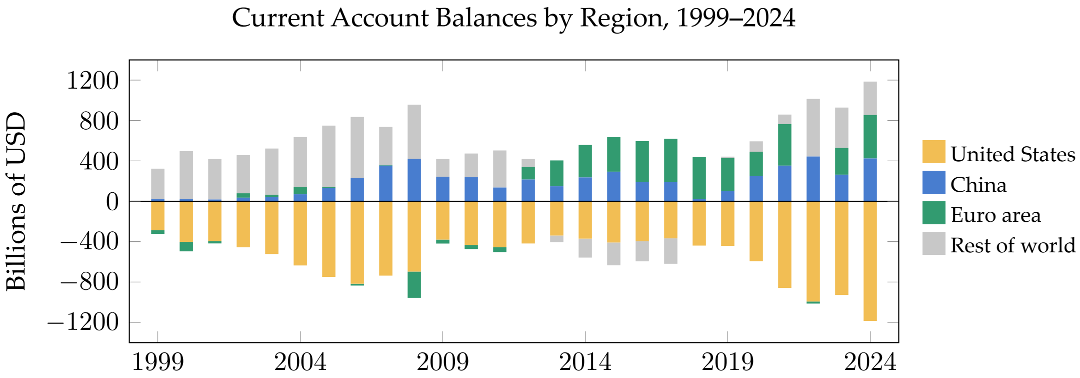


Net Foreign Wealth



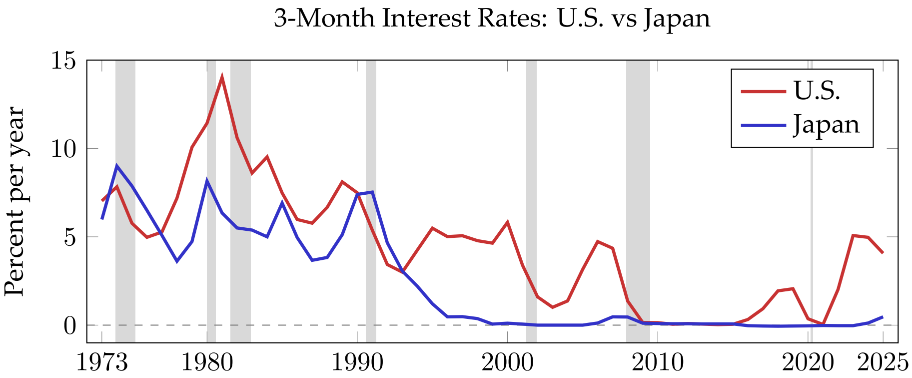
Source: BEA via FRED (NETFI, GDP). Constructed NFW = cumulative current account / GDP.

Global External Imbalances



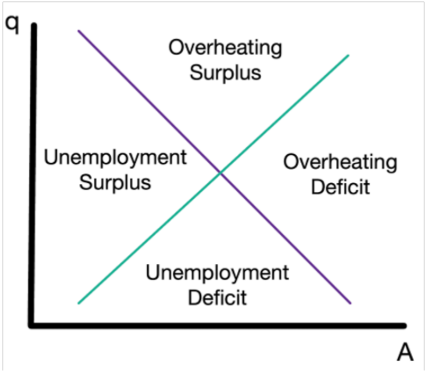
Source: IMF DataMapper API, WEO, indicator BCA (current account balance, billions USD). Rest of world = residual to balance global accounts.

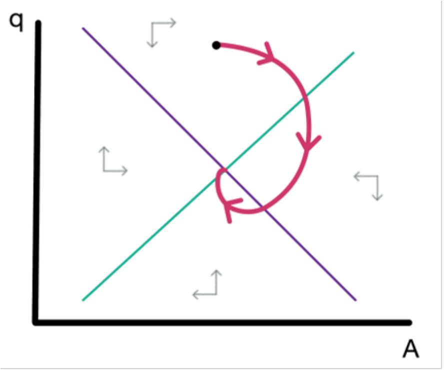
Large Interest Rate Differentials



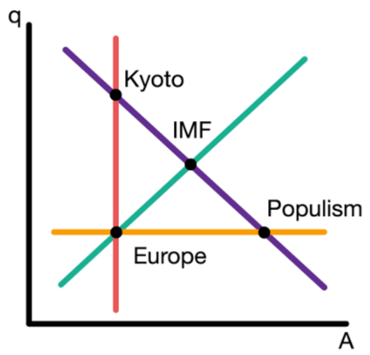
Source: FRED. US: TB3MS (3-month T-bill). Japan: IRSTCB01JPM156N (central bank rate, 1973–84), IRSTCI01JPM156N (call money rate, 1985–present). Annual averages.

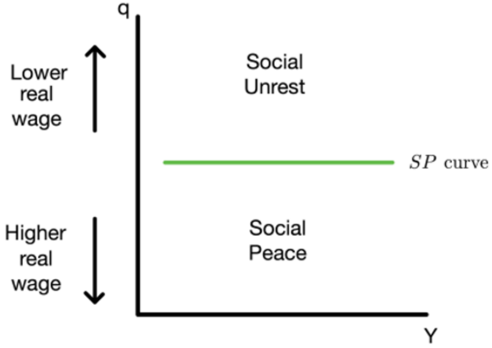
Exchange Rate Dynamics





Policy Trade-offs





Takeaways

- **To remember:** International finance connects exchange rates, trade balances, interest rates, and policy choices

- **To do for Friday:**
  - Read the note “Models in Economics”
  - Complete the “Getting Started” module on Canvas

ECON 1550: International Finance

Models in Economics

Bottom line to remember

"All models are wrong, some models are useful"

Example: Uncovered Interest Parity (UIP)

$$R_{\$} = R_{¥} + \frac{E^e_{\$/¥} - E_{\$/¥}}{E_{\$/¥}}$$

- Does not fit the data well
- We can still use it to determine $E_{\$/¥}$ given $R_{\$}$, $R_{¥}$, and $E^e_{\$/¥}$
- Combined with goods and money market equilibrium, we can understand (some or all) effects of monetary policy on $E_{\$/¥}$

Example: UIP (continued)

$$R_{\$} = R_{¥} + \frac{E^e_{\$/¥} - E_{\$/¥}}{E_{\$/¥}} + rp$$

- How much did we miss? Add an error term and call it **risk premium**
- If rp is independent of monetary policy, we did not miss anything
- If rp depends on monetary policy, we still captured one channel

Types of Variables

Endogenous

- Explained within the model

Exogenous

- Taken as given
- Not explained by the model

Parameters

- Exogenous; do not depend on policy

Types of Equations

Identities	• Hold by definition or construction
Behavioral	• Capture behavior that we include in a model • Hold by assumption
Equilibrium conditions	• Supply equals demand • Hold by "economic logic"

Solving a Model, Solving for a Variable

- "Solving for a variable" means expressing that variable in terms of exogenous variables only

- "Solving a model" means solving for all endogenous variables

Example 1

Exogenous variables

Variable	Description
T	taxes
Y	income
c_1	marginal propensity to consume

Endogenous variables

Variable	Description	Equation	Type of equation
C	consumption	$C = c_1 Y_D$	behavioral
Y_D	disposable income	$Y_D \equiv Y - T$	identity

Solution and Intuition

Example 2

Exogenous variables

Variable	Description
C	consumption
Y	income
c_1	marginal propensity to consume

Endogenous variables

Variable	Description	Equation	Type of equation
T	taxes	$Y_D \equiv Y - T$	identity
Y_D	disposable income	$C = c_1 Y_D$	behavioral

Solution and Intuition

Example 2

Exogenous variables

Variable	Description
C	consumption
Y	income
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Endogenous variables

Variable	Description	Equation	Type of equation
T	taxes	$Y_D \equiv Y - T$	identity
Y_D	disposable income	$C = c_1 Y_D$	behavioral

Solution and Intuition

Shocks

- Changes in exogenous variables
- Including changes in parameters
- Usually unforeseen, unforeseeable, or random

ECON 1550: International Finance

IS-LM-PC in one day

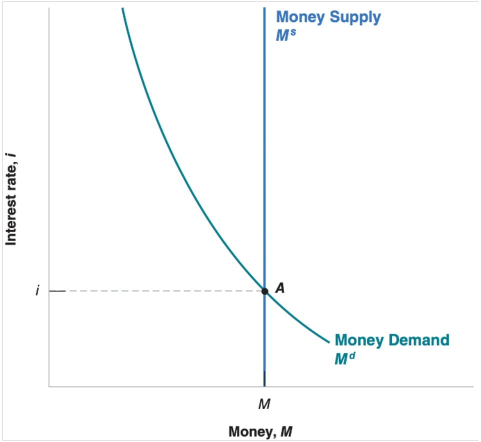
Announcements

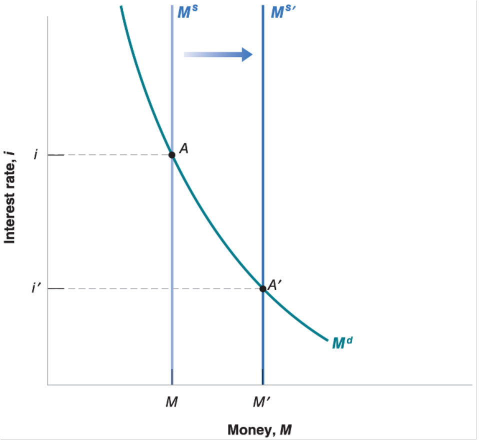
- Problem Set 1 due next Wednesday
- Read pages 13–23 of textbook before Friday lecture
- Office hours for this week on Canvas
- Section will be announced
- Review of Intermediate Macro note posted on Canvas

Agenda

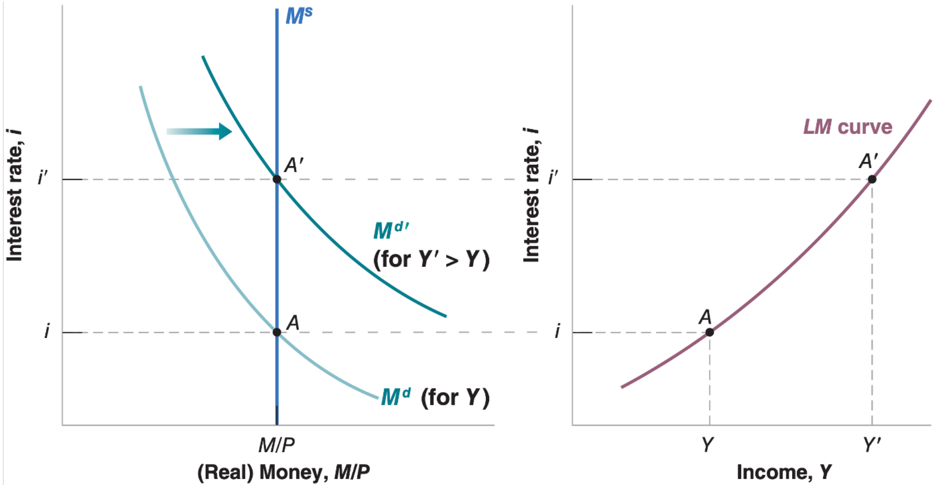
- Close loop on Tour of the class and models
- IS-LM
- IS-LM-PC

Exogenous money supply…

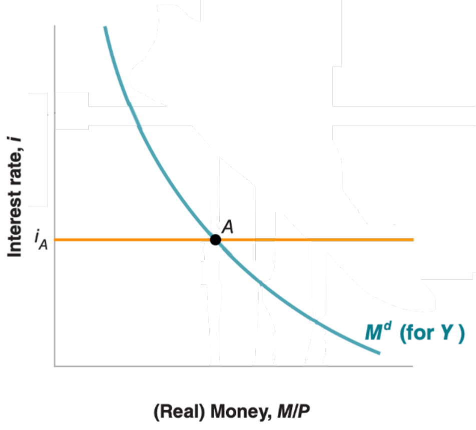


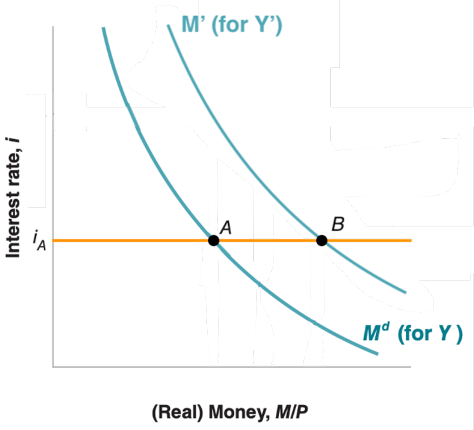


…leads to an upward sloping LM

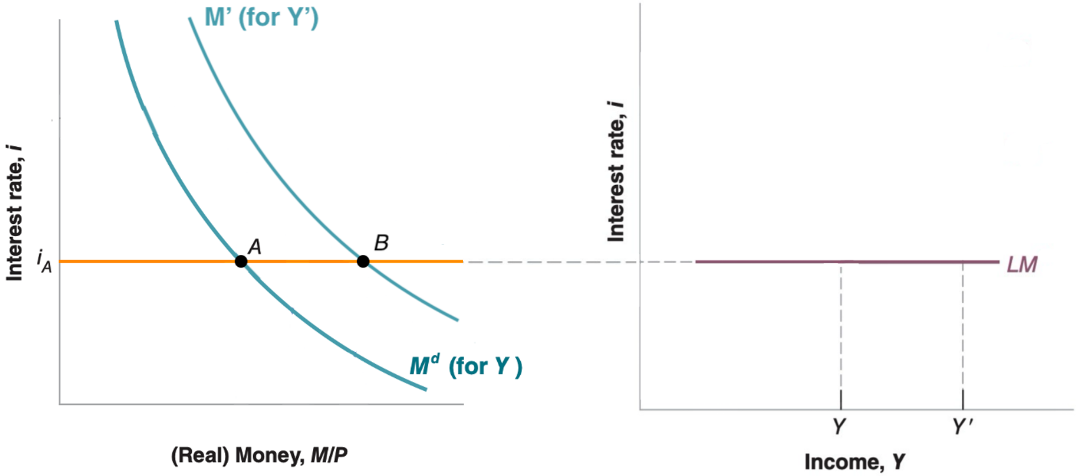


Exogenous interest rates…

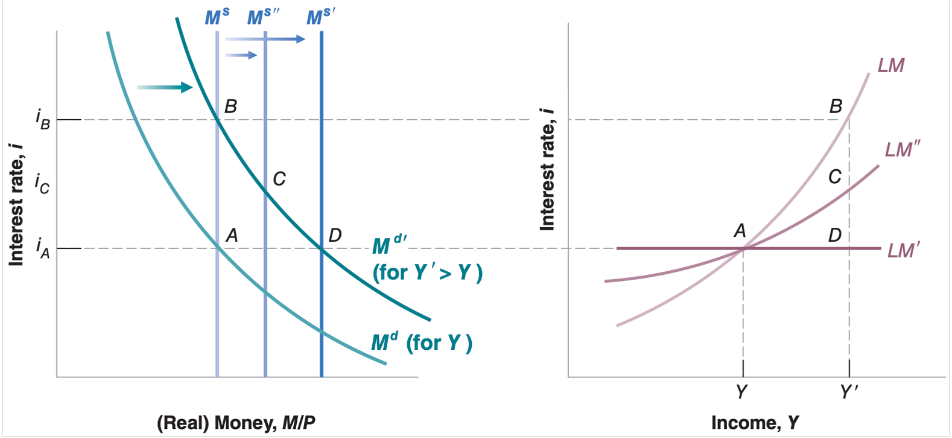




…lead to a flat LM



Endogenous Money Supply



A Model for the Labor Market

(Wage setting)	$W = P^e F(u, z)$
(Price setting)	$P = (1 + m)W$
(Definition of expected inflation)	$\pi^e = P^e/P - 1$
(Linear function F)	$F(u, z) = 1 - \alpha u + z$

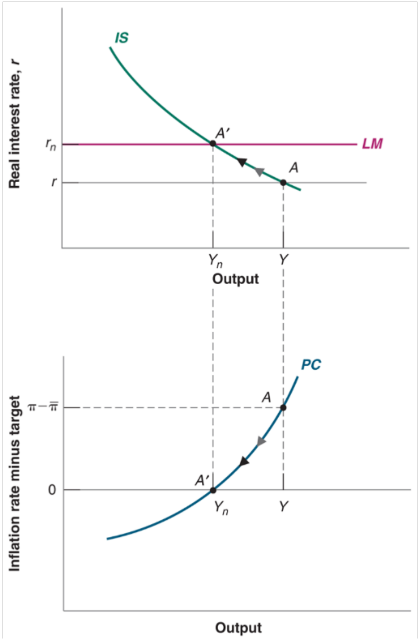
Phillips Curve

- Three equivalent forms

$$\pi = \pi^e - \alpha(u - u^n)$$

$$\pi = \pi^e + \alpha(Y - Y^n)$$

$$\pi = \pi^e + (m + z) - \alpha u$$



ECON 1550: International Finance

National Income Accounting for Open Economies

Announcements

- Problem Set 1 due today before midnight
- Solutions and Problem Set 2 posted right after
- Read pages 58–67 of textbook before Wednesday lecture
- Fill in survey for office hours and section (right now!)

Office Hours and Section Availability

Please fill in your availability:

https://www.when2meet.com/?34820140-APJfJ

Agenda

- Balance of payments account
- Exchange rate determination with asset approach

Macro Review: GDP

Gross Domestic Product (GDP) measures the total value of:

- **Production:** All final goods and services produced within a country
- **Income:** All income earned from production within a country
- **Value added:** Sum of value added at each stage of production

All three approaches yield the same number.

Closed Economy

$$Y = C + I + G$$

- All output is either consumed, invested, or purchased by government
- No trade with the rest of the world

Open Economy with GDP

$$GDP = C + I + G + \underbrace{EX - IM}_{NX}$$

- EX = Exports (domestic goods sold abroad)
- IM = Imports (foreign goods purchased domestically)
- NX = Net exports (trade balance)

GDP and GNP

- **GDP:** Value of production *within a country's borders*
  - Regardless of who owns the factors of production
- **GNP:** Value of production by *a country's residents*
  - Regardless of where production takes place
- **Relationship:**

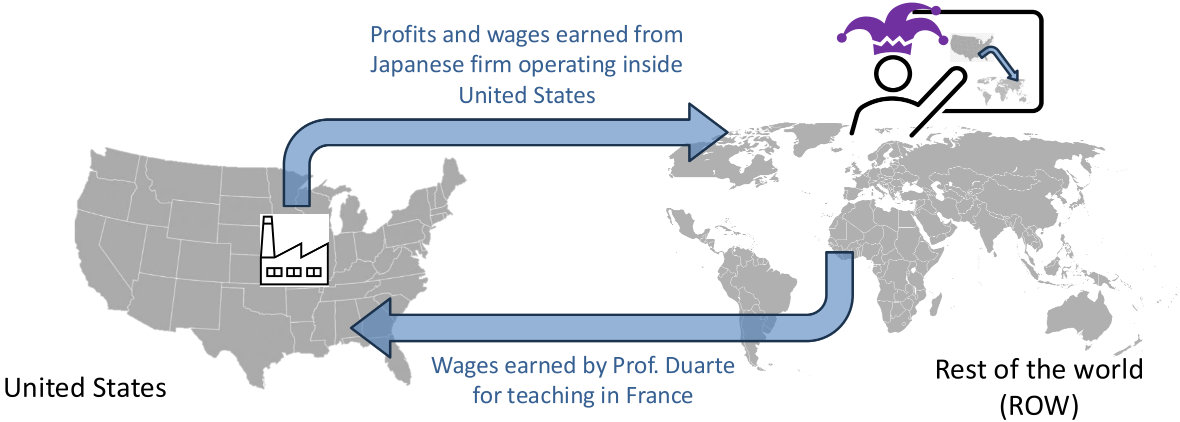
$$\text{GNP} = \text{GDP} + \text{Net Income from Abroad}$$

Open Economy with GNP

$$GNP = C + I + G + CA$$

- CA = Current account
- $CA = NX +$ Net income from abroad

GDP and GNP



Net Income = wages from Prof. Duarte teaching in France – profits and wages from firm operating inside US

United States GNP = United States GDP + Net Income

National Saving: Closed Economy

National saving = output not used for consumption or government spending

$$
\begin{aligned}
S &\equiv Y - C - G \\
&= (C + I + G) - C - G \\
&= I
\end{aligned}
$$

In a closed economy: $S = I$

National Saving: Open Economy

Starting from $Y = C + I + G + NX$:

$$S \equiv Y - C - G$$

$$= I + NX$$

In an open economy: $S = I + NX$

National Saving: Open Economy

Rearranging: $S - I = NX$

- If $S > I$: Trade surplus, country is a net lender
- If $S < I$: Trade deficit, country is a net borrower

Private Saving

Private saving = disposable income that is saved, not consumed

$$S^p \equiv Y - T - C$$

Public (Government) Saving

Government saving = tax revenue minus government spending

$$S^g \equiv T - G$$

- If $T > G$: Budget surplus ($S^g > 0$)
- If $T < G$: Budget deficit ($S^g < 0$)

Total Saving

Total national saving:

$$
\begin{aligned}
S &= S^p + S^g \\
&= (Y - T - C) + (T - G) \\
&= Y - C - G
\end{aligned}
$$

Using $S = I + NX$ from before, we get:

$$S^p + S^g = I + NX$$

Balance of Payments

Current Account	-200
Capital Account	-1
Financial Account	-201

$$\begin{array}{ccccc} \text{Current Account} & + & \text{Capital Account} & = & \text{Financial Account} \\ (-200) & + & (-1) & = & -201 \end{array}$$

Balance of Payments

Current Account	-200
Capital Account	-1
Financial Account	-201
Statistical discrepancy	0

$$\begin{matrix} \text{Statistical} \\ \text{Discrepancy} \end{matrix} = \begin{matrix} \text{Financial} \\ \text{Account} \end{matrix} - \left(\begin{matrix} \text{Current} \\ \text{Account} \end{matrix} + \begin{matrix} \text{Capital} \\ \text{Account} \end{matrix} \right)$$

$$0 = -201 - [\ (-200) + (-1)\ ]$$

U.S. Balance of Payments Accounts for 2025-Q3	($ bn)
Current Account	-226
Capital Account	-1
Financial Account	-410
Statistical discrepancy	-183

$$\begin{array}{ccccccccc} \text{Statistical Discrepancy} & = & \text{Financial Account} & - & \Big(& \text{Current Account} & + & \text{Capital Account} & \Big) \\ -183 & = & -410 & - & [& (-226) & + & (-1) &] \end{array}$$

Source: BEA

Current Account

1	Exports total
2	Goods
3	Services
4	Income receipts (primary income)
5	Imports total
6	Goods
7	Services
8	Income payments (primary income)
9	Net unilateral transfers (secondary income)
10	**Balance on current account**

Capital Account

11	Balance on capital account

Financial Account

12	Net U.S. acquisition of foreign financial assets
13	Official reserve assets
14	Other assets
15	Net U.S. incurrence of domestic liabilities
16	Official reserve assets
17	Other liabilities
18	Financial derivatives, net
19	**Net financial flows**
20	**Statistical discrepancy**

Bottom line to remember

Whenever goods cross borders, assets move in the opposite direction.

ECON 1550: International Finance

Exchange Rates and the Foreign Exchange Market: An Asset Approach

A model of exchange rate determination

Exogenous variables

Variable	Description
R	Domestic interest rate
R^*	Foreign interest rate
E^e	Expected exchange rate

Endogenous variables

Variable	Description	Equation	Type of equation
E	Exchange rate	$R = R^* + \frac{E^e - E}{E}$	Equilibrium condition

A model of exchange rate determination

- Two investment opportunities
  - Domestic bond with return $R_\$$ in Dollars
  - Foreign bond with return R^* in Euros

- To be indifferent between the two investments, the **uncovered interest parity condition** must hold:

$$\text{(UIP):}\;\; R_\$ = R^* + \frac{E^e_{\$/\text{EUR}}}{E_{\$/\text{EUR}}} - 1$$

Exchange Rates

Bonds

Realized vs Expected Returns

Expected Returns of Foreign Bond

Approximations

Uncovered Interest Parity

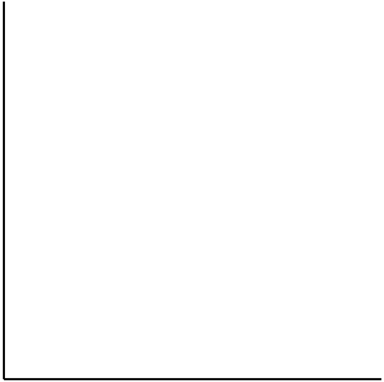
- For both strategies to have the same expected return

$$1 + R_{\$} = \frac{E^e_{\$/\mathrm{EUR}}}{E_{\$/\mathrm{EUR}}}(1 + R^*)$$

- Approximating

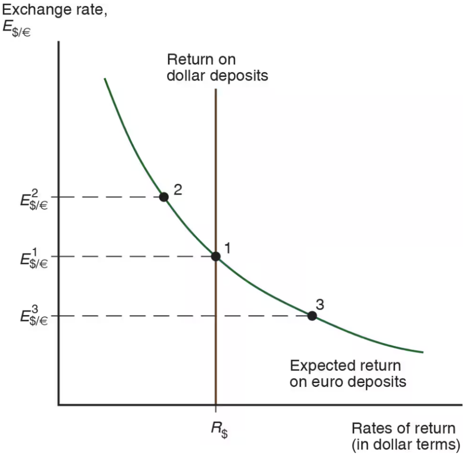
$$R_{\$} = R^* + \frac{E^e_{\$/\mathrm{EUR}}}{E_{\$/\mathrm{EUR}}} - 1$$

Equilibrium in Foreign Exchange Market



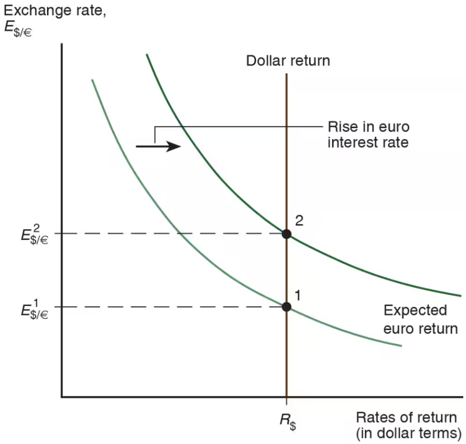
$$\text{UIP: } R_{\$} = R^* + \frac{E^e_{\$/\text{EUR}}}{E_{\$/\text{EUR}}} - 1$$

Equilibrium in Foreign Exchange Market



$$\text{UIP: } R_\$ = R^* + \frac{E^e_{\$/\mathrm{EUR}}}{E_{\$/\mathrm{EUR}}} - 1$$

Shocks: Rise in Euro Interest Rate



The carry trade

- Borrowing at "low" rate R and lending at "high" rate R^* is a **carry trade**

$$\begin{array}{c}\text{expected return}\\ \text{on carry trade}\end{array} = R^* + \left(\frac{E^e}{E} - 1\right) - R + \text{risk premium}$$

- Risk: Future exchange rate is not known when we start the carry trade, E^e can be different from the realized future exchange rate

Empirical Failure of UIP

Eight currency portfolios sorted by interest rate differential (portfolio 1 = lowest rates, portfolio 8 = highest).

High interest rate currencies earn higher mean excess returns and have higher Sharpe ratios.

Annual data, 1953–2002, US investor perspective.

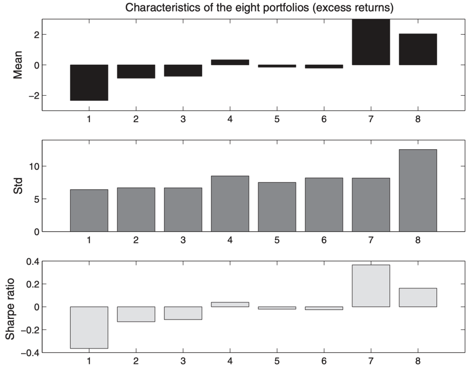


Figure 1. Eight Currency Portfolios

Source: Lustig & Verdelhan (2007), *American Economic Review*

Explanations For Carry Risk Premium

- Crash risk / peso problem
- Correlation with consumption
- Global Volatility Risk
- Liquidity
- Constrained intermediaries

Crash Risk

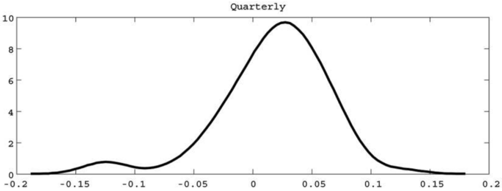


Fig. 1. U.S. dollar/Japanese yen exchange rate from 1996 to 2000

Kernel density of excess returns on a carry trade portfolio (long three high interest currencies, short three low interest currencies). Right: USD/JPY exchange rate, 1996–2000.

Source: Brunnermeier, Nagel, and Pedersen (2008), *NBER Macroeconomics Annual*

Consumption Risk

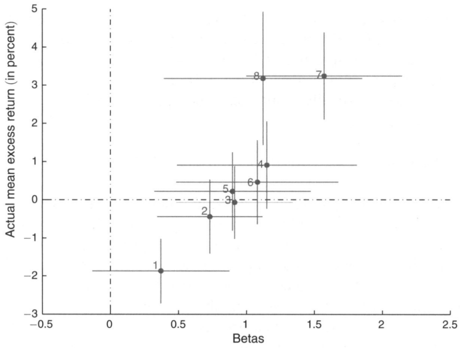


FIGURE 3. DURABLE CONSUMPTION GROWTH BETAS AND AVERAGE CURRENCY EXCESS RETURNS

The dots represent point estimates; the lines represent one standard deviation above and below. The sample is 1953–2008, annual data. Higher consumption betas correspond to higher currency excess returns.

Source: Lustig & Verdelhan (2011), *American Economic Review*

Global Volatility Risk

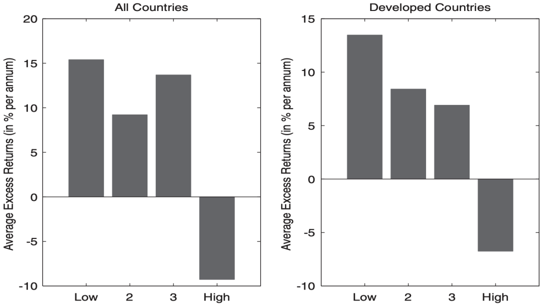
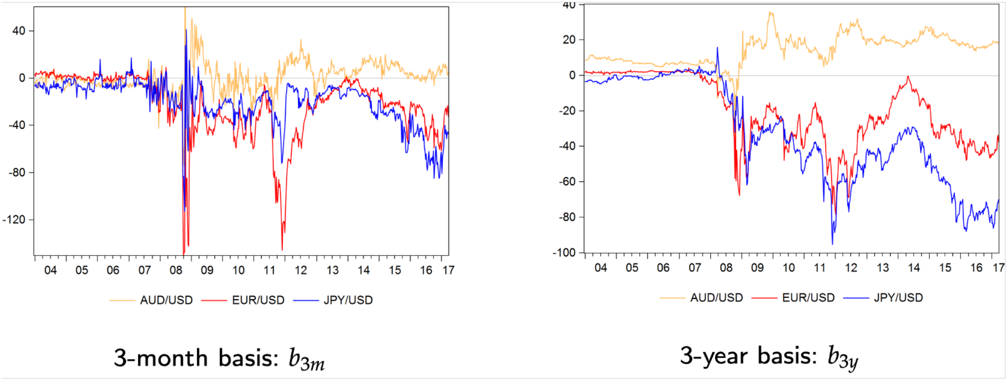


Figure 2. Excess returns and volatility. The figure shows mean excess returns for carry trade portfolios conditional on global FX volatility innovations being within the lowest to highest quartile of its sample distribution (four categories from "Low" to "High" shown on the x-axis of each panel). The bars show average excess returns for being long in portfolio 5 (largest forward discounts) and short in portfolio 1 (lowest forward discounts). The left panel shows results for all countries, while the right panel shows results for developed countries. The sample period is November 1983 to August 2009.

Mean excess returns for carry trade portfolios conditional on global FX volatility innovations being within the lowest to highest quartile. Carry trade earns high returns when volatility is low, but suffers large losses when volatility is high.

Source: Menkhoff, Sarno, Schmeling, and Schrimpf (2012), *Journal of Finance*

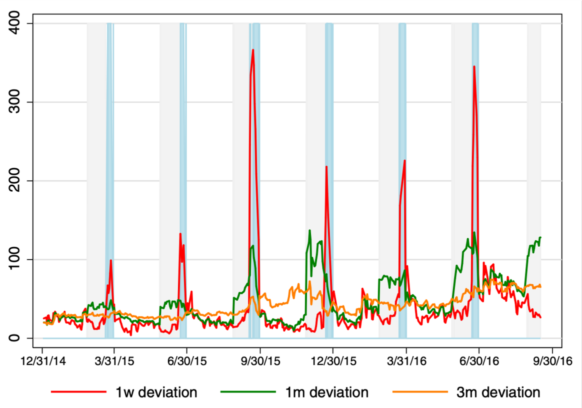
Violations of *Covered* Interest Parity

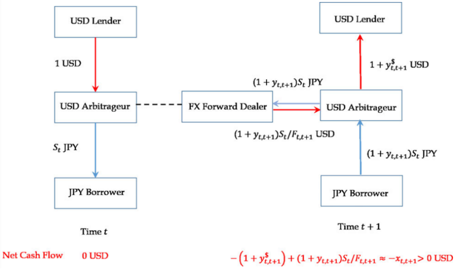


Source: Sushko, Borio, McCauley, and McGuire, "The Failure of Covered Interest Parity"

Intermediaries are Constrained

Illustration of quarter-end dynamics of CIP deviations.





Source: Du, Tepper, and Verdelhan, "Deviations from Covered Interest Rate Parity," *Journal of Finance*

ECON 1550: International Finance

Money, Interest Rates, and Exchange Rates

A model of the money market

Exogenous variables

Variable	Description
Y	Real income
M^s	Money supply
P	Price level

Endogenous variables

Variable	Description	Equation	Type of equation
R	Domestic interest rate	$M^d/P = L(R, Y)$	Behavioral equation
M^d	Money demand	$M^d = M^s$	Equilibrium condition

Description of the Money Market

- There are only two assets: money and domestic bonds
- Money
  - Can be used for transactions
  - Pays no interest
- Bonds
  - Cannot be used for transactions
  - Pay interest $i \geq 0$

Money Demand

- Money demand is higher when:
  - Higher price level $P \rightarrow$ need more money to buy goods
  - Lower nominal interest rate $R \rightarrow$ bonds less attractive
  - Higher income $Y \rightarrow$ want more money to buy more

- Capture idea with a behavioral equation

$$M^d = P \times L(\underset{(-)}{R}, \underset{(+)}{Y})$$

Real money demand

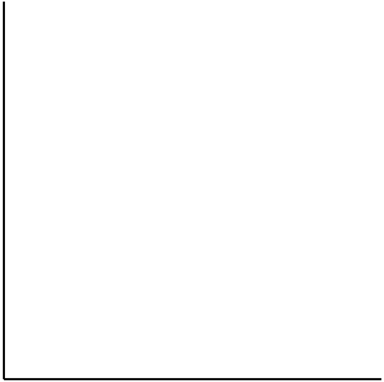
- Convenient to write in terms of real money demand

$$\frac{M^d}{P} = L(R, Y)$$

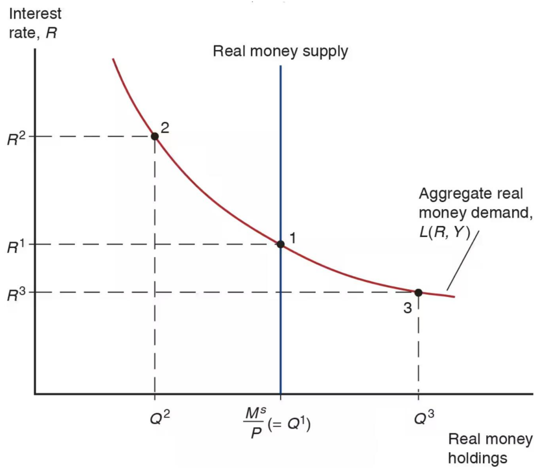
and real money supply

$$\frac{M^s}{P}$$

Equilibrium in money market



Equilibrium in money market



Money is defined by its function

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

Many types of money 1/2

- Commodity money: a physical commodity (like gold) that is used as money

- Convertible paper money: a piece of paper that can be exchanged by a commodity

Many types of money 2/2

- Fiat money: issued by a central bank, not backed by any commodity
- Digital currency: not backed by any commodity, privately issued, electronic payments

Fiat money

1. Central bank liabilities are special because they are the unit of account.
2. Currency is a promise to deliver future central bank liabilities.

Assets	Liabilities
\$0	\$0

$t = 0$

Assets	Liabilities
\$1 currency	\$1 money

$t = 1$

Assets	Liabilities
\$1 bonds	\$1 money

$t = 2$

Monetary policy

- Deposits at the Fed are called reserves
- “The” interest rate is just interest on reserves

ECON 1550: International Finance

Money, Interest Rates, and Exchange Rates

A model of the money market

Exogenous variables

Variable	Description
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M^s	Money supply
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Endogenous variables

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  - Pay interest $R \geq 0$

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Real money demand

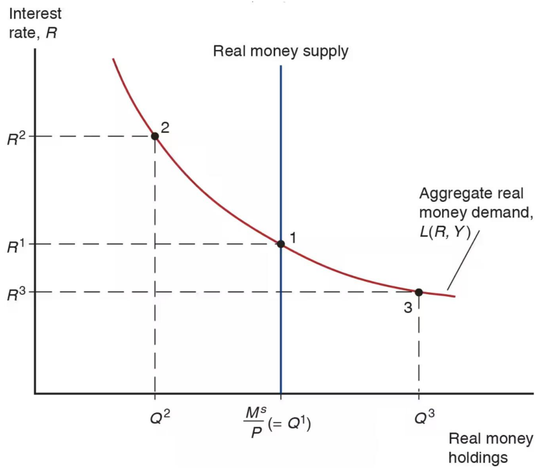
- Convenient to write in terms of real money demand

$$\frac{M^d}{P} = L(R, Y)$$

and real money supply

$$\frac{M^s}{P}$$

Equilibrium in money market



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Many types of money (1/2)

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$t = 0$

Assets	Liabilities
\$1 currency	\$1 money

$t = 1$

Assets	Liabilities
\$1 bonds	\$1 money

$t = 2$

Monetary policy

- Deposits at the Fed are called reserves
- “The” interest rate is just interest on reserves

Short-run FX and money market model

Exogenous variables

Variable	Description
R^*	Foreign interest rate
E^e	Expected exchange rate
Y	Real income
M^s	Money supply
P	Price level

Endogenous variables

Variable	Description	Equation	Type of equation
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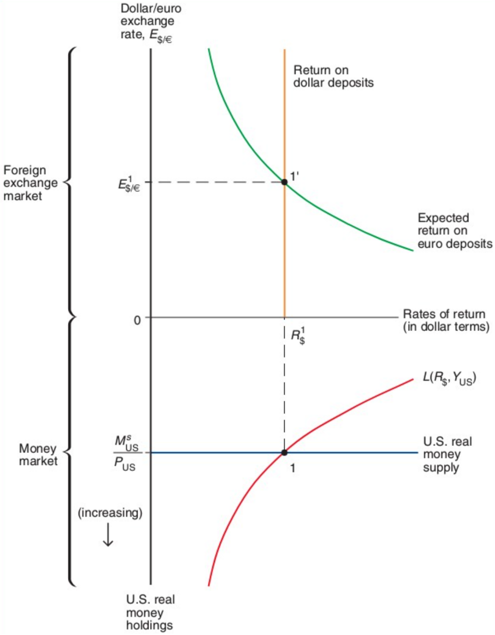
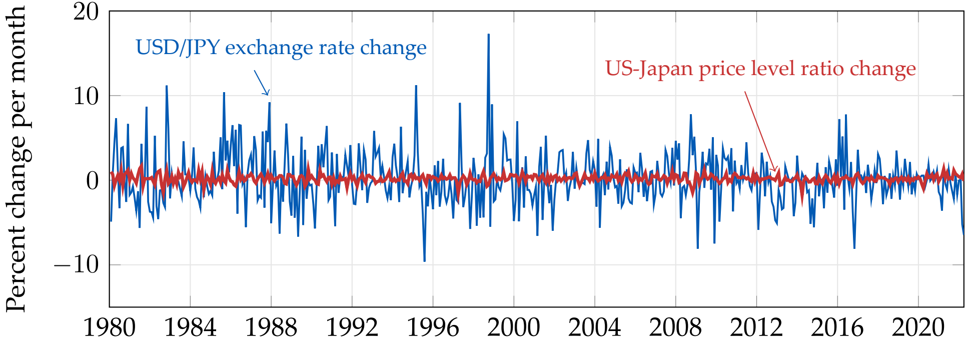
R	Domestic interest rate	$M^d/P = L(R, Y)$	Behavioral equation
M^d	Money demand	$M^d = M^s$	Equilibrium condition

Short-run equilibrium in FX and money markets



Exchange rates are very volatile



Source: FRED/CPIAUCSL; FRED/CPALCY01JPM661N; FRED/DEXJPUS (end-of-month, inverted to USD/JPY).

Conceptual definition of long-run equilibrium

- Hypothetical equilibrium that would result if economy runs indefinitely with no shocks

- Equivalently, the hypothetical equilibrium that would occur if prices were perfectly flexible and always adjusted instantaneously and frictionlessly

Definition of the long run in the model

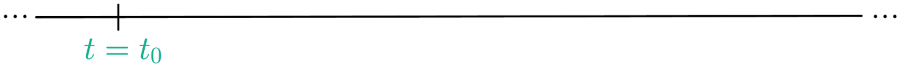
1. In the long run, $E = E^e$
   - By definition of the long run, all variables constant
   - By assumption of rational expectations, expectations must be correct in the long run
   - In the model, it means $E_{LR} = E^e_{LR}$

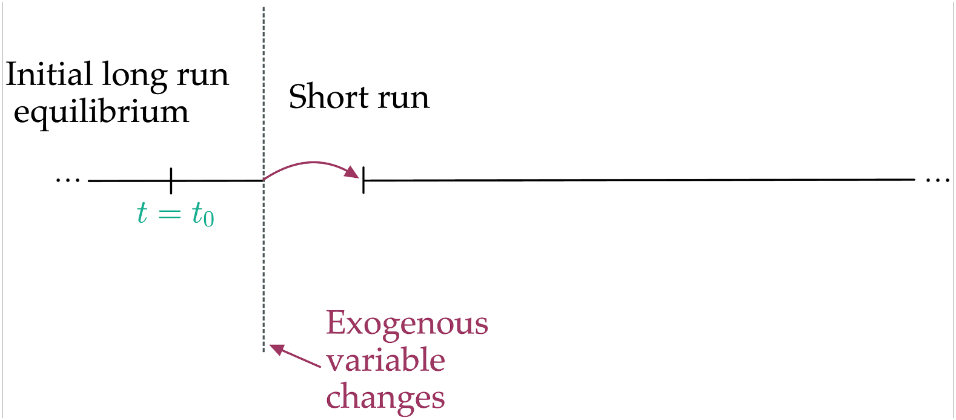
Assumptions about the short run

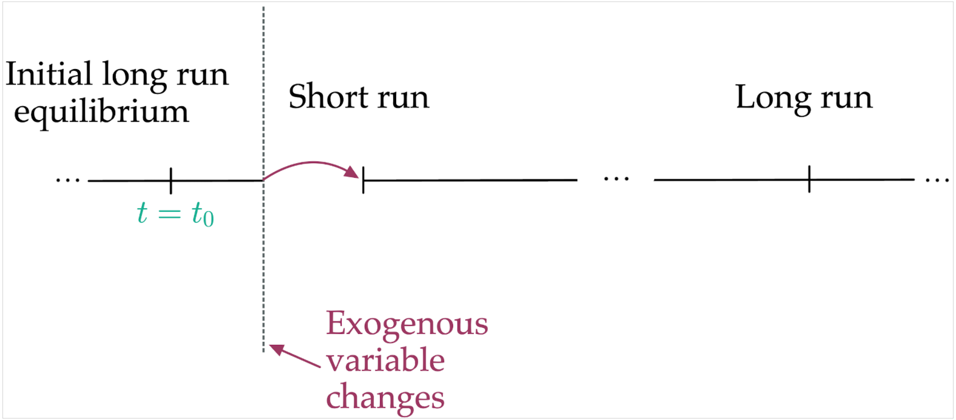
1. In the short run, P is fixed
   - Because prices are "sticky"
   - In the model, it means $P_0 = P_{SR}$

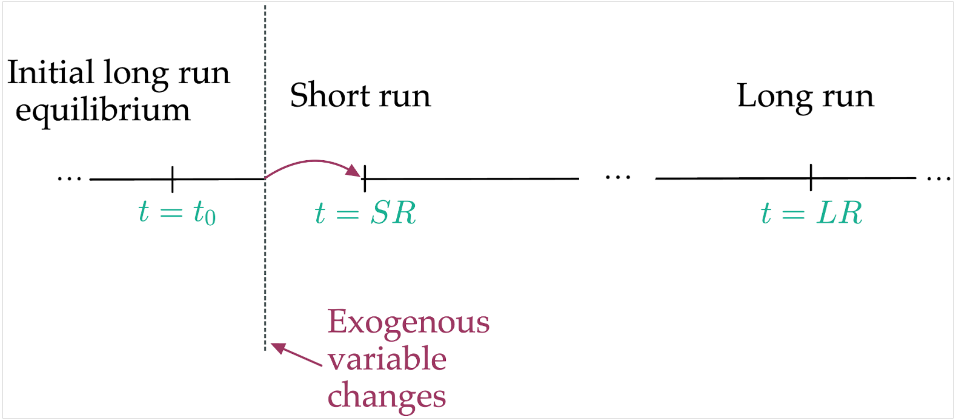
2. In the short run, E^e equals long-run E
   - By assumption of rational expectations
   - In the model, it means $E^e_{SR} = E_{LR}$

Initial long run equilibrium




Initial long run equilibrium
Short run
$t = t_0$
Exogenous variable changes


Initial long run equilibrium
Short run
Long run
$t = t_0$
Exogenous variable changes


Initial long run equilibrium
Short run
Long run
$t = t_0$
$t = SR$
$t = LR$
Exogenous variable changes

Results in the long run (1/3)

1. Long-run interest rate R_{LR} from FX market
   - Using $E_{LR} = E^e_{LR}$ and UIP:

$$R_{LR} = R^* + \frac{E^e_{LR}}{E_{LR}} - 1$$

$$\Rightarrow R_{LR} = R^*$$

Results in the long run (2/3)

2. Long-run price level P_{LR} from the money market
   - Using $R_{LR} = R^*$ and money market equilibrium condition:

$$\frac{M^s}{P_{LR}} = L(R_{LR}, Y) = L(R^*, Y)$$

$$\Rightarrow \quad P_{LR} = \frac{M^s}{L(R^*, Y)}$$

Results in the long run (3/3)

3. Long-run exchange rate E_{LR} from PPP (purchasing power parity)
   - Because E_{LR} is a nominal price, in the long run it moves proportionally to the price level:

$$E_{LR} \propto P_{LR}$$

Results in the short run (1/2)

1. Short-run exchange rate E_{SR} from UIP with $E^e = E_{LR}$
   – Using UIP and the short-run assumptions:

$$R = R^* + \frac{E_{LR} - E_{SR}}{E_{SR}} \quad \Rightarrow \quad E_{SR} = \frac{E_{LR}}{1 + R - R^*}$$

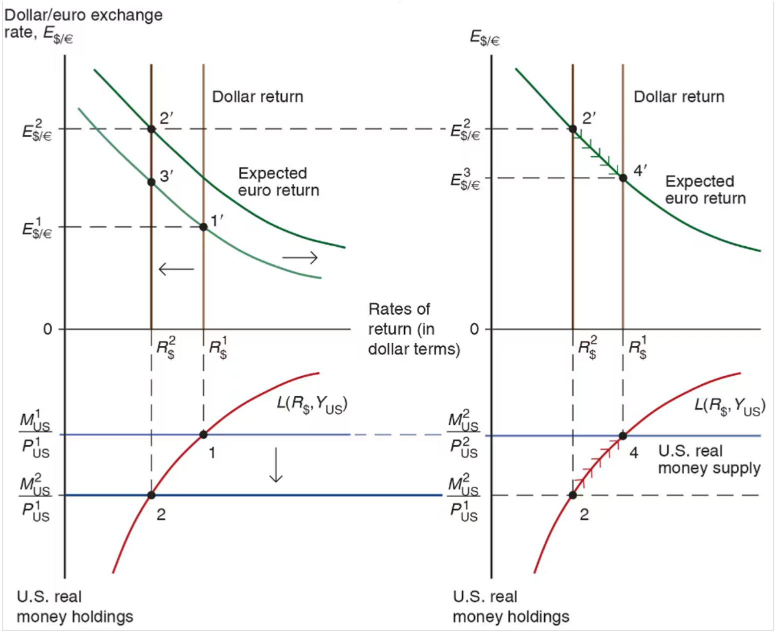
Results in the short run (2/2)

2. Short-run domestic interest rate R_{SR} from the money market
   - Using money market equilibrium condition and P fixed at P_0 in the short run:

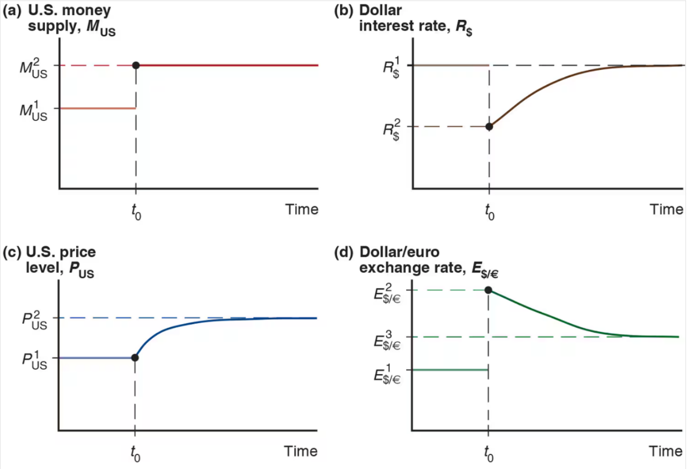
$$\frac{M^s}{P_{SR}} = L(R_{SR}, Y) \quad \Rightarrow \quad \frac{M^s}{P_0} = L(R_{SR}, Y),$$

   which can be solved for R_{SR}

Permanent Money Supply Changes



Exchange Rate Overshooting



Long-run FX and money market model

Exogenous variables

Variable	Description
Y^n	Potential output
M^s	Money supply
R^*	Foreign interest rate

Endogenous variables

Variable	Description	Equation	Type of eq
E	Exchange rate	$R = R^* + \frac{E^e - E}{E}$	Eq. condition
M^d	Money demand	$M^d/P = M^s/P$	Eq. condition
E^e	Expected exchange rate	$E^e = E$	Behavioral
R	Domestic interest rate	$P = \frac{M^d}{L(R, Y^n)}$	Eq. condition
P	Price level	P fixed in the short run	Behavioral

Overshooting

1. Properties of initial, SR, LR equilibria

2. Dynamic FX and money market model

3. Example
   - Solve with equations
   - Solve graphically

Properties of initial, SR, and LR equilibria

Long run:

- $E^e = E$

  $\Rightarrow E_0^e = E_0$ and $E_{LR}^e = E_{LR}$

- E proportional to P and M^s

  $\Rightarrow E_0 = kM_0^s$ and $E_{LR} = kM_{LR}^s$ (k is a parameter)

Properties of initial, SR, and LR equilibria

Short run:

- Prices are fixed

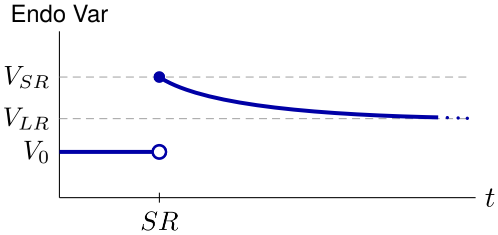
  $\Rightarrow P_{SR} = P_0$

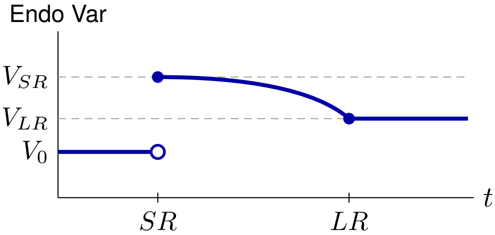
- Rational expectations

  $\Rightarrow E^e_{SR} = E_{LR}$

Transition between SR and LR

- Slow monotonic transition between SR value and LR value
- No indication of shape





Dynamic FX and money market model

Exogenous variables

Variable	Description
M^s	Path of money supply
R^*	Path of foreign interest rate
Y	Path of income (GNP)
k	Long-run proportionality constant for E and M^s

Endogenous variables

Variable	Description
E	Exchange rate
E^e	Expected exchange rate
P	Price level
R	Domestic interest rate
M^d	Money demand

Equations that apply at all times

(UIP) : $R = R^* + \frac{E^e}{E} - 1$ (equilibrium condition)

(MD) : $\frac{M^d}{P} = L(\underset{(-)}{R},\ \underset{(+)}{Y})$ (behavioral)

(MS = MD) : $\frac{M^s}{P} = \frac{M^d}{P}$ (equilibrium condition)

Equations that apply in SR equilibria only

(Sticky P) : $P_{SR} = P_0$ (behavioral)

(RE) : $E^e_{SR} = E_{LR}$ (behavioral)

Equations that apply in LR equilibria only

(PPP) or (Flex P) : $E_0 = kM_0^s, \quad E_{LR} = kM_{LR}^s$ (behavioral)

(Defn LR) or (RE) : $E_0^e = E_0, \quad E_{LR}^e = E_{LR}$ (behavioral)

Example

Need to specify:

1. Function $L(R, Y)$

2. Path of exogenous variables

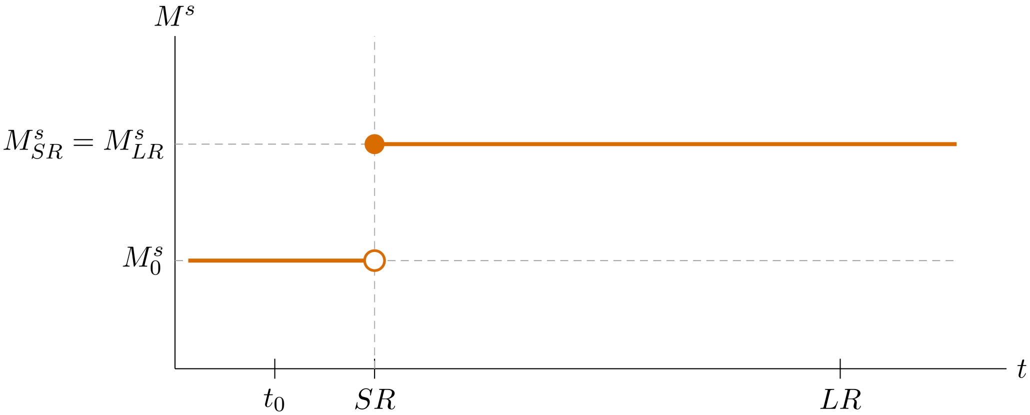
Assume:

1. $L(R, Y) = \dfrac{Y}{1+R}$

2. $R^* = 0.08, \; Y = 1, \; k = 1$

$$\{M_0^s, \; M_{SR}^s, \; M_{LR}^s\} = \{1, \; 1.05, \; 1.05\}$$

Example: Permanent increase in M^s



Solution steps

1. Solve initial LR equilibrium ($t = t_0$)

2. Solve LR equilibrium ($t = LR$)

3. Solve SR equilibrium ($t = SR$)

Solution sub-steps

LR (steps 1 and 2)			SR (step 3)		
(a) Flex P / PPP	$\longrightarrow$	E	(a) P fixed	$\longrightarrow$	P
(b) Defn LR / RE	$\longrightarrow$	E^e	(b) MS = MD	$\longrightarrow$	R
(c) UIP	$\longrightarrow$	R	(c) RE	$\longrightarrow$	E^e
(d) MS = MD	$\longrightarrow$	P	(d) UIP	$\longrightarrow$	E

Step 1: Solve initial LR equilibrium ($t = t_0$)

$$\begin{array}{llcl}
\text{(a)} & \text{Flex P / PPP} \rightarrow E & : & E_0 = kM_0^s = 1 \cdot 1 = 1 \\
\text{(b)} & \text{Defn LR / RE} \rightarrow E^e & : & E_0^e = E_0 = 1 \\
\text{(c)} & \text{UIP} \rightarrow R & : & R_0 = R^* + \dfrac{E_0^e}{E_0} - 1 \\
 & & & \quad = 0.08 + \dfrac{1}{1} - 1 = 0.08
\end{array}$$

Step 1: Solve initial LR equilibrium ($t = t_0$)

(d) MS = MD $\to P$:
$$\frac{M_0^s}{P_0} = \frac{Y_0}{1 + R_0}$$
$$\Rightarrow P_0 = M_0^s \cdot \frac{1 + R_0}{Y_0}$$
$$= 1 \times 1.08 = 1.08$$

Solution for t_0: $P_0 = 1.08,\ R_0 = 0.08,\ E_0^e = 1,\ E_0 = 1$

Step 2: Solve LR equilibrium ($t = LR$)

$$
\begin{array}{lll}
\text{(a)} \quad \text{Flex P / PPP} \to E & : & E_{LR} = kM^s_{LR} = 1 \cdot 1.05 = 1.05 \\[2ex]
\text{(b)} \quad \text{Defn LR / RE} \to E^e & : & E^e_{LR} = E_{LR} = 1.05 \\[2ex]
\text{(c)} \quad \text{UIP} \to R & : & R_{LR} = R^*_{LR} + \dfrac{E^e_{LR}}{E_{LR}} - 1 \\[2ex]
 & & \phantom{R_{LR}} = 0.08 + \dfrac{1.05}{1.05} - 1 = 0.08
\end{array}
$$

Step 2: Solve LR equilibrium ($t = LR$)

(d) MS = MD $\rightarrow P$: $$\frac{M^s_{LR}}{P_{LR}} = \frac{Y_{LR}}{1 + R_{LR}}$$

$$\Rightarrow P_{LR} = M^s_{LR} \cdot \frac{1 + R_{LR}}{Y_{LR}}$$

$$= 1.05 \times 1.08 = 1.134$$

Solution for LR: $P_{LR} = 1.134, \; R_{LR} = 0.08, \; E^e_{LR} = 1.05, \; E_{LR} = 1.05$

Step 3: Solve SR equilibrium ($t = SR$)

(a) P fixed $\rightarrow P$: $P_{SR} = P_0 = 1.08$

(b) MS = MD $\rightarrow R$: $\frac{M^s_{SR}}{P_{SR}} = \frac{Y_{SR}}{1 + R_{SR}}$

$$\Rightarrow \frac{1.05}{1.08} = \frac{1}{1 + R_{SR}}$$

$$\Rightarrow 1 + R_{SR} = \frac{1.08}{1.05}$$

$$\Rightarrow R_{SR} = \frac{1.08}{1.05} - 1 \approx 0.02857$$

Step 3: Solve SR equilibrium ($t = SR$)

$$\text{(c)} \quad \text{RE} \to E^e : \quad E^e_{SR} = E_{LR} = 1.05$$

$$\text{(d)} \quad \text{UIP} \to E : \quad R_{SR} = R^*_{SR} + \frac{E^e_{SR}}{E_{SR}} - 1$$

$$\Rightarrow \; 0.02857 = 0.08 + \frac{1.05}{E_{SR}} - 1$$

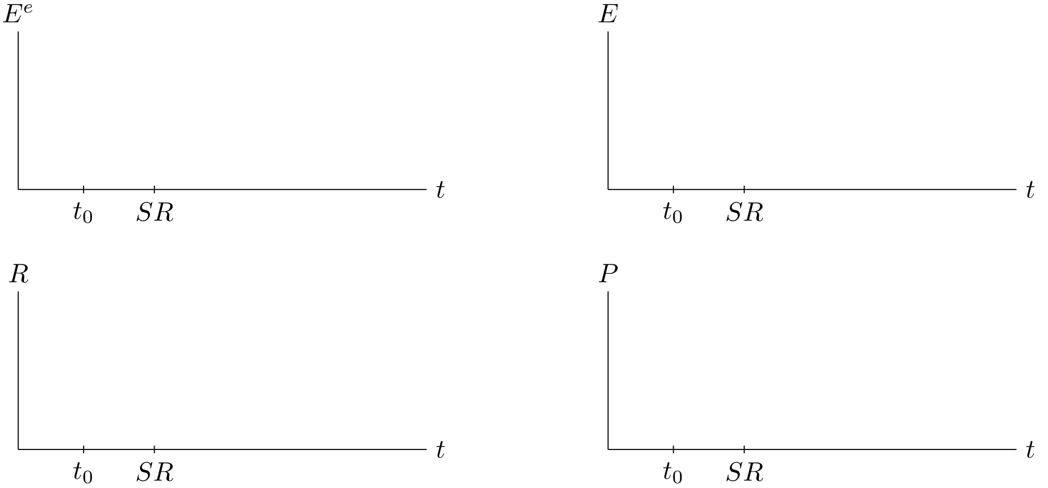
$$\Rightarrow \; E_{SR} = \frac{1.05}{0.02857 - 0.08 + 1} = \frac{1.05}{0.94857} \approx 1.1069$$

Solution for SR: $P_{SR} = 1.08, \; R_{SR} \approx 0.029, \; E^e_{SR} = 1.05, \; E_{SR} \approx 1.107$

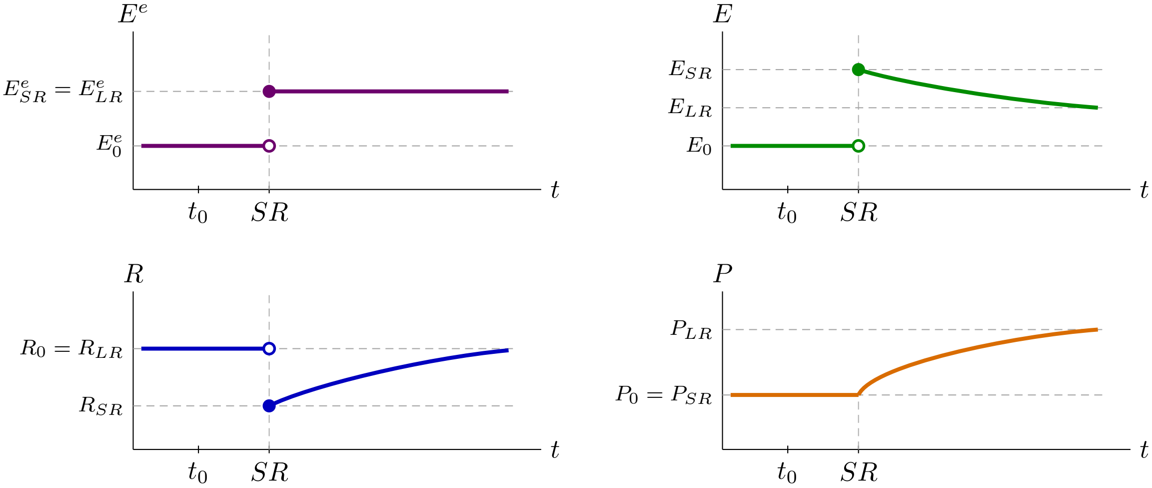
Example: solution summary

	t_0	SR	LR
P	1.08	1.08	1.134
R	0.08	0.029	0.08
E^e	1	1.05	1.05
E	1	1.107	1.05

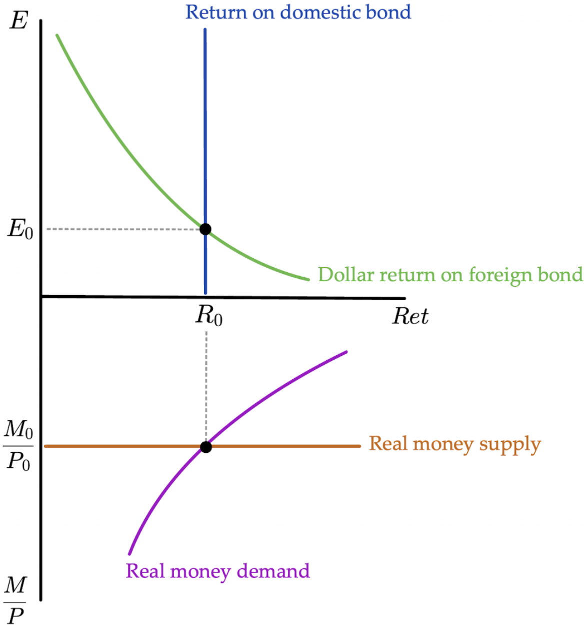
Paths of solution



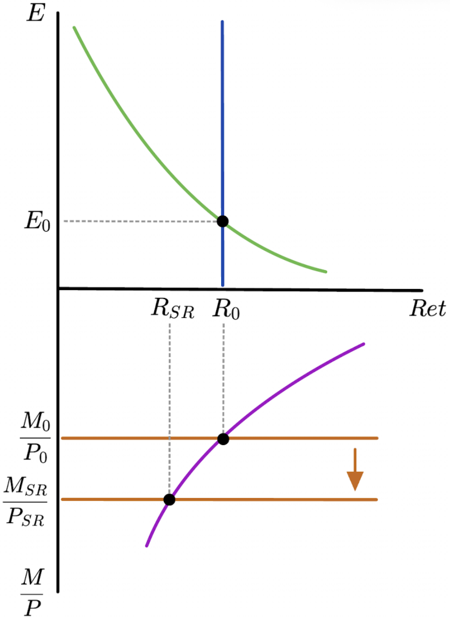
Paths of solution



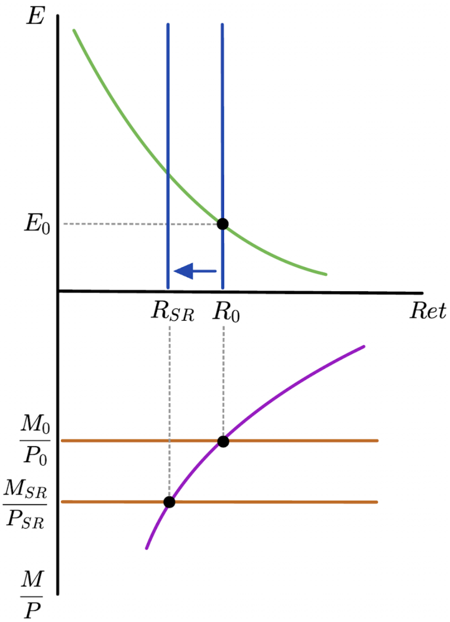
Solve with plots: Initial LR equilibrium



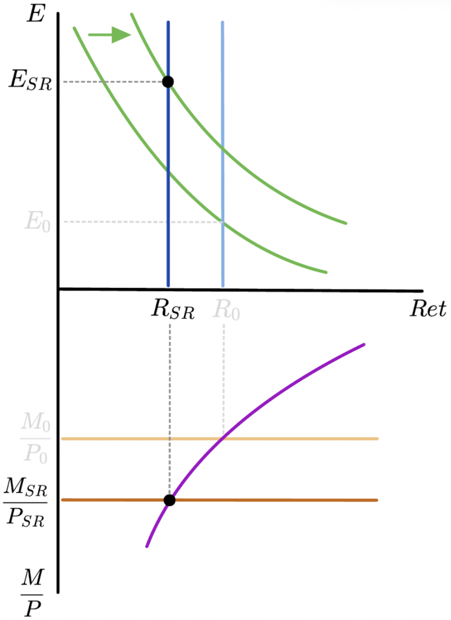
Higher M^s lowers R



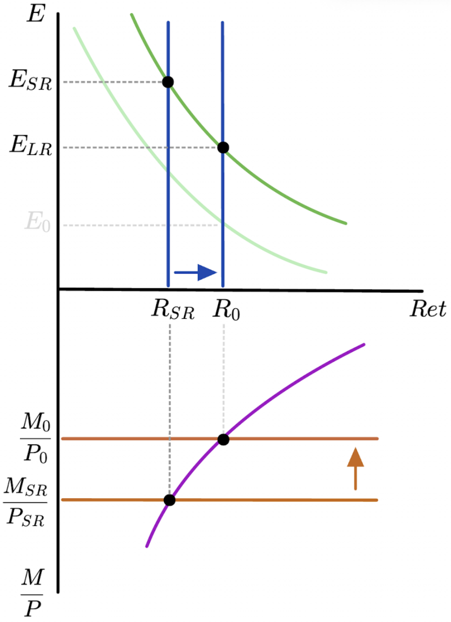
Lower R causes depreciation



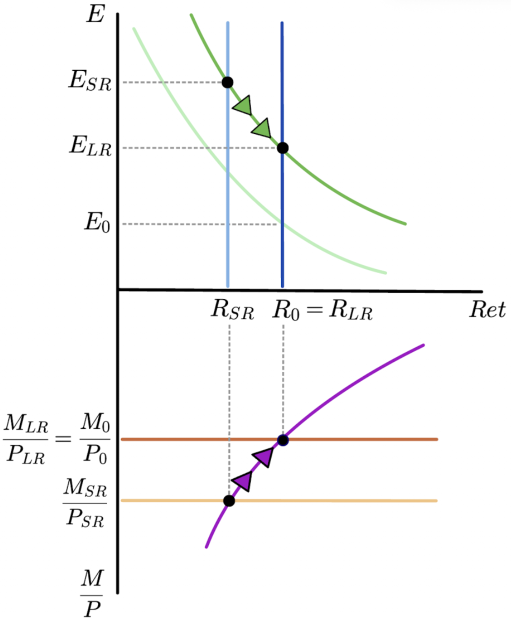
Higher E^e shifts dollar return on foreign bond



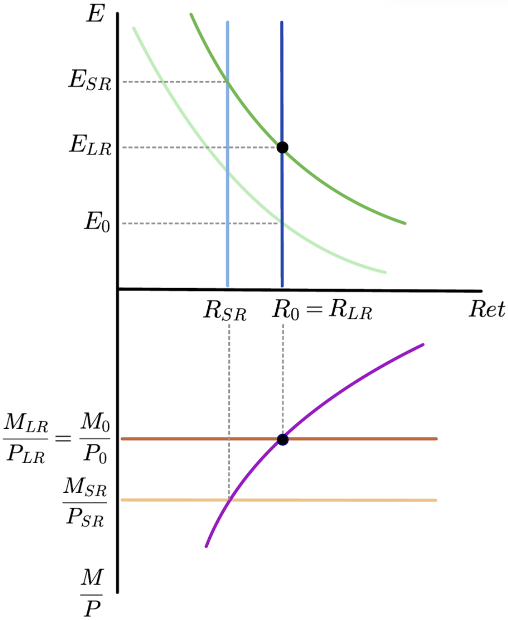
SR equilibrium



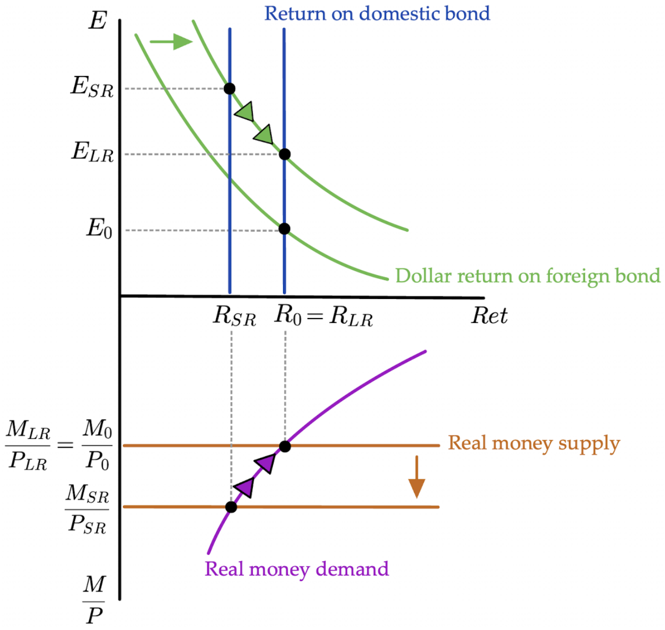
Transition between SR and LR



Final LR equilibrium



Solve with plots:
All steps
together



Equilibrium Determination Map

	Initial	SR	LR
E	flex P / PPP	FX mkt	flex P / PPP
E^e	defn LR	RE	defn LR
R	FX mkt	money mkt	FX mkt
P	money mkt	fixed P	money mkt

PPP = purchasing power parity $\Rightarrow E \propto P \propto M^s$

defn LR = definition of the long run $\Rightarrow E_0^e = E_0$ and $E_{LR}^e = E_{LR}$

RE = rational expectations $\Rightarrow \begin{cases} E_{SR}^e = E_{LR} \\ E_0^e = E_0 \text{ and } E_{LR}^e = E_{LR} \end{cases}$

ECON 1550 International Finance

Price Levels and the Exchange Rate in the Long Run

Law of One Price (LOOP)

- The LOOP holds if for every good i with dollar price P^i_{US} and euro price P^i_E, we have

$$P^i_{US} = E_{\$/€} \times P^i_E$$

- This is a theory of exchange rate determination:

$$E_{\$/€} = \frac{P^i_{US}}{P^i_E}$$

Purchasing Power Parity (PPP)

- PPP holds if

$$P_{US} = E_{\$/€} \times P_E$$

where P_{US} is the US price level and P_E is the euro area price level

- This is also a theory of exchange rate determination:

$$E_{\$/€} = \frac{P_{US}}{P_E}$$

Relative PPP

- Relative PPP holds if

$$\frac{E_{\$/€,t} - E_{\$/€,t-1}}{E_{\$/€,t-1}} = \pi_{US,t} - \pi_{E,t}$$

  where π_t is inflation $\pi_t = P_t/P_{t-1} - 1$

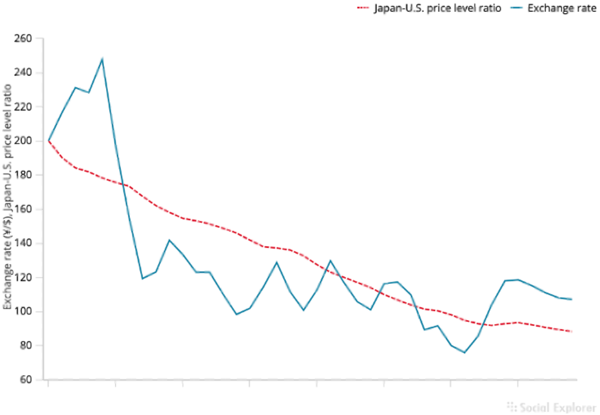
- This is also a theory of exchange rate determination

$$E_{\$/€,t} = (\pi_{US,t} - \pi_{E,t} + 1)E_{\$/€,t-1}$$

Relative PPP does not hold very well in the real world

Figure 16-2

The Yen/Dollar Exchange Rate and Relative Japan–U.S. Price Levels, 1980–2019



The graph shows that relative PPP does not track the yen/dollar exchange rate during 1980–2015.

Source: IMF, *International Financial Statistics*. Exchange rates and price levels are end-of-year data.

Problems With PPP

- Price levels of different countries report different baskets of goods
  - E.g. GDP deflator is the basket of goods in GDP for each country
- Deviations from perfectly competitive frictionless markets
  - Transport costs and trade barriers
  - Monopoly power

Expected Relative PPP

- Expected relative PPP (or relative PPP in expectations)

$$\frac{E^e_{\$/€} - E_{\$/€}}{E_{\$/€}} = \pi^e_{US} - \pi^e_{E}$$

where π^e is *expected* inflation $\pi^e = P^e/P - 1$

- This is also a theory of exchange rate determination

$$E_{\$/€} = \frac{E^e_{\$/€}}{\pi^e_{US} - \pi^e_{E} + 1}$$

Relationships

- LOOP $\Rightarrow$ PPP $\Rightarrow$ Relative PPP $\Rightarrow$ Expected relative PPP
- Expected relative PPP + UIP $\Rightarrow$ Fisher effect

$$\frac{E^e_{\$/€} - E_{\$/€}}{E_{\$/€}} = \pi^e_{US} - \pi^e_E \quad \text{and} \quad R_\$ = R_€ + \frac{E^e_{\$/€} - E_{\$/€}}{E_{\$/€}}$$

imply

$$R_\$ - R_€ = \pi^e_{US} - \pi^e_E$$

Common variables across all models

Exogenous variables

Variable	Description
R^*	Foreign interest rate
$M^s,\ M^{s*}$	Money supply
$g_M,\ g_{M^*}$	Money supply growth rates

Endogenous variables

Variable	Description	Equation	Type of equation
P	Price level	$M^s/P = L(R, Y)$	Behavioral + eq. condition
P^*	Foreign price level	$M^{s*}/P^* = L(R^*, Y^*)$	Behavioral + eq. condition
π, π^*	Inflation	$\pi = g_M - g_L$	Definition
r^e, r^{e*}	Real interest rates	$r^e = R - \pi^e$	Definition

Model 1: PPP

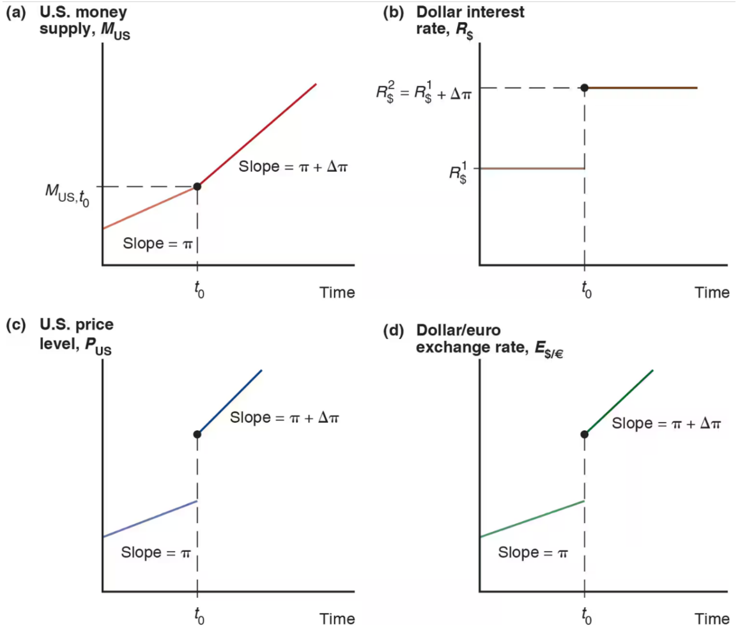
Exogenous variables

Variable	Description
R	Domestic interest rate
$Y,\ Y^*$	Real incomes

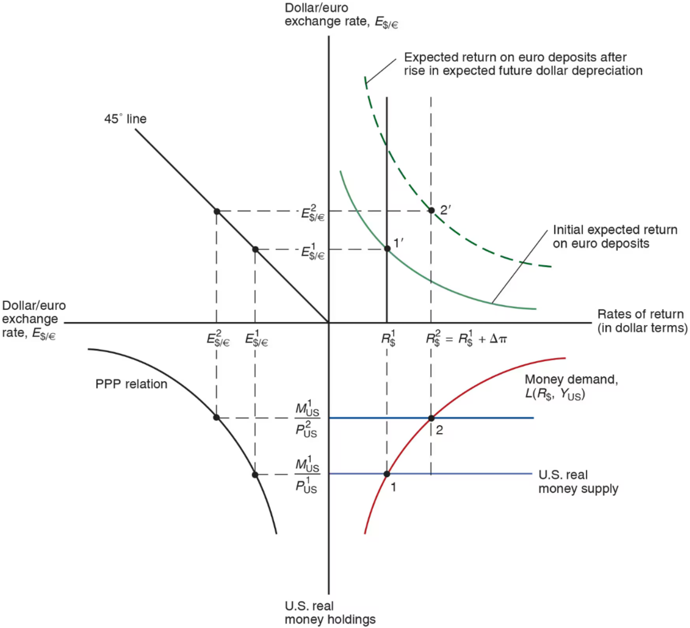
Endogenous variables

Variable	Description	Equation	Type of equation
E	Exchange rate	$E = P/P^*$	Behavioral

Changes in growth rate of money supply



Changes in growth rate of money supply



Model 2: PPP^e + UIP

Exogenous variables

Variable	Description
$Y,\ Y^*$	Real incomes

Endogenous variables

Variable	Description	Equation	Type of equation
$E^e/E-1$	Expected depreciation	$E^e/E-1=\pi^e-\pi^{e*}$	Behavioral
R	Interest rate	$R=R^*+E^e/E-1$	Eq. condition

Model 3: real E + relative output

- The real exchange rate

Model 3: real E + relative output

- Real exchange rate calculation

Model 3: real E + relative output

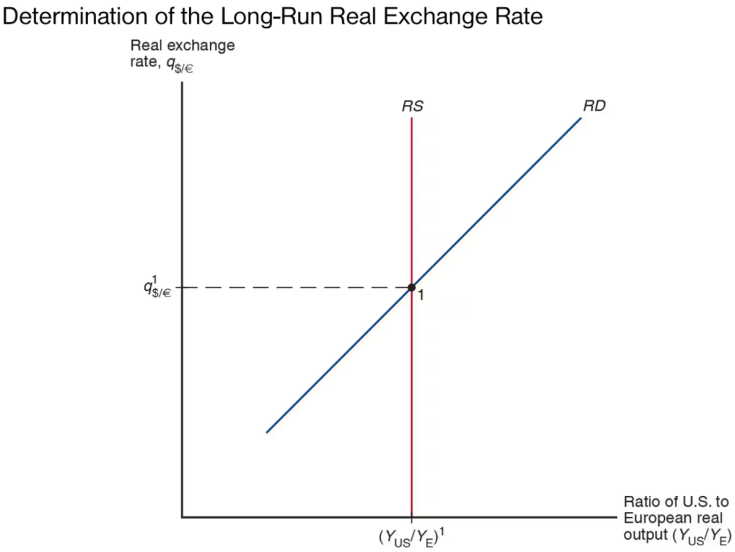
Exogenous variables

Variable	Description
RS	Relative output supply
q	Real exchange rate

Endogenous variables

Variable	Description	Equation	Type of equation
Y/Y^*	Relative output	$RD(q) = RS$	Eq. cond.
E	Nominal exchange rate	$E = qP/P^*$	Definition

Model 3 equilibrium



ECON 1550 International Finance

Output and the Exchange Rate in the Short Run

Behavioral equations in the goods market

$$Y = C + I + G + CA$$

DEMAND FOR DOMESTIC GOOD $= C + I + G + CA$

SUPPLY FOR DOMESTIC GOOD $= Y$

Demand for domestic goods

DEMAND FOR DOM GOODS $= C + I + G + CA = D$

DOMESTIC DEMAND FOR GOODS $\equiv A = C + I + G$

$$A + EX - IM = A + CA = D$$

Demand for domestic goods

$C = C(\underset{(+)}{Y_D})$ CONSUMPTION (OF DOM. AND FOREING)

$Y_D \equiv Y - T$ DISPOSABLE INCOME

$I = \bar{I}$ EXOGENOUS INVESTMENT

$G = \bar{G}$ " GOV. PURCHASES

BOTH DOM AND FOR. GOODS

$CA = CA(q, Y-T, Y^*)$

$q \equiv \frac{EP^*}{P} = \frac{\text{DOLLAR PRICE OF FOREIGN GOOD}}{\text{DOLLAR PRICE OF DOM GOOD}}$

Demand for domestic goods

$CA = EX - IM$

$EX = EX(\underset{(+)}{q}, \underset{(+)}{Y^*})$

$IM = IM(\underset{(-)}{q}, \underset{(+)}{Y_D})$

$q\uparrow$ VOLUME $\downarrow$ PRICE $q\uparrow$

VOLUME DOMINATES

$q\uparrow$ REAL DEPR.

$\frac{EP^*}{P} = q \Rightarrow$ HOME GOOD APPEARS CHEAPER

$\underbrace{IM}_{\text{DOM GOOD}} = \overbrace{\underbrace{PRICE}_{\frac{\text{DOM GOOD}}{\text{FOREIGN GOOD}}}}^{=q} \times \underbrace{VOLUME}_{\text{FOREIGN GOOD}}$

A short-run model of the goods market

Exogenous variables

Variable	Description
E	Nominal exchange rate
I	Investment
G	Government spending
T	Taxes
P	Price level
P^*	Foreign price level
Y^*	Foreign income

Endogenous variables

Variable	Description	Equation	Type of equation
Y	Income, production	$Y = D$	Equilibrium condition
Y_D	Disposable income	$Y_D \equiv Y - T$	Identity
EX	Exports	$\mathrm{EX} = \mathrm{EX}(\underset{(+)}{q}, \underset{(+)}{Y^*})$	Behavioral
IM	Imports	$\mathrm{IM} = \mathrm{IM}(\underset{(-)}{q}, \underset{(+)}{Y_D})$	Behavioral
CA	Current account	$\mathrm{CA} \equiv \mathrm{EX} - \mathrm{IM} = \mathrm{CA}(\underset{(+)}{q}, \underset{(-)}{Y_D}, \underset{(+)}{Y^*})$	Identity
D	Demand for domestic goods	$D \equiv C + I + G + \mathrm{CA}$	Identity
A	Domestic demand	$A \equiv C + I + G$	Identity
C	Consumption	$C = \mathrm{C}(\underset{(+)}{Y_D})$	Behavioral
q	Real exchange rate	$q \equiv \dfrac{EP^*}{P}$	Identity

DD Curve

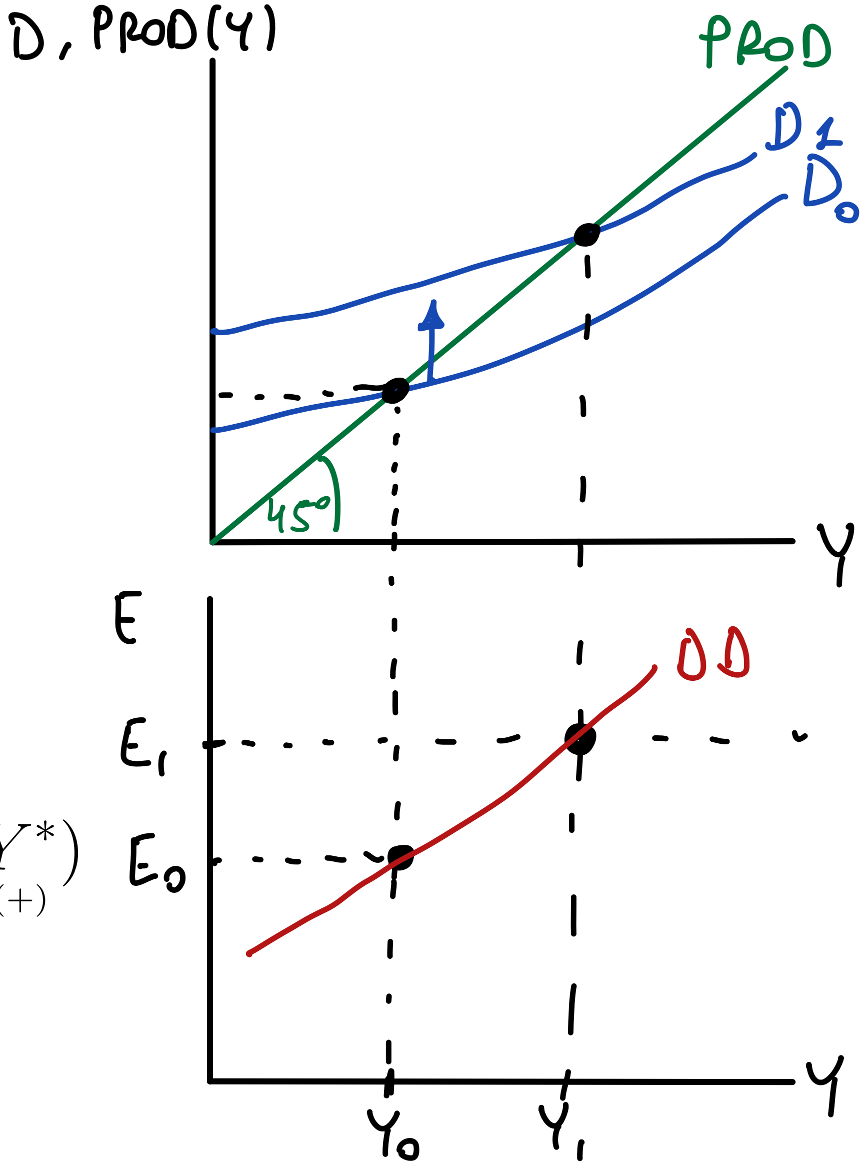
$$Y = D$$

$$Y = C + I + G + \text{CA}$$

$$Y = \underset{(+)}{\mathrm{C}(Y_D)} + I + G + \text{CA}(\underset{(+)}{q}, \underset{(-)}{Y_D}, \underset{(+)}{Y^*})$$

$$Y = \underset{(+)}{\mathrm{C}(Y_D)} + I + G + \text{CA}(\underset{(+)}{EP^*/P}, \underset{(-)}{Y_D}, \underset{(+)}{Y^*})$$

Y↑ C↑ BUT CA↓. HOWEVER,
D ALWAYS ↑



$D = C + I + G + NX$ WHEN $Y\uparrow$

$C\uparrow$ $NX\downarrow$ SO D?

NOT UNCLEAR, $D\uparrow$

C : CONS. OF DOM. AND FOREIGN GOODS

$C - IM$ = DOM DEM. FOR DOM GOOD

$NX = \underbrace{EX}_{\text{DOES NOT CHANGE}} - \underbrace{IM}_{\text{IM GOES UP}}$

$C = C_{\text{DOM GOOD}} + C_{\text{FOREIGN GOOD}}$

IM = DOM DEMAND FOR FOREIGN

Short-run FX and money market model

Exogenous variables

Variable	Description
R^*	Foreign interest rate
E^e	Expected exchange rate
Y	Real income
M^s	Money supply
P	Price level

Endogenous variables

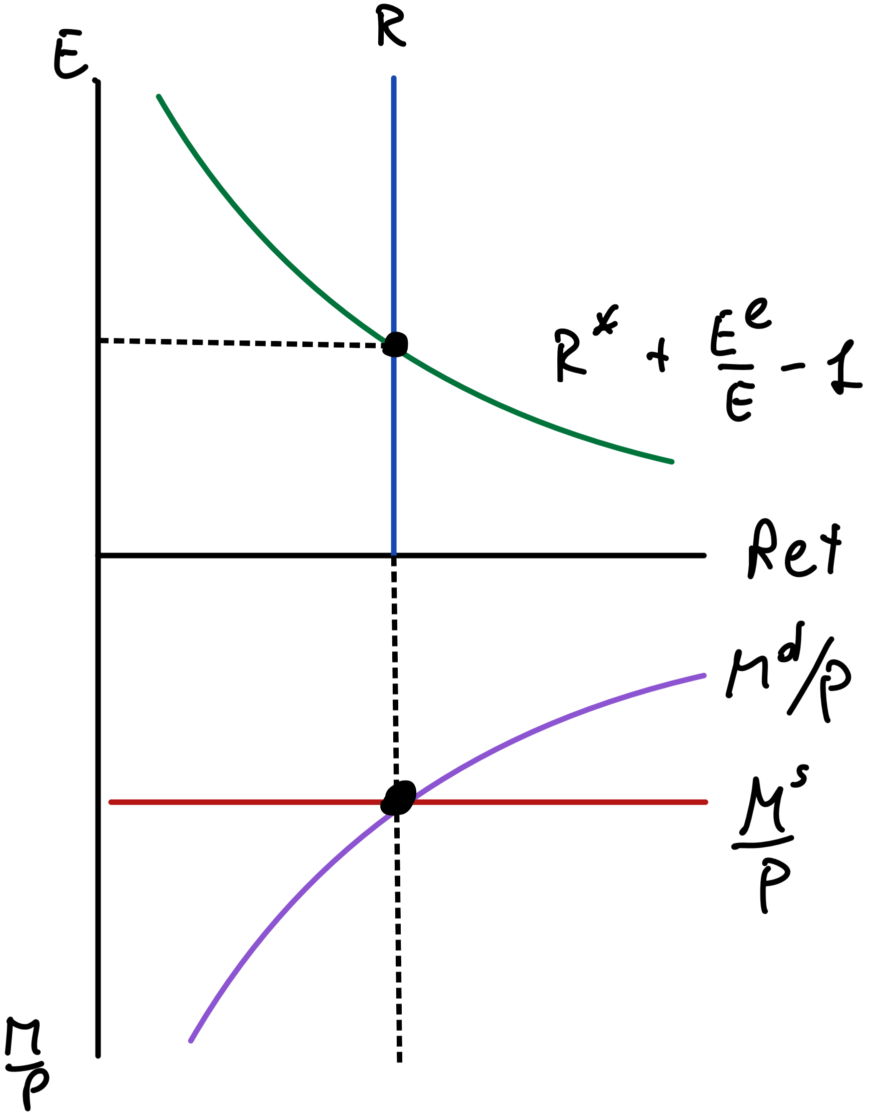
Variable	Description	Equation	Type of equation
E	Exchange rate	$R = R^* + \dfrac{E^e - E}{E}$	Equilibrium condition
R	Domestic interest rate	$M^d/P = \mathrm{L}(R, Y)$	Behavioral equation
M^d	Money demand	$M^d = M^s$	Equilibrium condition

AA Curve

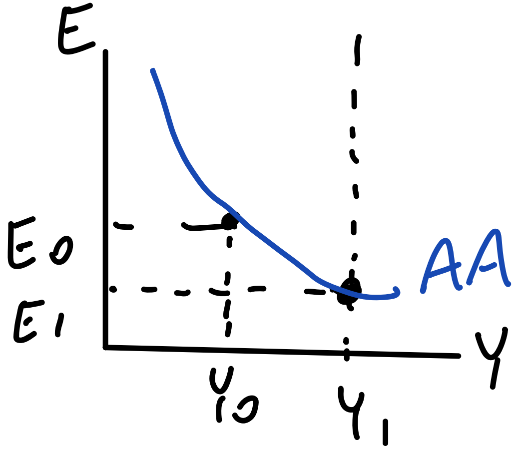
$$\text{(UIP)}: \qquad R = R^* + \frac{E^e}{E} - 1$$

$$\text{(MS)} = \text{(MD)}: \qquad \frac{M^s}{P} = \mathrm{L}(\underset{(-)}{R}, \underset{(+)}{Y})$$

$\left.\begin{array}{l} \text{Y EXO} \\ \text{E ENDO} \end{array}\right\}$ FIND E FOR GIVEN Y



AA Curve

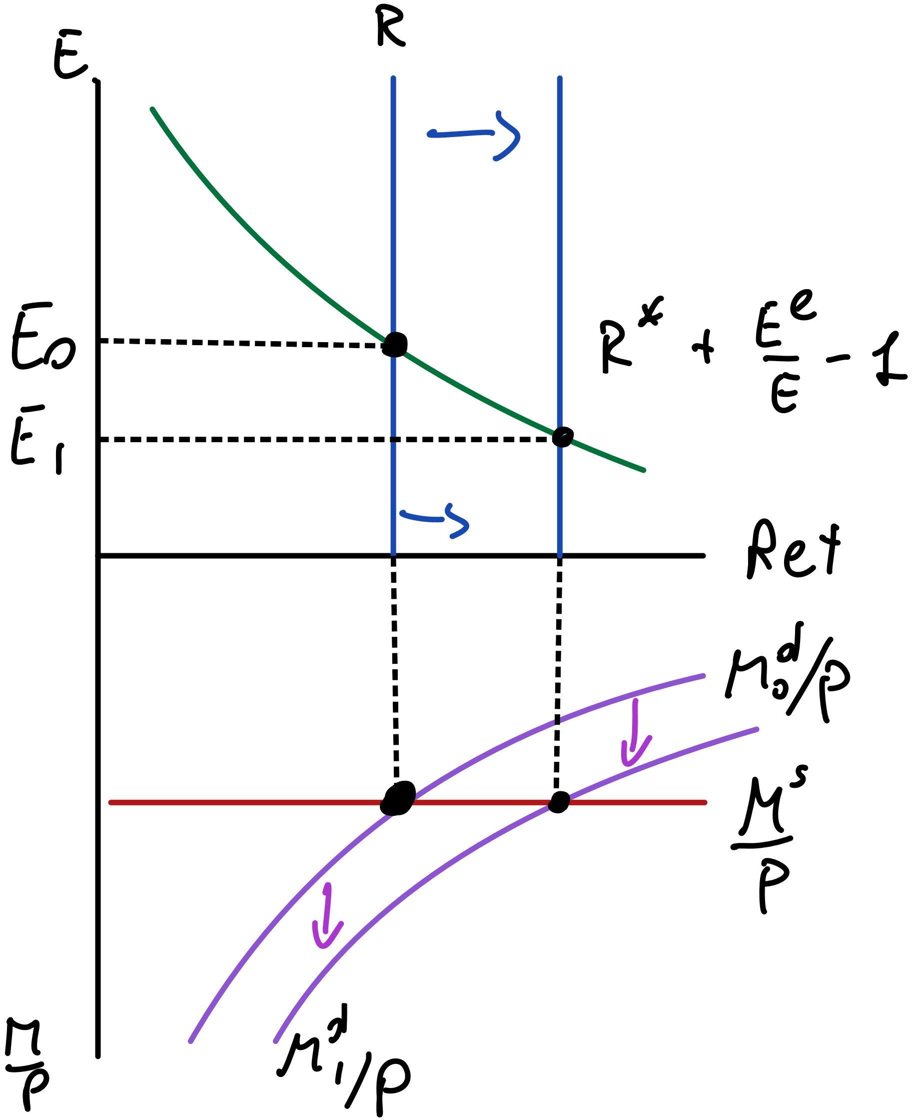


(UIP): $R = R^* + \frac{E^e}{E} - 1$

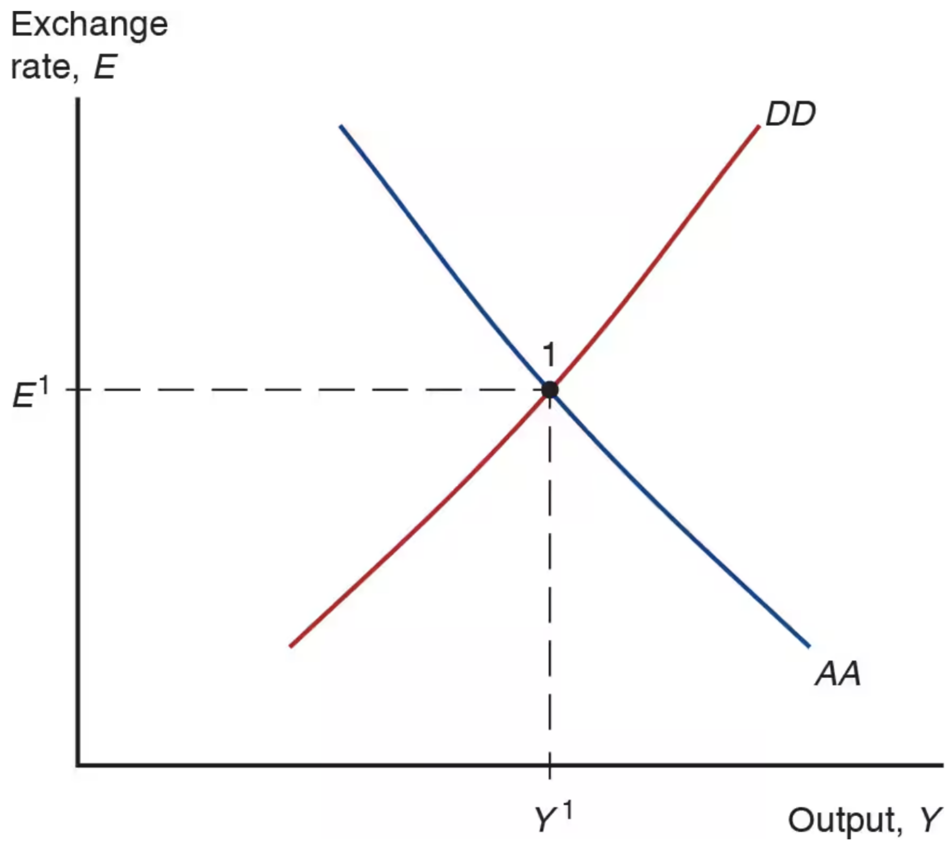
(MS) = (MD): $\frac{M^s}{P} = \mathrm{L}(\underset{(-)}{R}, \underset{(+)}{Y})$

(Y_0, E_0) WITH $Y_1 > Y_0$

(Y_1, E_1) $E_1 < E_0$



Short-run Equilibrium in *AA*-*DD* model



GOODS

E EXO

MM + FX

Y EXO

COMBINE

Y, E ARE BOTH ENDO

Example: DD Schedule

$$\underset{(+)}{\mathrm{C}(Y_D)} = 1 + 0.75Y_D$$

$$\mathrm{EX}(\underset{(+)}{q}, \underset{(+)}{Y^*}) = 0.15 + 0.5q + 0.1Y^*$$

$$\mathrm{IM}(\underset{(-)}{q}, \underset{(+)}{Y_D}) = 0.1 - 0.2q + 0.12Y_D$$

$$Y_D = Y - T$$

$$q = \frac{EP^*}{P}$$

How to find the DD schedule

EQ. COND FOR GOODS:

$$Y = D$$

$$Y = C + I + G + CA$$

$$Y = 1 + 0.75(Y - T) + I + G +$$

$$+ 0.15 + 0.5q + 0.1Y^*$$

$$- 0.1 + 0.2q - 0.12(Y - T)$$

Example: DD Schedule

• CAN SOLVE FOR E TO GET EXPLICIT E = FUNCTION OF Y.

$$\text{C}(\underset{(+)}{Y_D}) = 1 + 0.75Y_D$$

$$\text{EX}(\underset{(+)}{q}, \underset{(+)}{Y^*}) = 0.15 + 0.5q + 0.1Y^*$$

$$\text{IM}(\underset{(-)}{q}, \underset{(+)}{Y_D}) = 0.1 - 0.2q + 0.12Y_D$$

$$Y_D = Y - T$$

$$q = \frac{EP^*}{P}$$

How to find the DD schedule

$$Y = 1 + 0.75(Y-T) + I + G + 0.15 + 0.5q + 0.1Y^* - 0.1 + 0.2q - 0.12(Y-T)$$

$$Y = 1 + 0.15 - 0.1 + I + G + (0.75 - 0.12)(Y-T) + (0.5 + 0.2)\frac{EP^*}{P} + 0.1Y^*$$

Example: AA Schedule

$$R = R^* + \frac{E^e - E}{E}$$

$$\frac{M^d}{P} = \frac{M^s}{P}$$

$$\frac{M^d}{P} = \mathrm{L}(\underset{(-)}{R}, \underset{(+)}{Y})$$
$$= 1.1 - R + 0.05Y$$

• CAN SOLVE FOR E TO GET:

E = FUNCTION OF Y

How to find the AA schedule

$$\frac{M^s}{P} = \frac{M^d}{P}$$

$$\frac{M^s}{P} = 1.1 - R + 0.5Y$$

$$\frac{M^s}{P} = 1.1 - R^* - \frac{E^e}{E} + 1 + 0.5Y$$

Example: AA Schedule

$$R = R^* + \frac{E^e - E}{E}$$

$$\frac{M^d}{P} = \frac{M^s}{P}$$

$$\frac{M^d}{P} = \mathrm{L}(\underset{(-)}{R}, \underset{(+)}{Y})$$
$$= 1.1 - R + 0.05Y$$

• CAN SOLVE FOR E TO GET:

E = FUNCTION OF Y

How to find the AA schedule

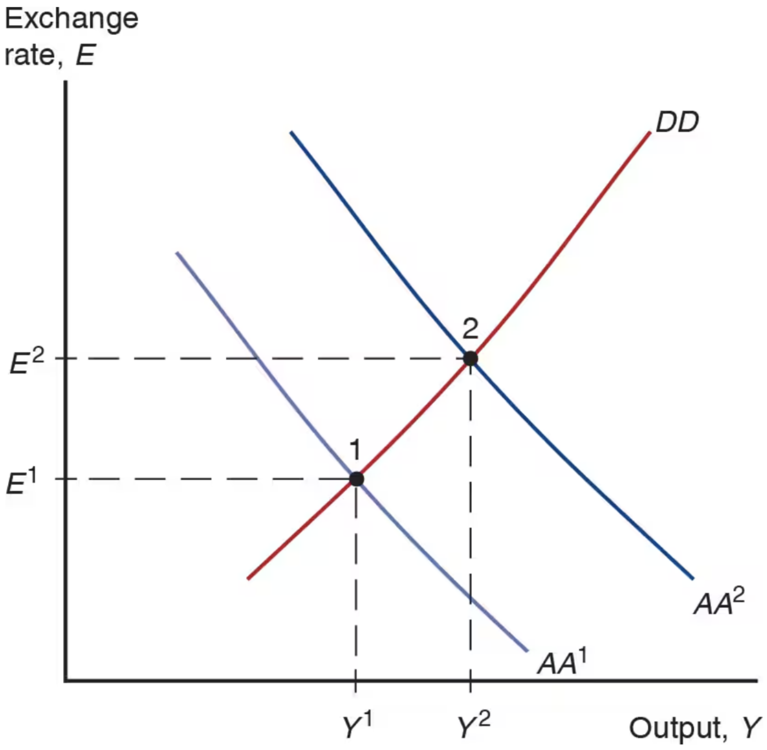
$$\frac{M^s}{P} = 1.1 - R^* - \frac{E^e}{E} + 1 + 0.5Y$$

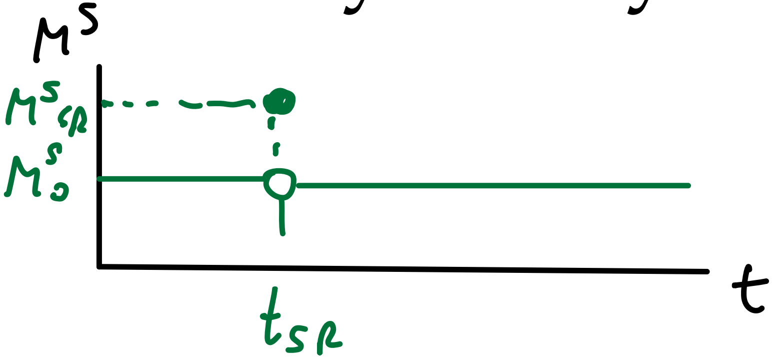
SOLVE FOR E:

$$E^e/E = 1.1 - R^* + 1 - M^s/P + 0.5Y$$

$$E = \frac{E^e}{1.1 - R^* + 1 - M^s/P + 0.5Y}$$

Temporary Change in Monetary Policy





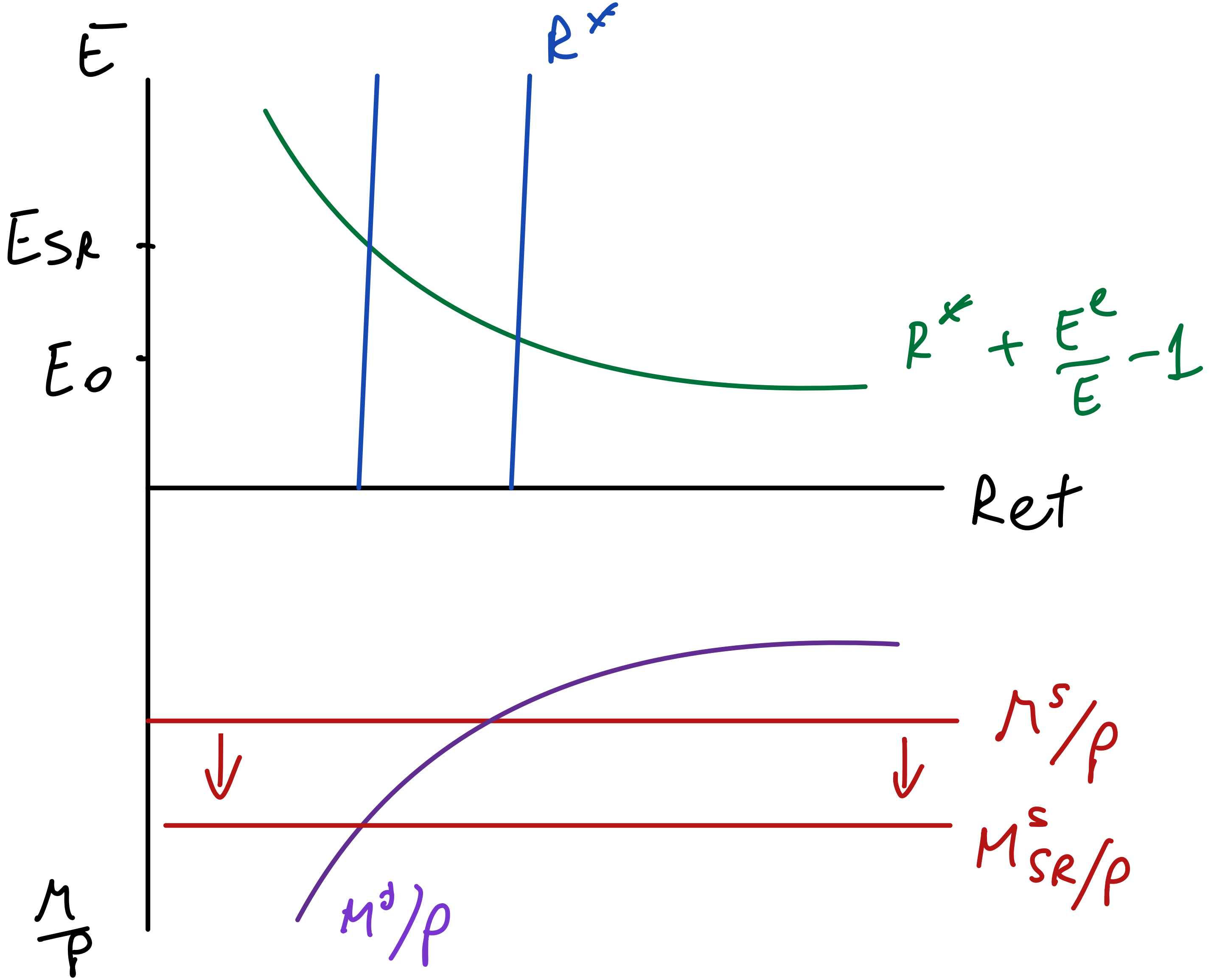
TEMPORARY SHOCKS

- KEEP LONG RUN E UNCHANGED $\Rightarrow$ $E^e_{SR} = E_{LR}$ UNCHANGED
- $P_{SR} = P_0$ FIXED

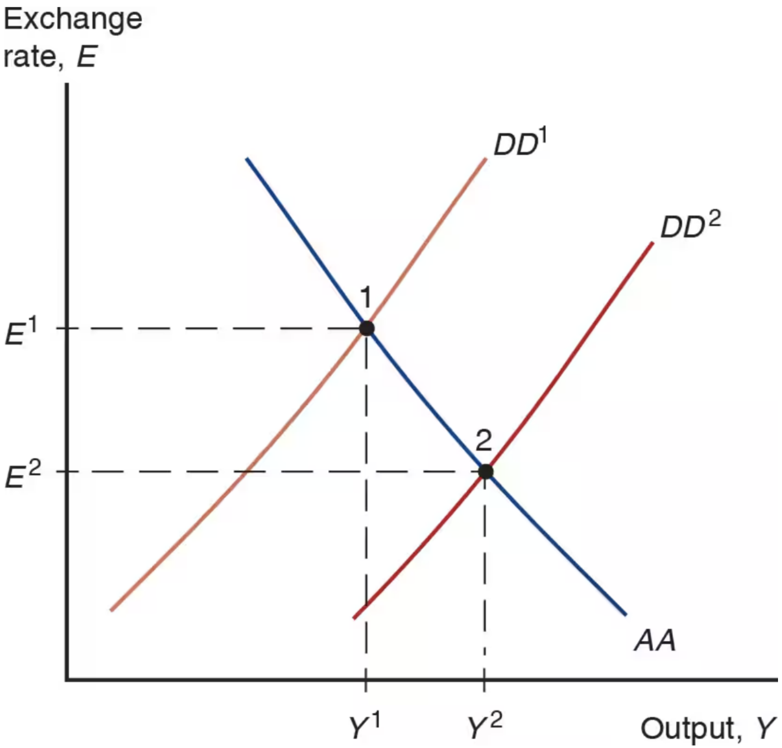
$M^S \uparrow$

LEADS TO

$E \uparrow$



Temporary Change in Fiscal Policy



G↑ IN SR ONLY

D↑ Y↑ FOR ANY E

=> DD SHIFTS TO THE RIGHT

Example: DD Schedule

$$\underset{(+)}{\mathrm{C}(Y_D)} = 1 + 0.75Y_D$$

$$\mathrm{EX}(\underset{(+)}{q}, \underset{(+)}{Y^*}) = 0.15 + 0.5q + 0.1Y^*$$

$$\mathrm{IM}(\underset{(-)}{q}, \underset{(+)}{Y_D}) = 0.1 - 0.2q + 0.12Y_D$$

$$Y_D = Y - T$$

$$q = \frac{EP^*}{P}$$

- Plug in given C, EX, IM, Y_D, q into the equilibrium condition for the goods market $Y = C + I + G + \mathrm{EX} - \mathrm{IM}$ to get:

$$Y = 1.05 + 0.63(Y - T) + 0.7\frac{EP^*}{P} + I + G + 0.1Y^*$$

- Solve for E to get the DD curve:

$$E = \frac{1}{0.7}\frac{P}{P^*}\left(-1.05 + 0.37Y + 0.63T - I - G - 0.1Y^*\right)$$

Example: AA Schedule

$$R = R^* + \frac{E^e}{E} - 1$$

$$\frac{M^d}{P} = \frac{M^s}{P}$$

$$\frac{M^d}{P} = \mathrm{L}(\underset{(-)}{R}, \underset{(+)}{Y}) = 1.1 - R + 0.05Y$$

- Plug in UIP into money market equilibrium condition:

$$\frac{M^s}{P} = 1.1 - \left(R^* + \frac{E^e}{E} - 1\right) + 0.05Y$$

- Solve for E to get the AA curve:

$$E = \frac{E^e}{2.1 - \frac{M^s}{P} - R^* + 0.05Y}$$

Full AA-DD Model

$$\text{DD Schedule:} \quad Y = \mathrm{C}(Y-T) + I + G + \mathrm{CA}(EP^*/P, Y-T, Y^*)$$

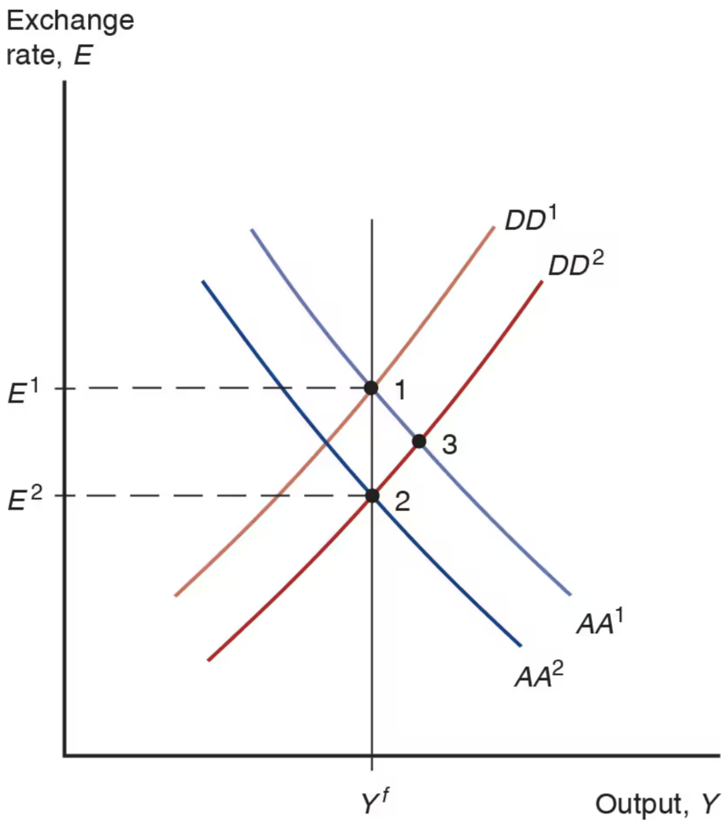
$$\text{AA Schedule:} \quad \frac{M^s}{P} = \mathrm{L}\left(R^* + \frac{E^e}{E} - 1, Y\right)$$

$$\text{Phillips Curve:} \quad \pi = \pi^e + \alpha(Y - Y^f)$$

$$\text{Definition of inflation:} \quad \pi_t = \frac{P_t}{P_{t-1}} - 1$$

$$\text{Definition of expected inflation:} \quad \pi_t^e = \frac{P_{t+1}^e}{P_t} - 1$$

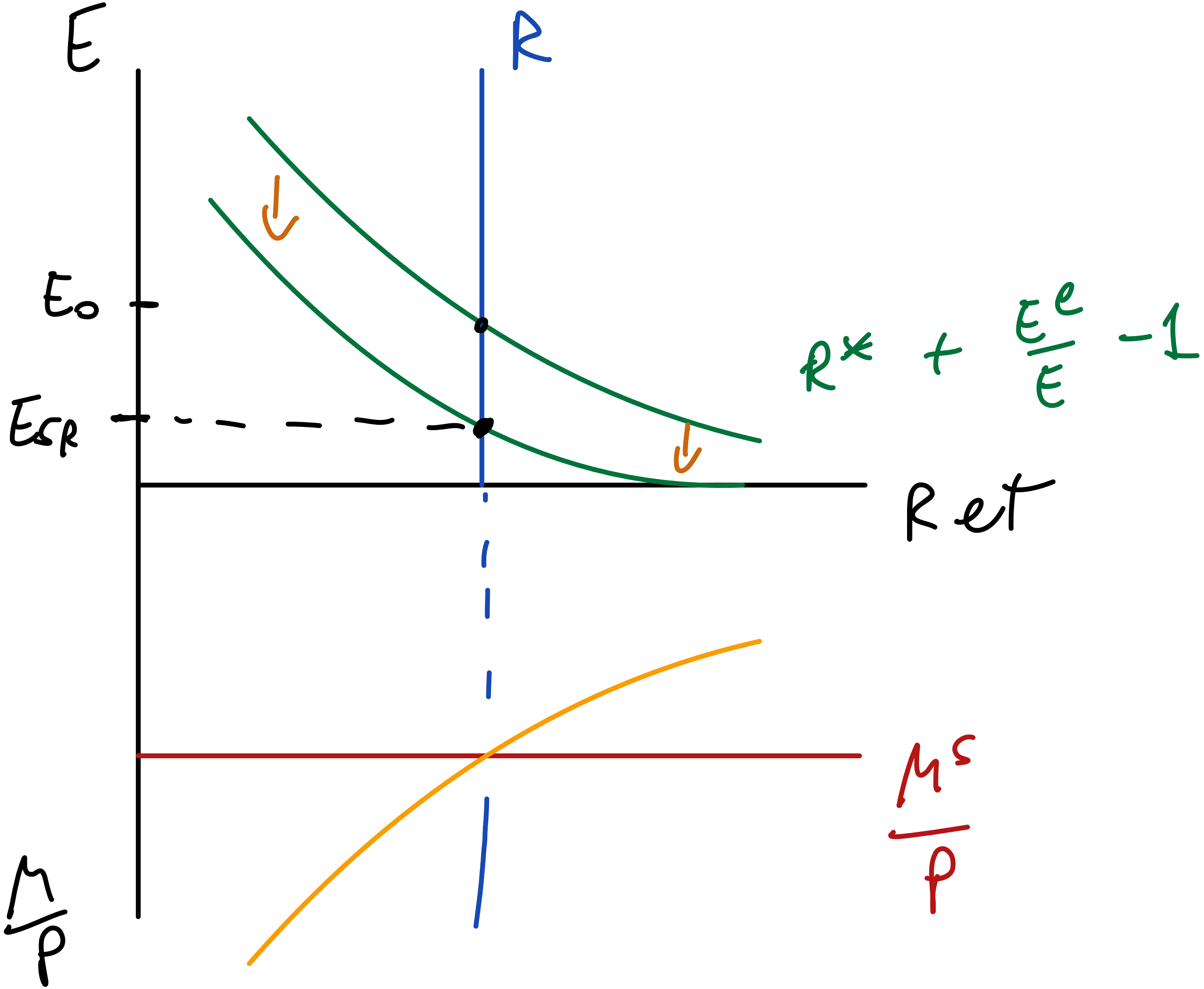
Permanent Shifts in Fiscal Policy



$G\uparrow$ PERMANENTLY

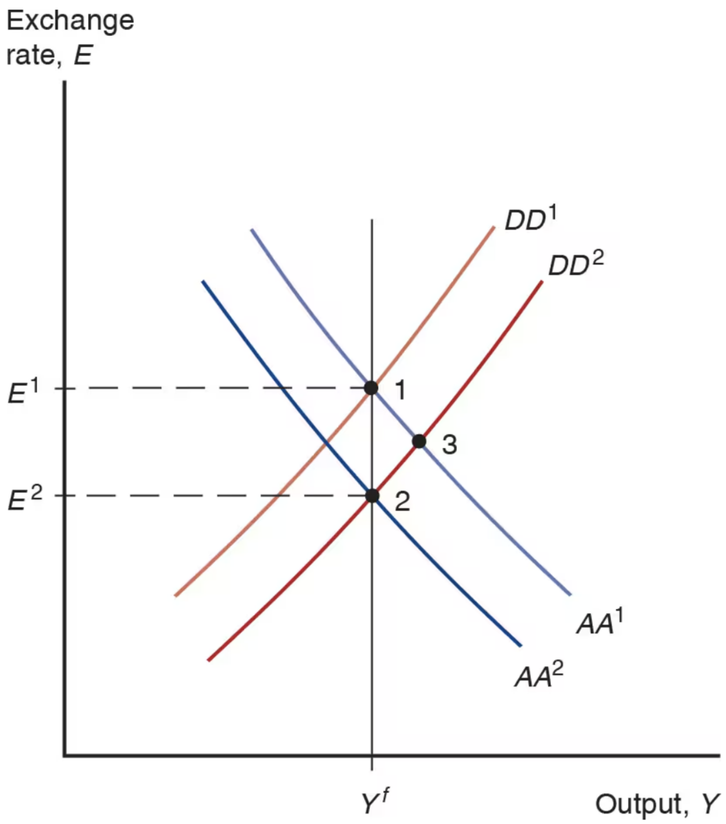
$\Rightarrow D\uparrow \Rightarrow Y\uparrow \Rightarrow$ DD SHIFTS TO THE RIGHT

$(AA): \frac{M^s}{P} = L\left(R^* + \frac{E^e - E}{E}, Y\right)$



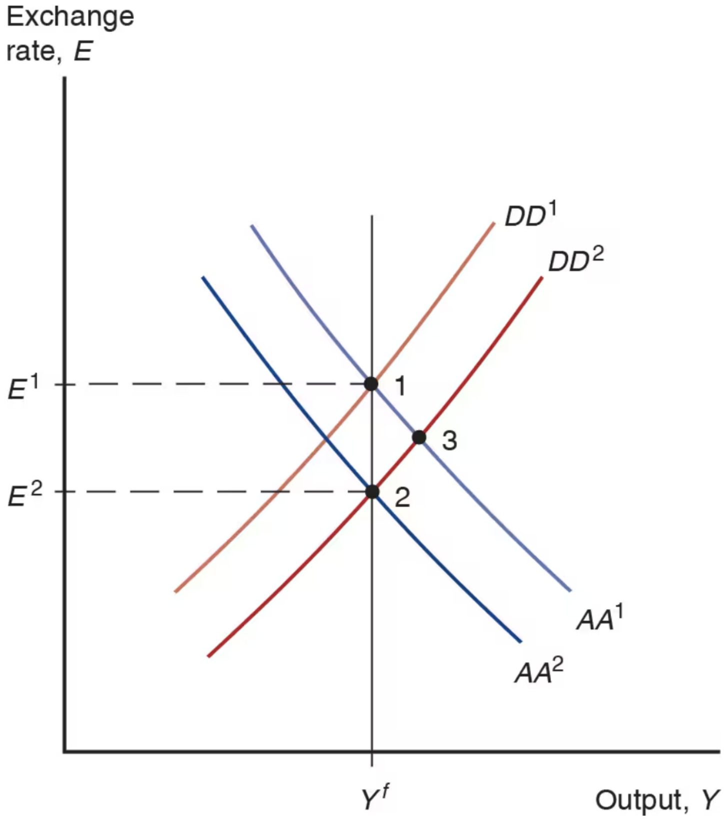
E
R
E_0
E_{ER}
$R^* + \frac{E^e}{E} - 1$
Ret
$\frac{M^s}{P}$
$\frac{M}{P}$

Permanent Shifts in Fiscal Policy



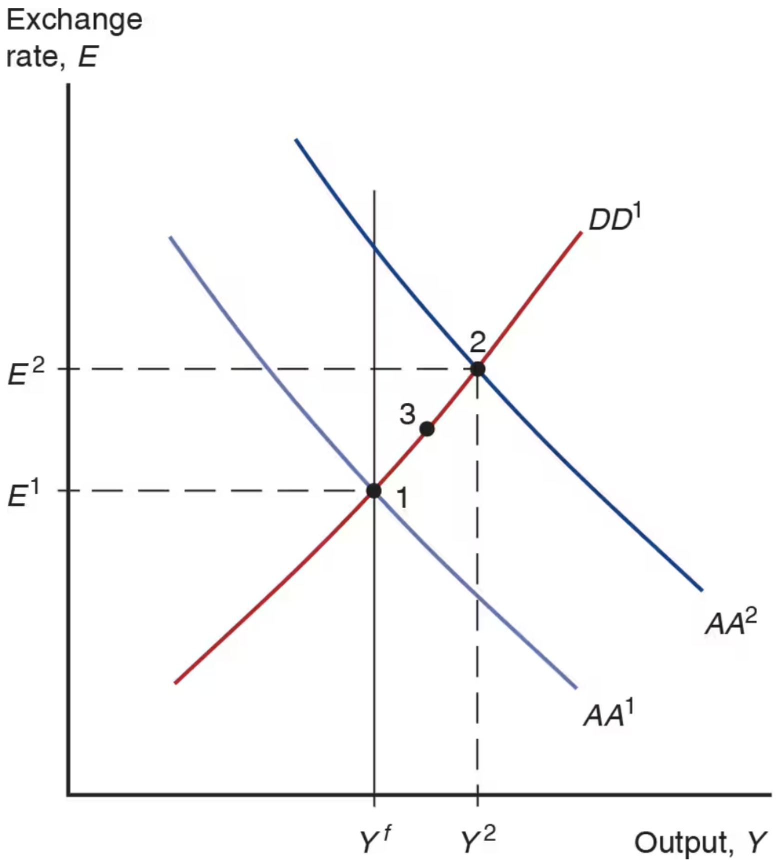
- Start in a medium run equilibrium at point 1 with $R_0 = R^*$ and $E_0^e = E^1$
- Increase in G shifts DD to the right
- At point 3, exchange rate is lower than E_1
- Since the shift in DD is permanent, appreciation at point 3 is also expected to be permanent
- E^e must also go down
- Lower E^e shifts AA down
- But how much?

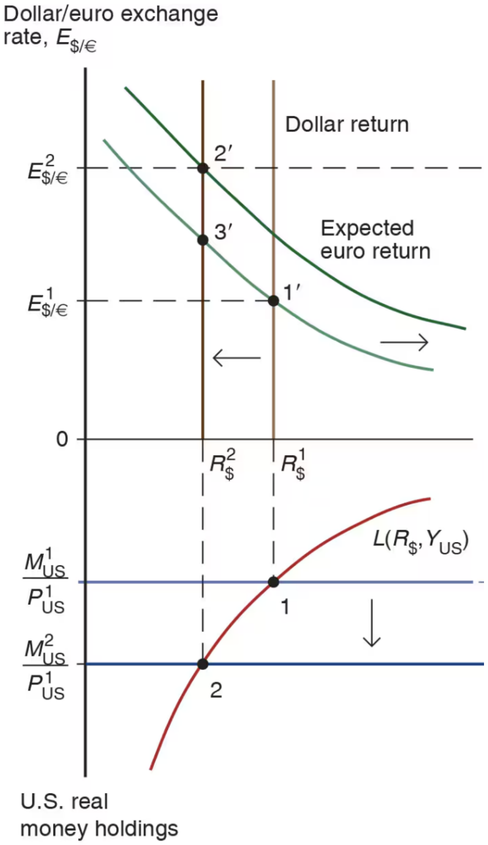
Permanent Shifts in Fiscal Policy



- There are no more shifts expected to occur, E^e remains constant
- Real money supply is constant
- Long run real money demand must stay unchanged
- Then P never changes
- MS=MD implies R does not change
- UIP implies E does not change either
- If Y must be equal to its original level Y^f, AA^1 must shift to AA^2

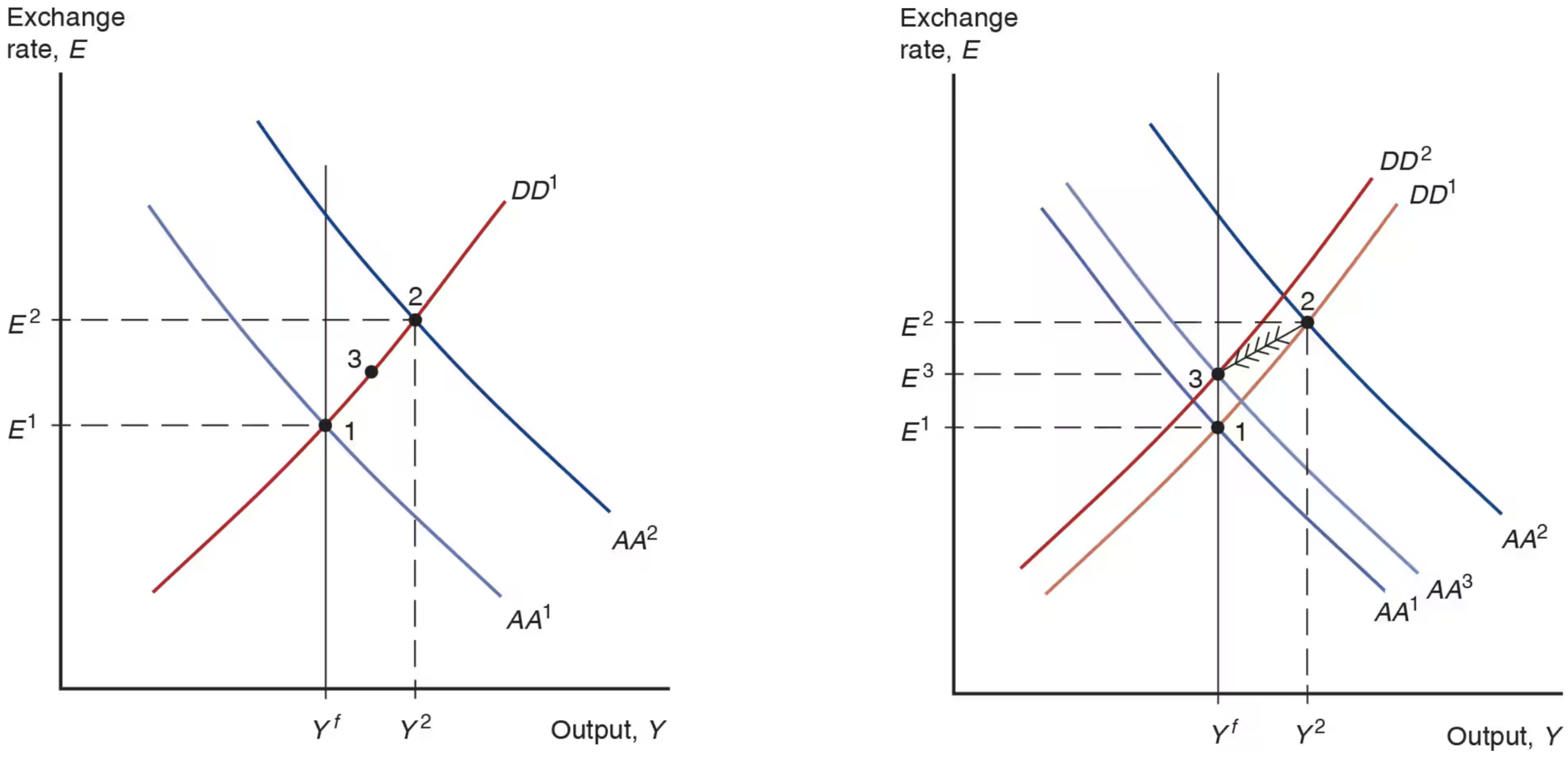
Permanent Shifts in Monetary Policy



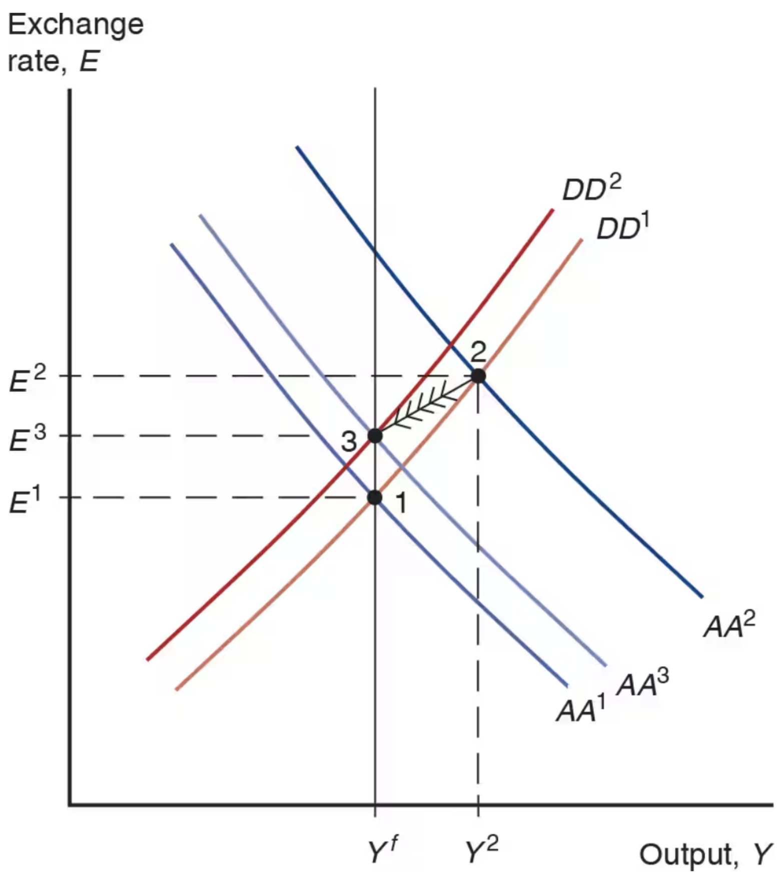


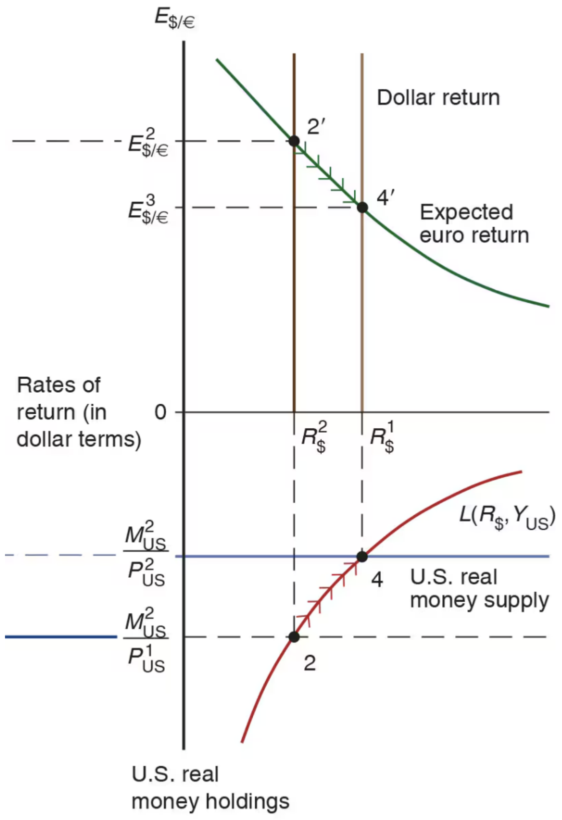
(a) **Short-run effects**

Permanent Shifts in Monetary Policy



Permanent Shifts in Monetary Policy





(b) Adjustment to long-run equilibrium

DD Schedule with Tariffs

IMPORT TARIFFS - "AD VALOREM" → PROPORTIONAL

$$\underbrace{IM}_{\text{UNITS OF DOM GOOD}} = \underset{\downarrow}{q} \times \underbrace{VOLUME}_{\text{IN UNITS OF FOREIGN GOOD}}$$

CHANGE OF UNITS

$$IM(\underset{(-)}{q}, \underset{(+)}{Y-T})$$

$$= q \times VOLUME(\underset{(-)}{q}, \underset{(+)}{Y-T})$$

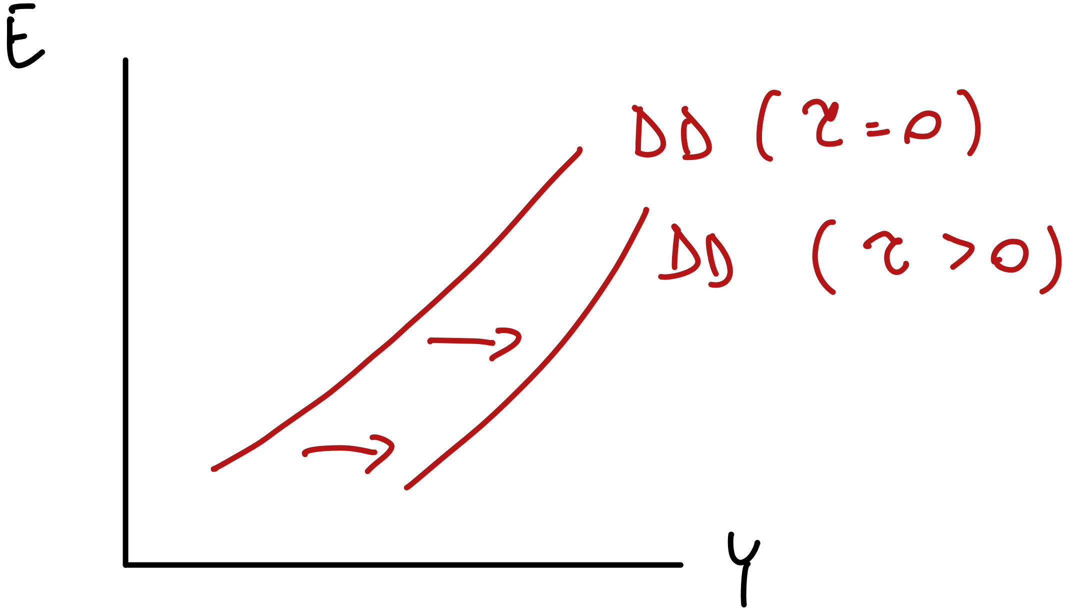
$$= q\, VOLUME\left(\frac{EP^*}{P}, Y-T\right)$$

$$IM = q \times VOLUME\left(\frac{EP^{*}}{P}\underset{\uparrow}{(1+\tau)} \, , \; Y - T \right)$$

AD VALOREM TARIFF

$$IM = IM\left(\underset{(-)}{q} \, , \; \underset{(+)}{Y-T} \, , \; \underset{(-)}{\tau} \right)$$

$$Y = C + I + G + EX - IM(\underset{(-)}{\tau})$$

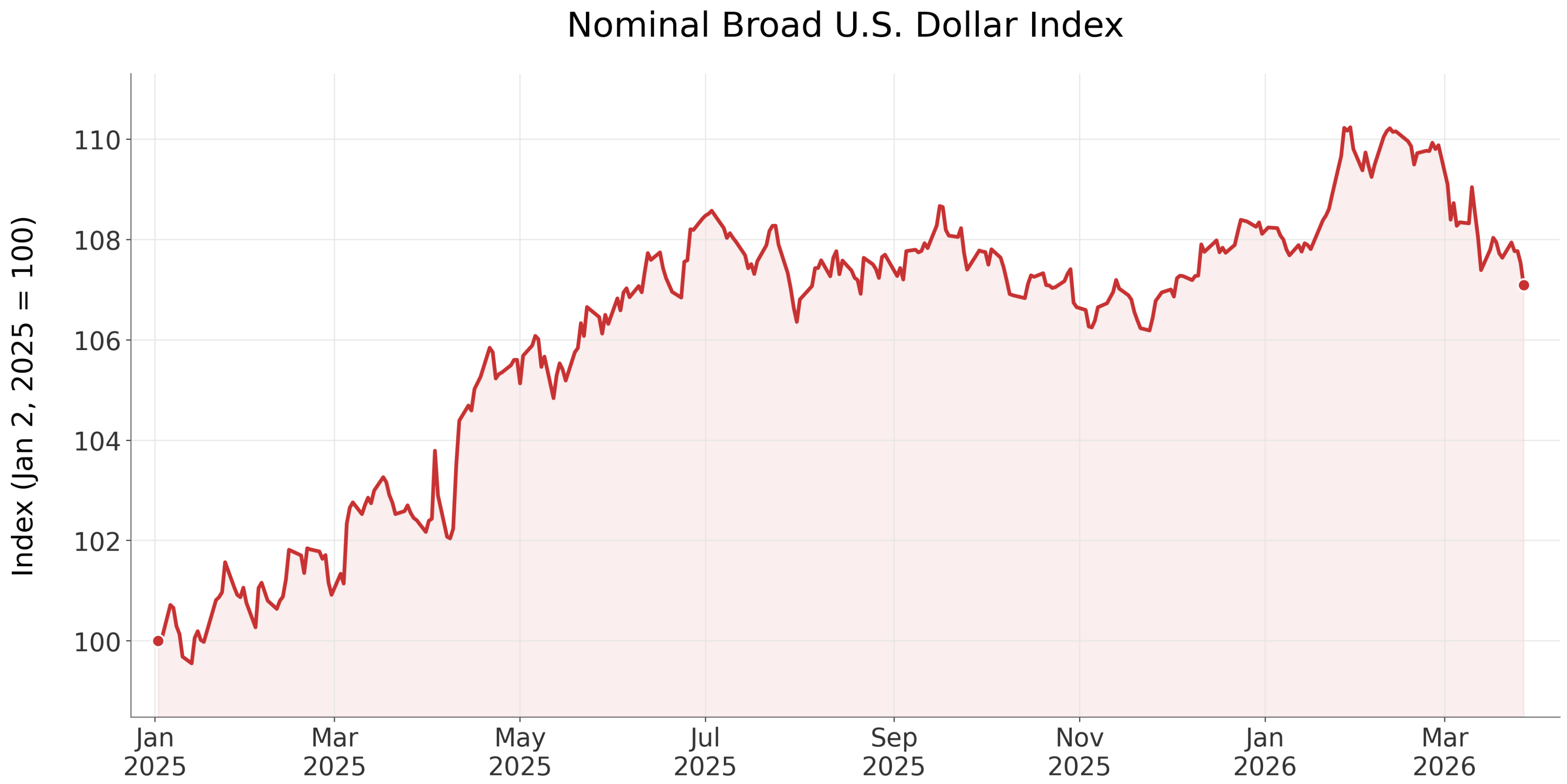


DD SHIFTS TO THE RIGHT WHEN τ GOES UP

ECON 1550 International Finance

A Tour of the World

Tariff Wars



Sources: Reuters tariff timeline; White House fact sheet (Feb. 20, 2026); data: FRED DTWEXBGS (Mar. 20, 2026).

Tariff authorities for executive branch

- **International Emergency Economic Powers Act, IEEPA (1977)** During declared national emergency
- **Section 232, Trade Expansion Act (1962)** For threats to national security
- **Section 301, Trade Act (1974)** To address unfair trade practices
- **Section 122, Trade Act (1974)** During balance-of-payments emergency

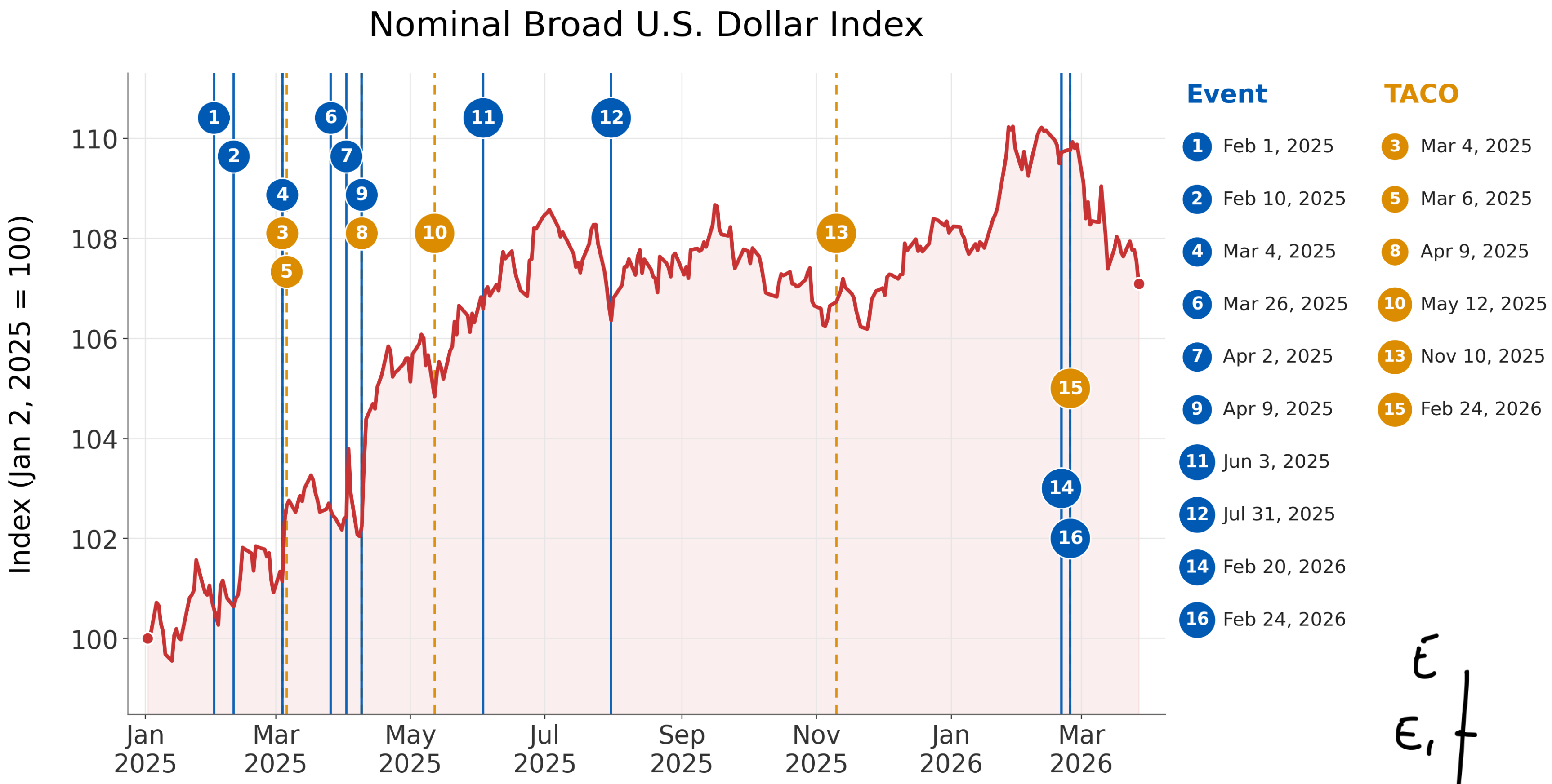
Declared emergencies for IEEPA tariffs

The failure of each country to…

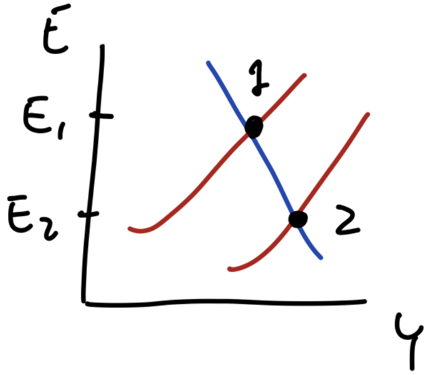
- Canada — “take adequate steps to alleviate the illegal migration and illicit drug crises”
- Mexico — “arrest, seize, detain, or otherwise intercept Mexican drug trafficking organizations, other drug and human traffickers, criminals at large, and illicit drugs”
- China — “blunt the sustained influx of synthetic opioids”

Timeline of major tariff events

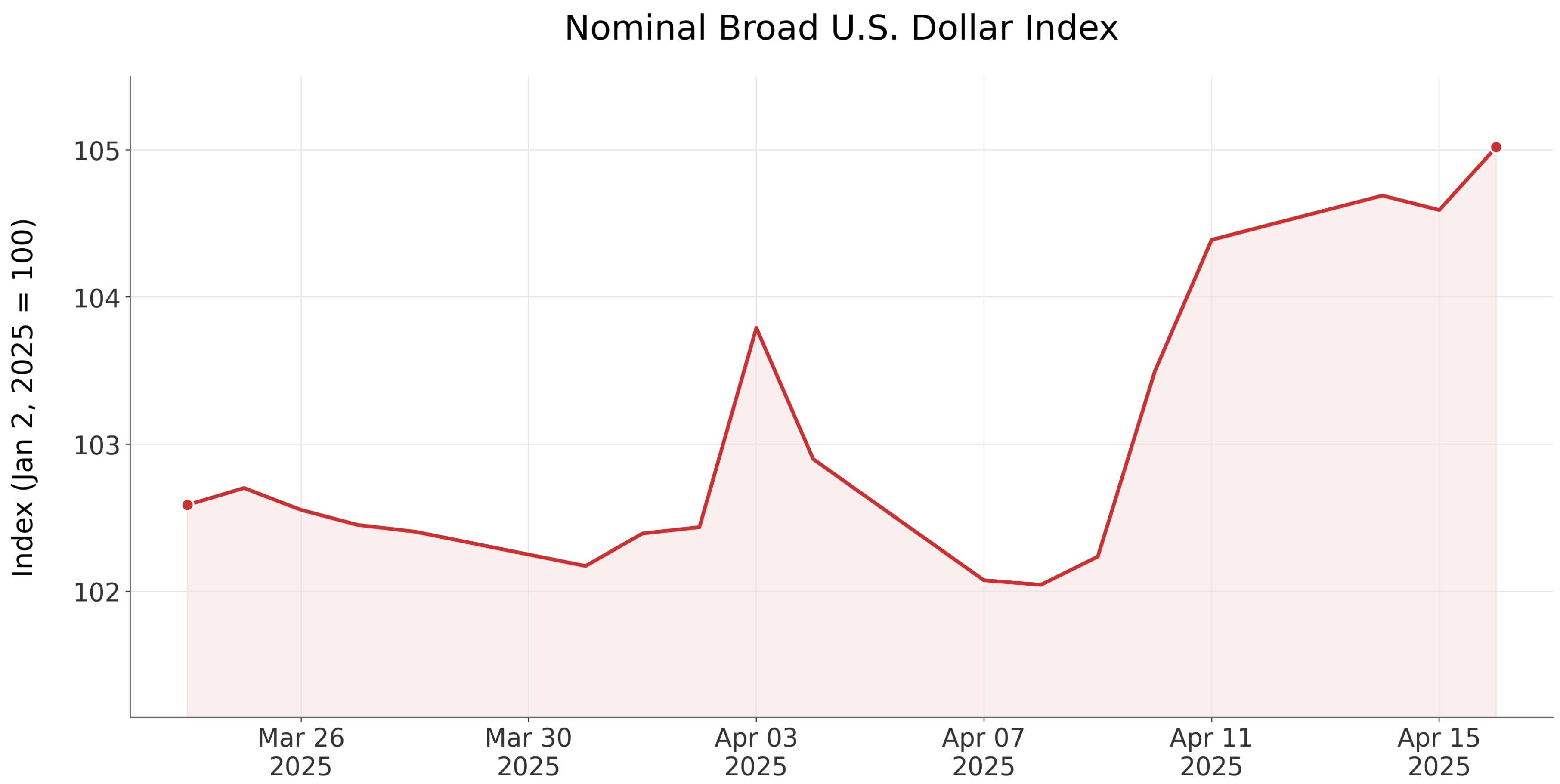
	Event	TACO
2025		
Feb 1	25% on Canada/Mexico; 10% on China (IEEPA)	Canada/Mexico delayed to Mar 4
Feb 10	Steel/aluminum to 25%, no exemptions (Sec. 232)	
Mar 4	Canada/Mexico take effect; China to 20%	Mar 6: USMCA-compliant exempt until Apr
Mar 26	25% on autos/parts (Sec. 232)	
Apr 2	“Liberation Day” 10% + country-specific	Apr 9: 10% paused ex China
Apr 9	China raised to 145%	May 12: 30% for 90 days; Nov: 1-yr deal
Jun 3	Steel/aluminum to 50% (Sec. 232); UK stays 25%	
Jul 31	Reciprocal tariffs on $\sim$60 partners (10–41%)	
2026		
Feb 20	Supreme Court strikes down IEEPA tariffs	All IEEPA tariffs terminated Feb 24
Feb 24	10% surcharge on most imports (Sec. 122)	Expires Jul 24, 2026

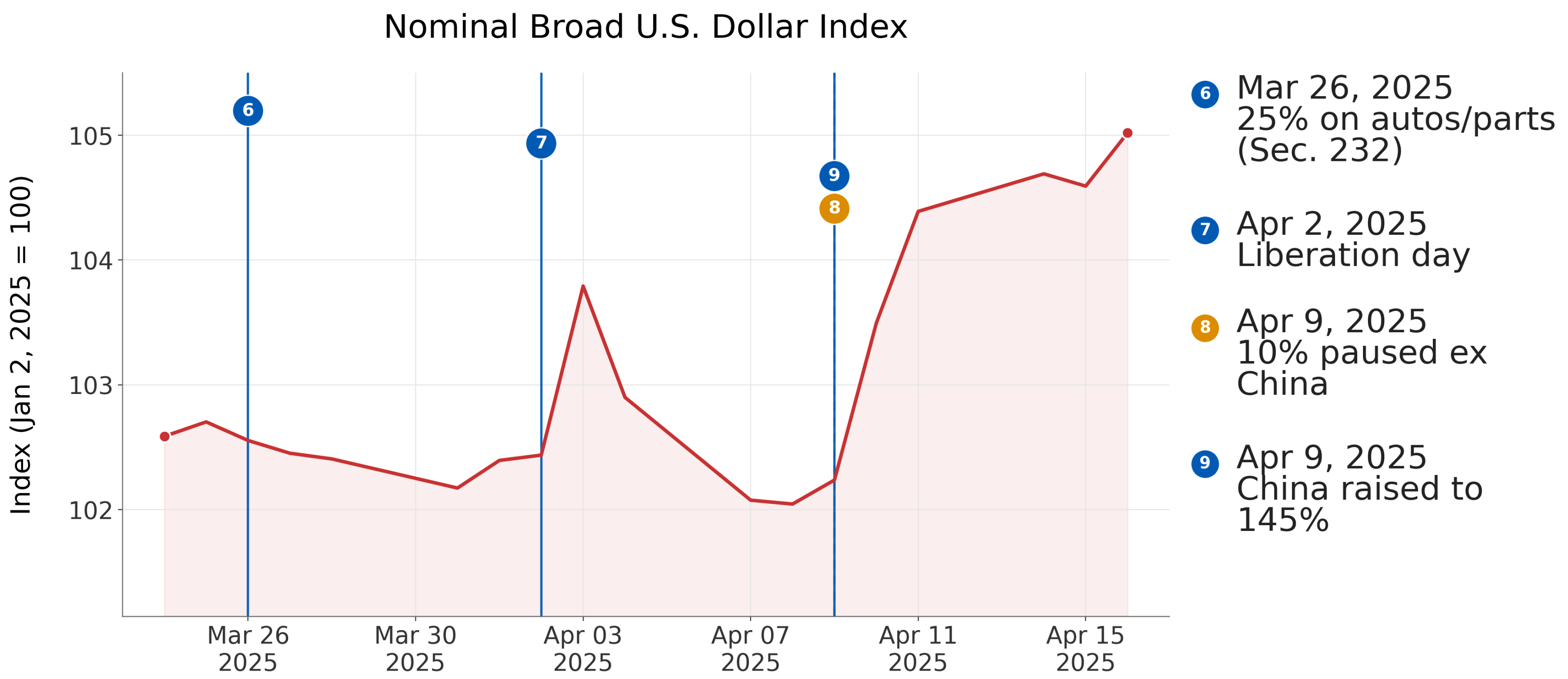


Nominal Broad U.S. Dollar Index
Index (Jan 2, 2025 = 100)
110
108
106
104
102
100
Jan 2025
Mar 2025
May 2025
Jul 2025
Sep 2025
Nov 2025
Jan 2026
Mar 2026
Event
1 Feb 1, 2025
2 Feb 10, 2025
4 Mar 4, 2025
6 Mar 26, 2025
7 Apr 2, 2025
9 Apr 9, 2025
11 Jun 3, 2025
12 Jul 31, 2025
14 Feb 20, 2026
16 Feb 24, 2026
TACO
3 Mar 4, 2025
5 Mar 6, 2025
8 Apr 9, 2025
10 May 12, 2025
13 Nov 10, 2025
15 Feb 24, 2026



E
E1
E2
1
2
Y


Nominal Broad U.S. Dollar Index
Index (Jan 2, 2025 = 100)
105
104
103
102
Mar 26 2025
Mar 30 2025
Apr 03 2025
Apr 07 2025
Apr 11 2025
Apr 15 2025


Nominal Broad U.S. Dollar Index
Index (Jan 2, 2025 = 100)
105
104
103
102
Mar 26 2025
Mar 30 2025
Apr 03 2025
Apr 07 2025
Apr 11 2025
Apr 15 2025
6
7
8
9
6 Mar 26, 2025 25% on autos/parts (Sec. 232)
7 Apr 2, 2025 Liberation day
8 Apr 9, 2025 10% paused ex China
9 Apr 9, 2025 China raised to 145%

The dollar fell despite rising tariffs

- Nominal broad dollar index: 129.46 on Jan 2, 2025 $\rightarrow$ 120.28 on Mar 20, 2026—roughly a 7% depreciation over about 15 months.

- AA-DD model says tariffs should make the dollar *appreciate*

- Yet the dollar weakened through most of the tariff escalation.

Why might tariffs weaken the dollar?

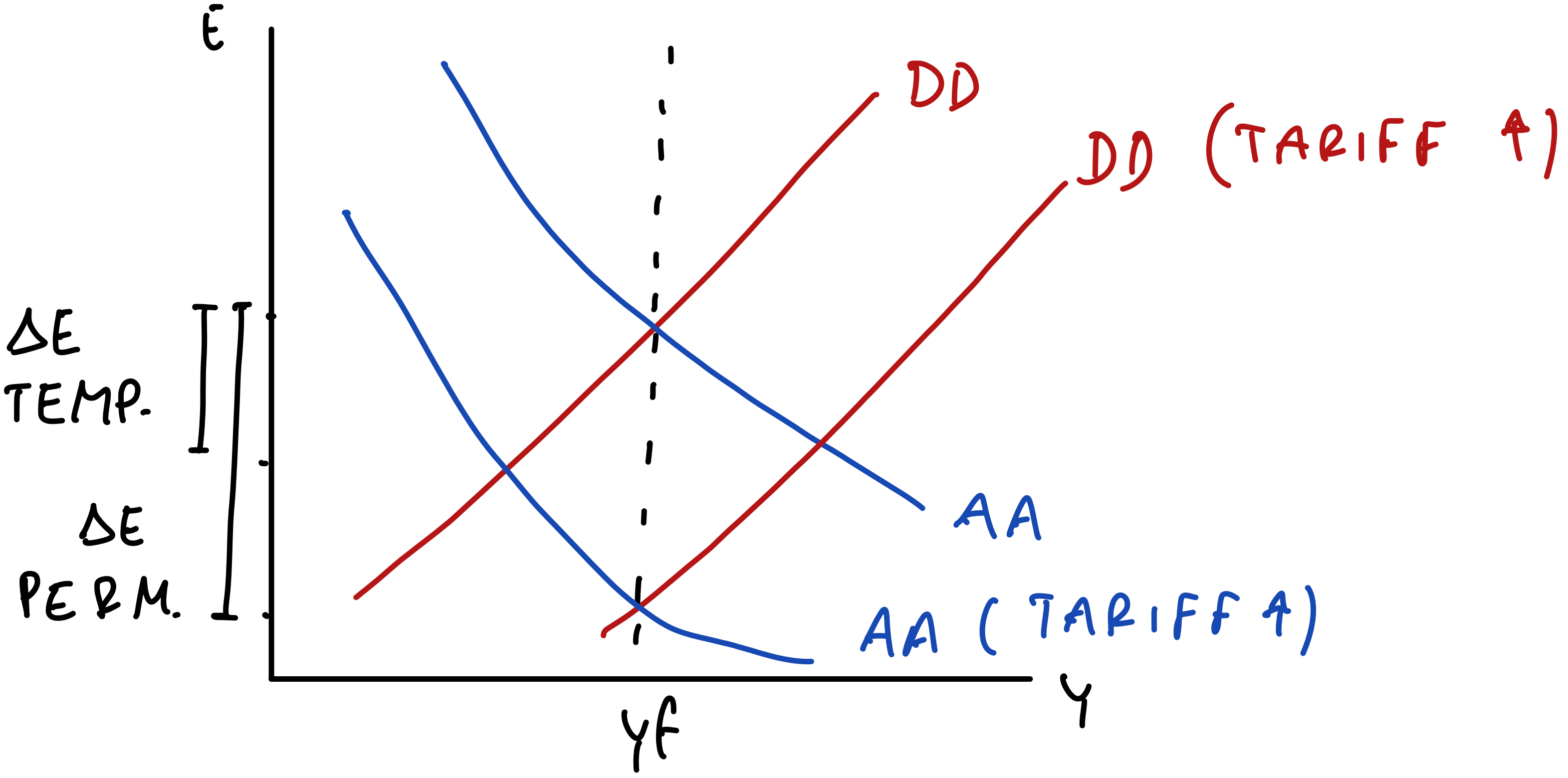
- Retaliation: trading partners imposed their own tariffs
- Duration of tariffs: the IEEPA legal challenge raised questions about tariffs being permanent or temporary
- Uncertainty: frequent reversals, volatile policies
- The overall behavior combines all effects

Retaliation: Not huge

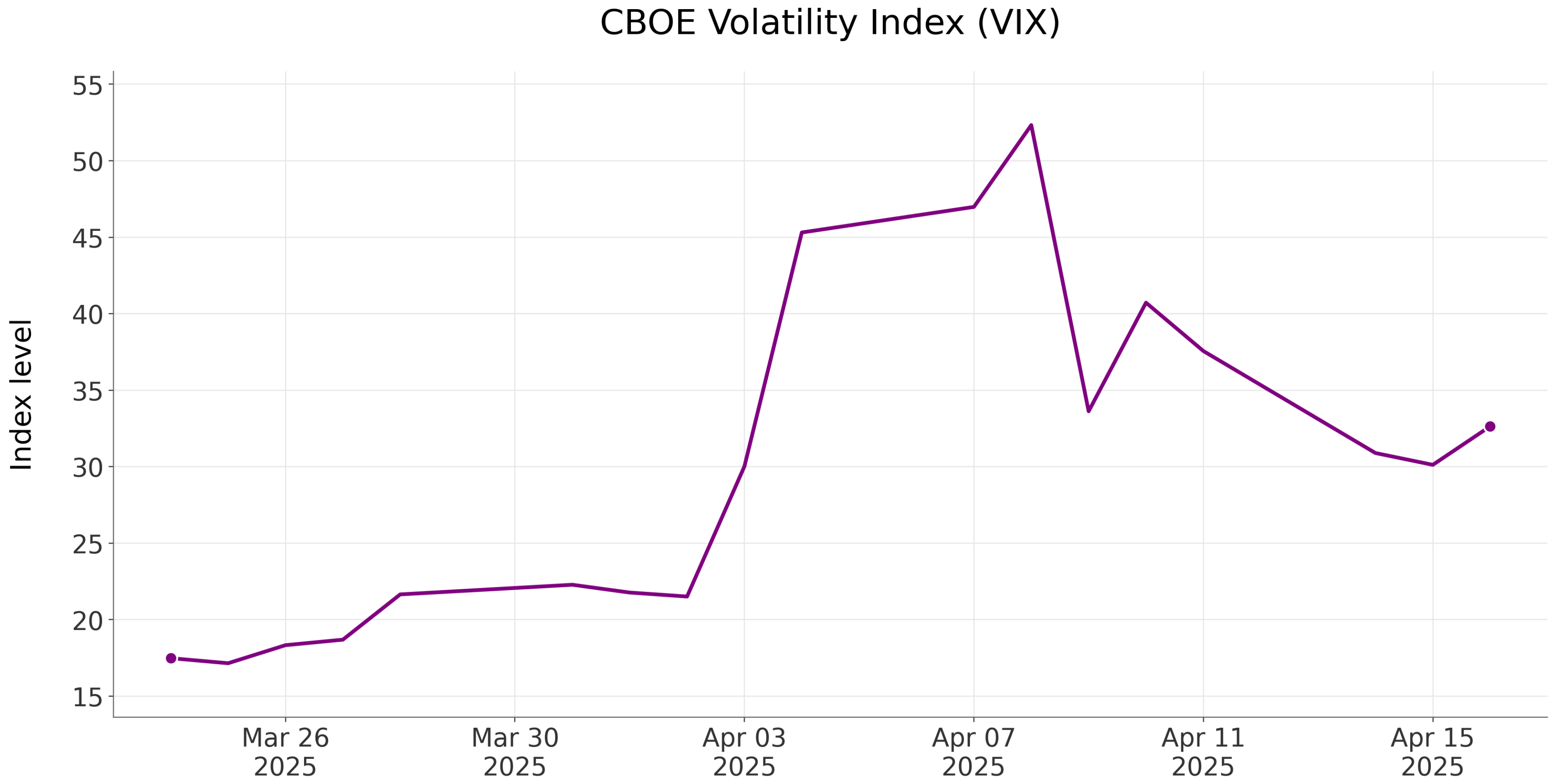
	Before (Jan 2025)	**Now** (Mar 2026)	**Peak** (Apr 2025)
On foreign goods entering the U.S.	2.2%	**10%**	**28%**
On U.S. goods entering other countries	1.9%	**3.2%**	—

Sources: Yale Budget Lab (peak); Tax Foundation; WTO tariff profiles; U.S. Census Bureau export data (2024). All figures are trade-weighted averages.

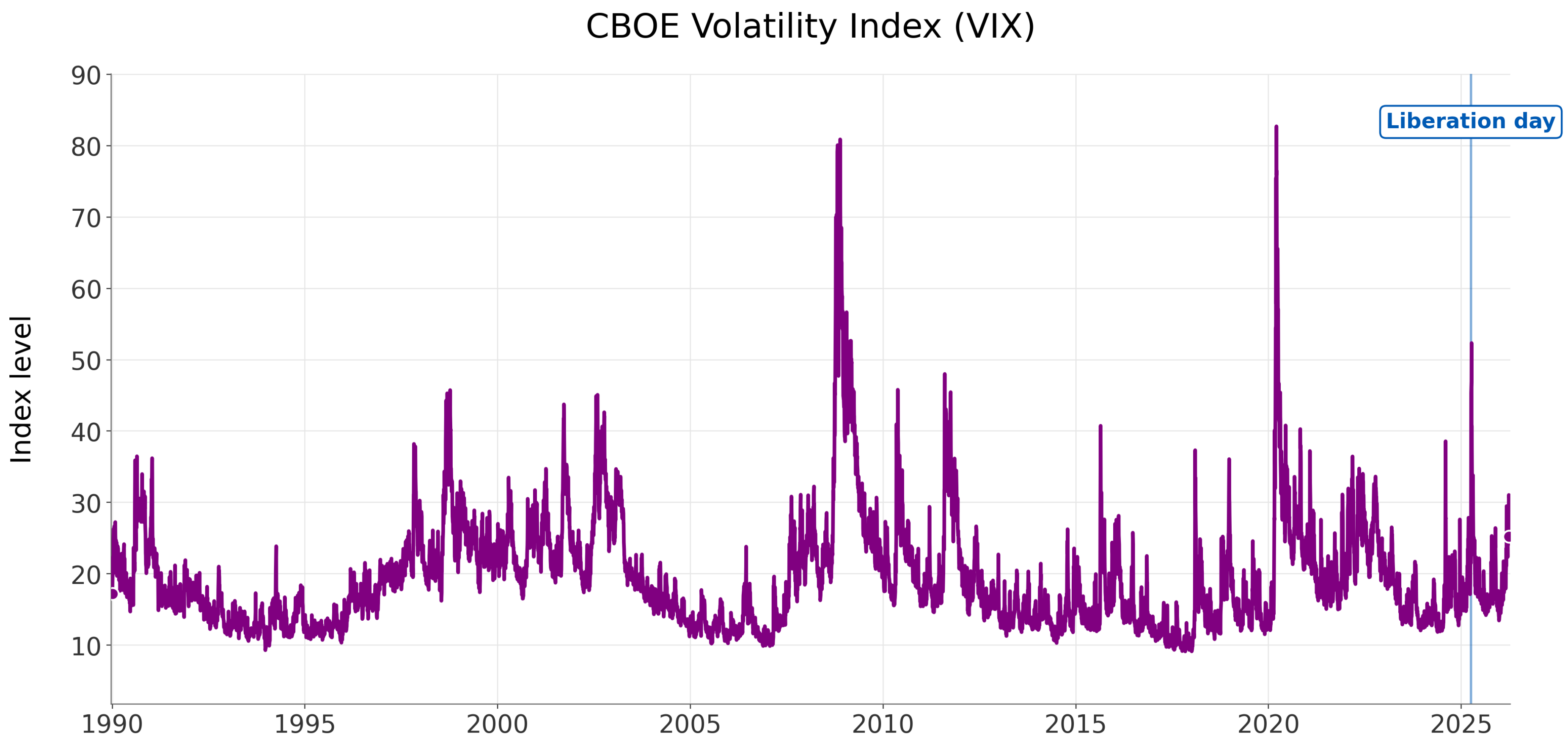
Duration of tariffs: changes size of appreciation only, not direction



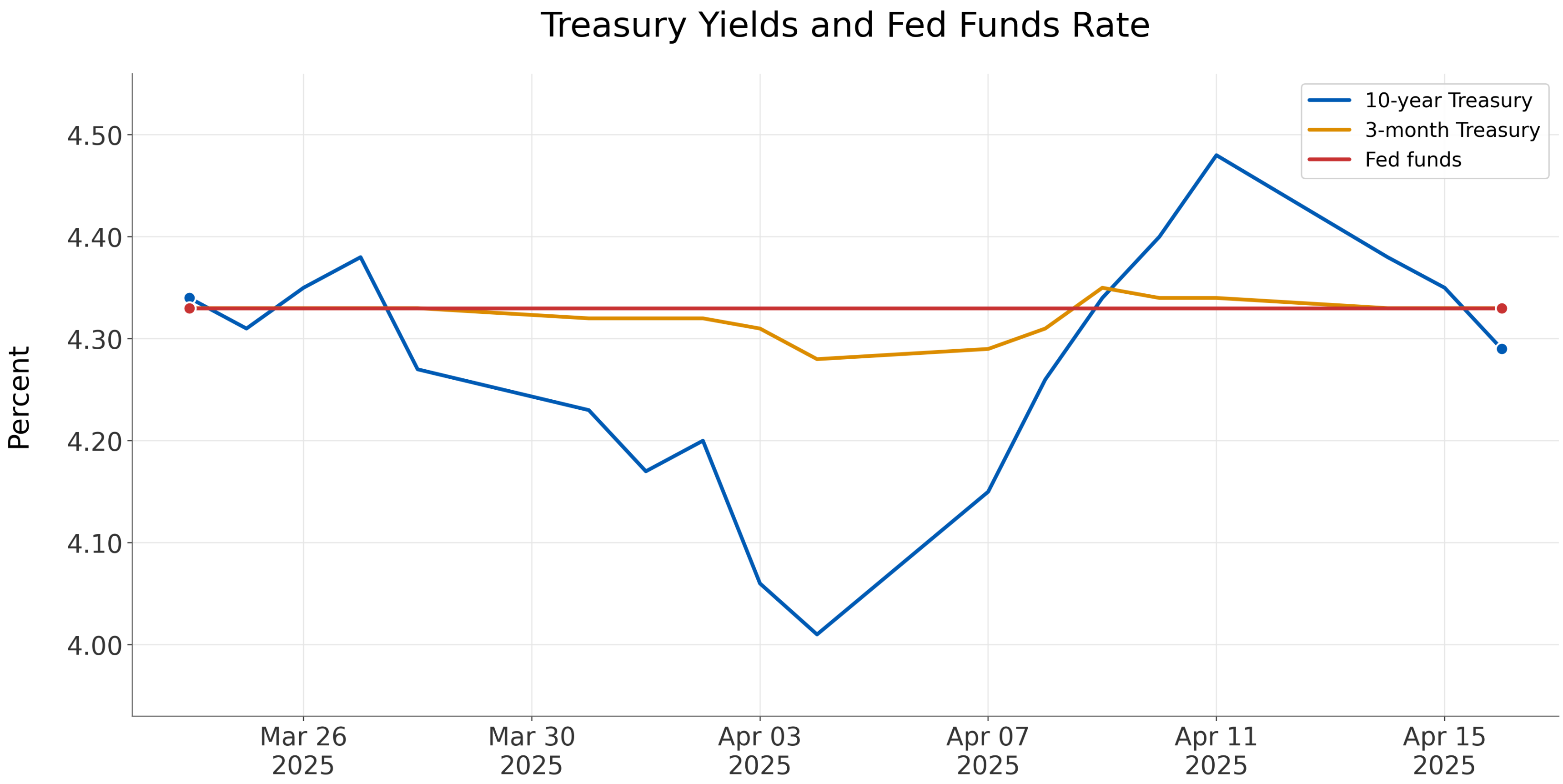
Uncertainty: Increase in risk premium



Source: FRED VIXCLS.


CBOE Volatility Index (VIX)
Index level
90
80
70
60
50
40
30
20
10
1990
1995
2000
2005
2010
2015
2020
2025
Liberation day

U.S. rates in the VIX window

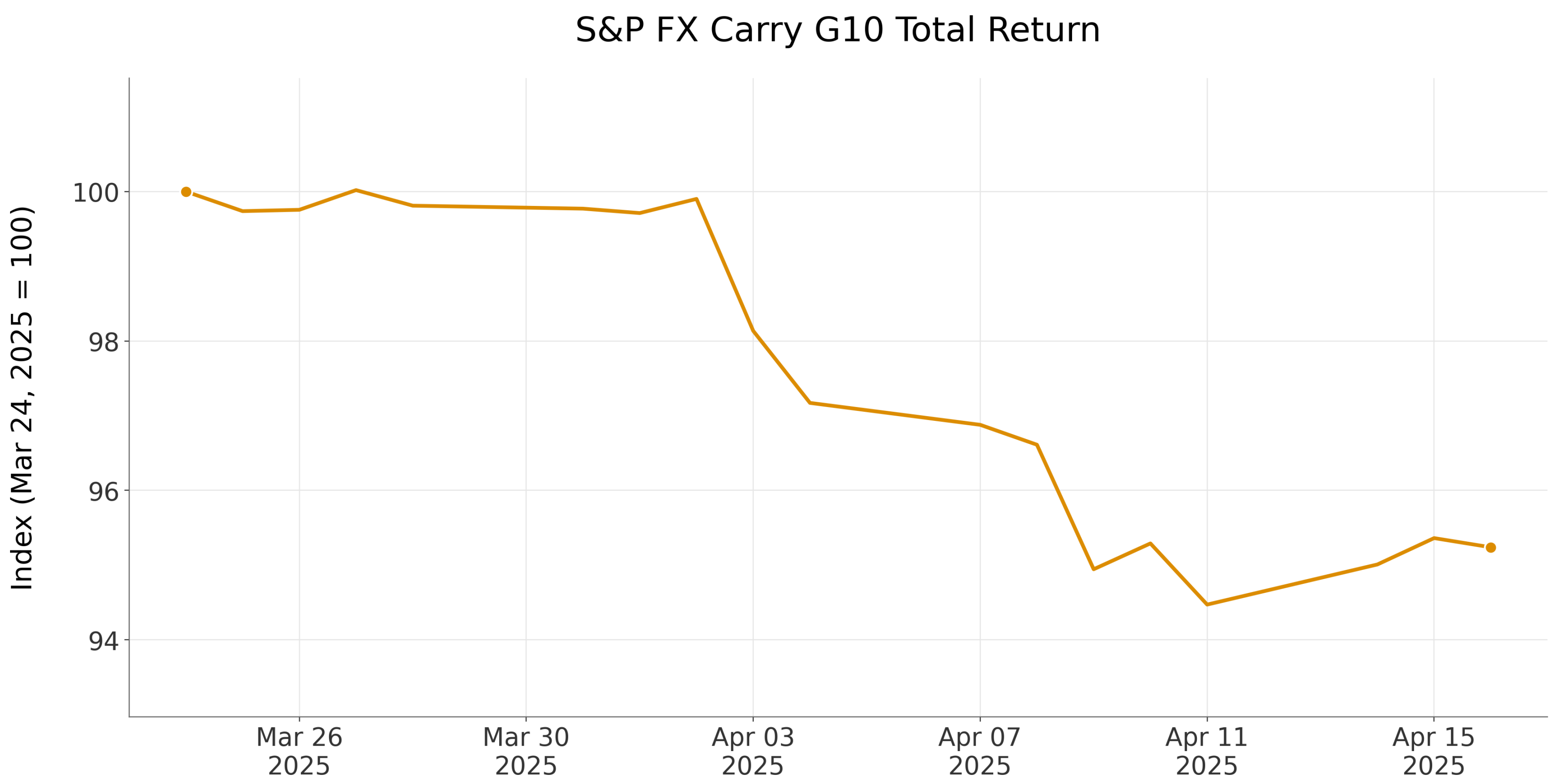


Source: FRED DGS10, FRED DGS3MO, and FRED DFF.

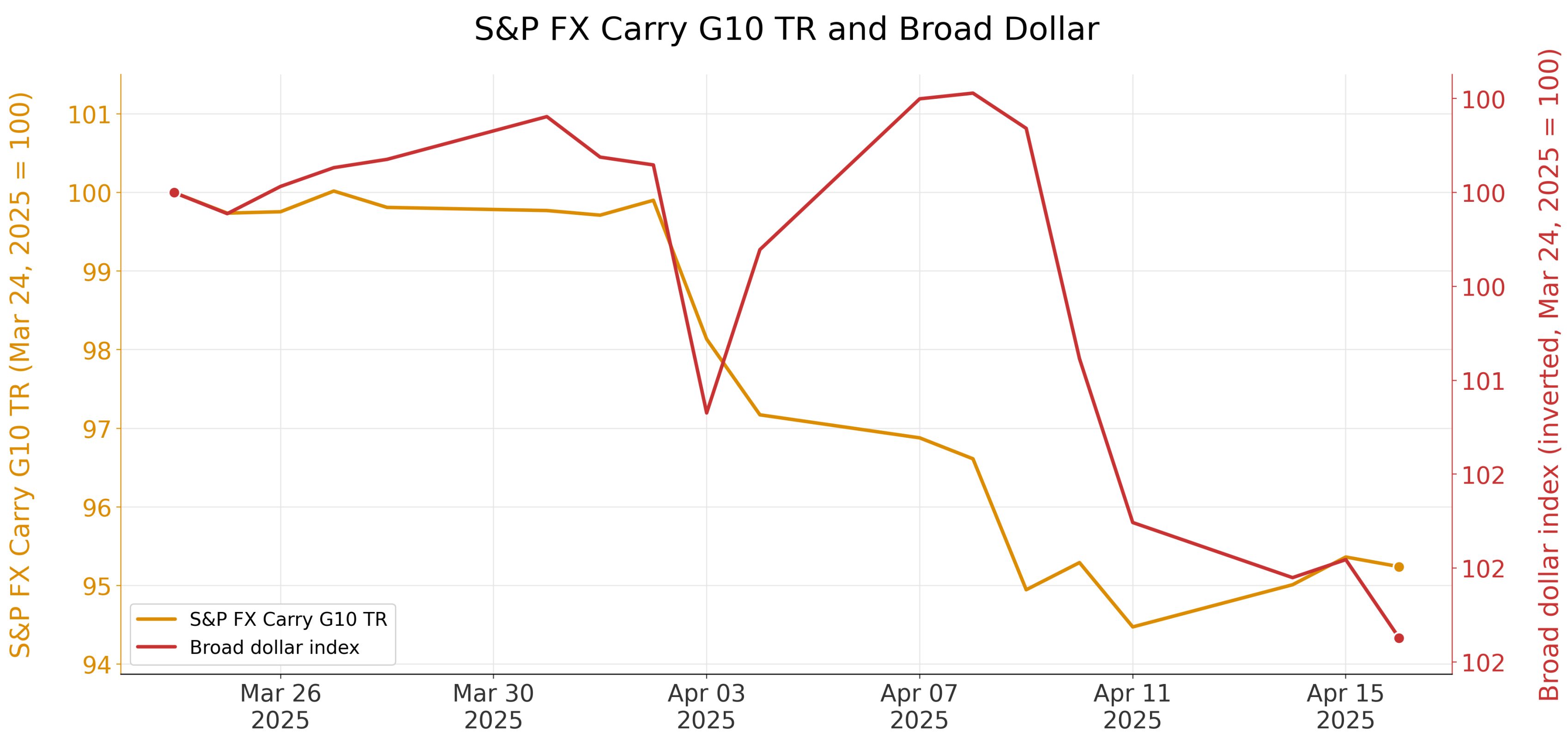
Carry Trade Index: S&P FX Carry G10 TR

- Rank currencies by 3-month interest rate
- Lend in the 3 highest interest rate currencies; borrow in the lowest three
  - 3 highest NOK/GBP/AUD
  - 3 lowest CHF/JPY/SEK
- Rebalanced quarterly

Carry Trade Index: S&P FX Carry G10 TR

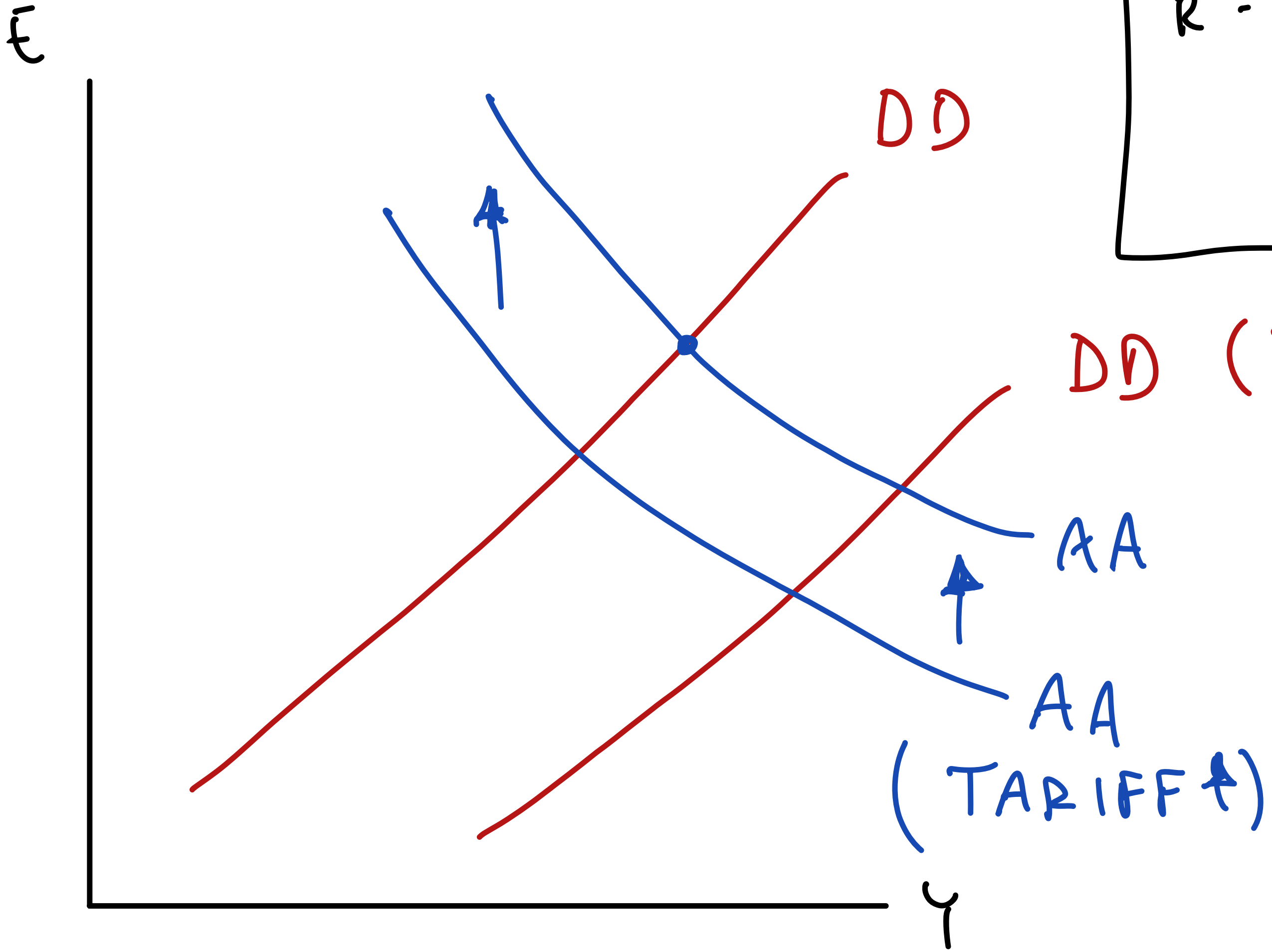


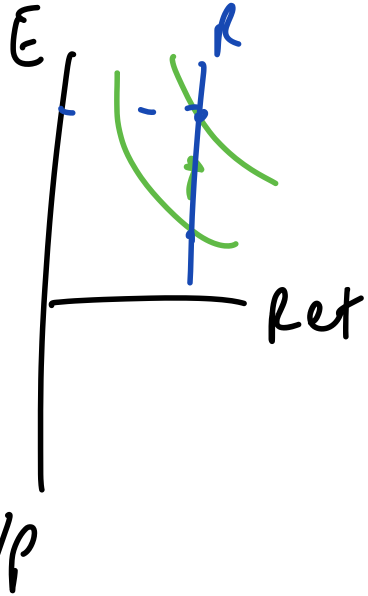
Source: S&P Dow Jones Indices daily total-return index levels for the S&P Risk Premia FX Carry G10 Index (USD) TR. Rebased to 100 on Mar. 24, 2025.



S&P FX Carry G10 TR and Broad Dollar
S&P FX Carry G10 TR (Mar 24, 2025 = 100)
Broad dollar index (inverted, Mar 24, 2025 = 100)
101
100
99
98
97
96
95
94
100
100
100
101
102
102
102
Mar 26 2025
Mar 30 2025
Apr 03 2025
Apr 07 2025
Apr 11 2025
Apr 15 2025
S&P FX Carry G10 TR
Broad dollar index

$$R = R^* + \frac{E^e}{E} - 1 + RP$$



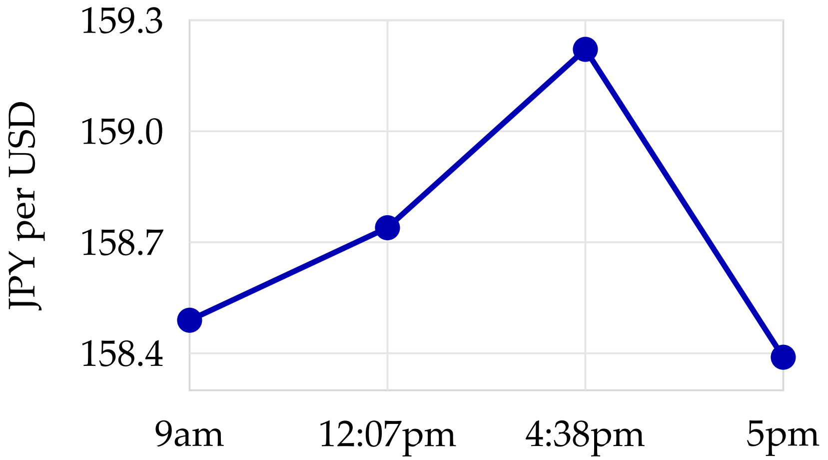


The December 2025 yen episode

- On December 19, 2025, the BOJ raised its policy rate from 0.5% to 0.75%, but the yen weakened rather than strengthened
- The move had been widely telegraphed, so markets had largely priced it in
- Gov. Ueda's cautious, data-dependent guidance did not signal a clearly faster tightening path
- Investors judged the decision as not hawkish enough and pushed USD/JPY higher

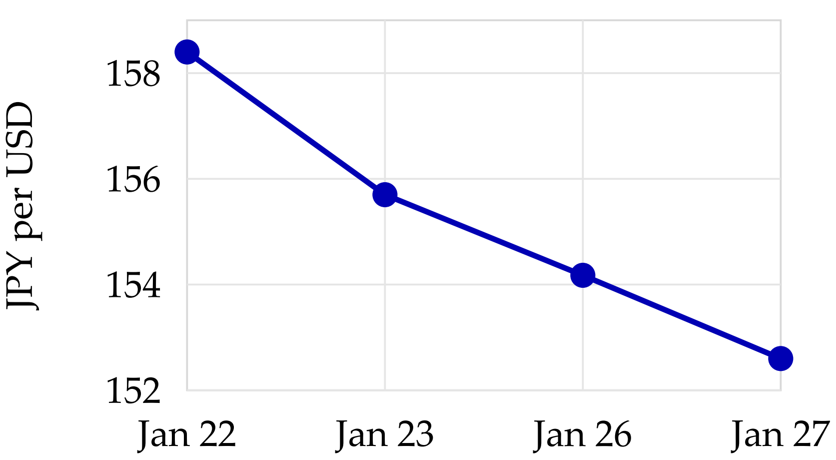
The January 2026 yen episode

Jan. 23 intraday



Yen weakened, then partially reversed

Daily



Yen strengthened sharply

Sources: BOJ Jan. 23 FX list; Minkabu intraday quotes; MTFX; Macrotrends.

Timeline of the turn

When	What happened	USD/JPY
Jan. 22	BOJ meeting opens.	158.43
Jan. 23, 12:07 pm	Statement: no hawkish surprise. USD/JPY edges up.	158.74
Jan. 23, 3:30–4:38 pm	Ueda press conference: no tightening	159.22
Jan. 23, late U.S.	Expectations of government intervention to prevent yen depreciation	155.72
Jan. 27	Higher interest rates expected	152.21

Sources: BOJ statement; Ueda press conference summary (NRI); Reuters rate-check report; MTFX; Macrotrends.

Why the direction changed

First: why did JPY weaken?

- The BOJ statement and Ueda's press conference signaled lower future interest rates than expected
- Despite no actual change in the interest rate, expected lower interest rate led to depreciation

Then: why did JPY strengthen?

- A NY Fed survey revealed market expects FX intervention to prevent JPY from falling
- Markets now concerned about JPY depreciation
- Depreciation $\rightarrow$ higher inflation $\rightarrow$ higher expected interest rates $\rightarrow$ appreciation

Sources: BOJ statement; Summary of Opinions; Reuters; Ueda press conference summary (NRI).

ECON 1550 International Finance

A Tour of the World

When Safe Havens Stop Working

Are Treasuries still a safe haven?

Axel Christensen · 2nd

Connect ···

Managing Director, Chief Investment Strategist Latin Am...

2w ·

The Middle East conflict is upending well-established relationships in global markets.

In past geopolitical crises, long-term U.S. Treasuries would often rally and cushion equity market selloffs. But instead, yields have jumped. That aligns with our view that we are at risk of an inflationary supply shock — not a classic demand-driven slowdown. And why government bonds provide a diversification mirage.

Full AA-DD Model

DD Schedule: $$Y = \mathrm{C}(Y-T) + I + G + \mathrm{CA}(EP^*/P, Y-T, Y^*)$$

AA Schedule: $$\frac{M^s}{P} = \mathrm{L}\left(R^* + \frac{E^e}{E} - 1, Y\right)$$

Phillips Curve: $$\pi = \pi^e + \alpha(Y - Y^f)$$

Definition of inflation: $$\pi_t = \frac{P_t}{P_{t-1}} - 1$$

Definition of expected inflation: $$\pi_t^e = \frac{P_{t+1}^e}{P_t} - 1$$

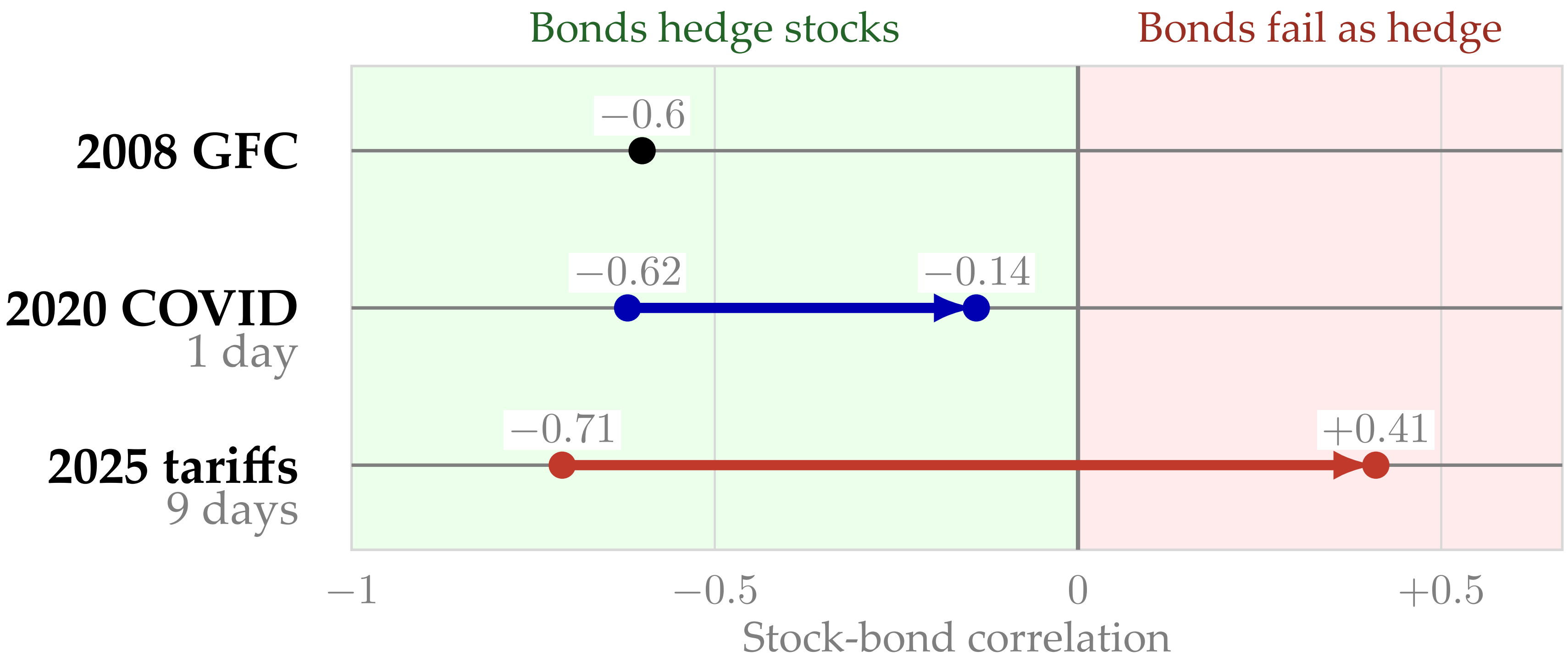
Supply shock vs demand shock

Same shock, different outcome

	Why	Stocks	Treasuries	Dollar	
2008 GFC	More demand for safety	↓	↑	↑	classic hedge
2020 COVID	Scramble for cash	↓	↓	↑	mixed
2025 tariffs	Investors cut U.S. exposure	↓	↓	↓	both failed

Sources: Hu, Jin, & Pan (2025); ECB Financial Stability Review, Nov. 2025; BIS Working Paper 966; Acharya & Laarits (NBER); Fed IFDP 1427.

The stock-bond correlation flip



Sources: Hu, Jin, & Pan (2025) stock-bond correlation series; BIS Working Paper 966 on March 2020 Treasury stress.

ECON 1550 — Problem Set 1 Answer Key

Spring 2026

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Submission:	Canvas or Gradescope

1. **Multiple Choice**

For each question, select the one correct answer.

(a) In the IS-LM-PC model, when the money supply is exogenous and the nominal interest rate is endogenous, the LM curve is

- ◯ (A) flat
- ✓ **(B) upward sloping**
- ◯ (C) downward sloping
- ◯ (D) vertical

Solution:

- (A) Do not select. A flat LM curve occurs when the interest rate is exogenous.
- **(B) Select.** When income increases, money demand increases. However, equilibrium requires that money demand remains equal to the unchanged exogenous money supply. The nominal interest rate must increase to reduce the money demand by an amount that exactly offsets the increase in money demand induced by the higher income.
- (C) Do not select. A downward sloping LM would imply that the interest rate goes down as income increases, which contradicts that money demand is increasing in income and decreasing in the interest rate.
- (D) Do not select. A vertical LM curve implies that any value for the interest rate is an equilibrium value. However, with an exogenous money supply and a money demand that is decreasing in the interest rate, there is always only one equilibrium value of the interest rate.

(b) In the IS-LM-PC model, when the money supply is endogenous and the nominal interest rate is exogenous, the LM curve is

✓ **(A) flat**
◯ (B) upward sloping
◯ (C) downward sloping
◯ (D) vertical

Solution: Any shape for the LM other than flat implies that the interest rate changes when output changes. However, when the interest rate is exogenous, it cannot change in response to changes in any of the variables of the model. Exogenous variables can only change if we assume they change for reasons outside the model.

- **(A) Select.**
- (B) Do not select.
- (C) Do not select.
- (D) Do not select.

(c) Assume the nominal interest rate is exogenous. An increase in this exogenous nominal interest rate

✓ **(A) keeps the IS curve unchanged**
◯ (B) shifts the IS curve to the right
◯ (C) shifts the IS curve to the left
◯ (D) cannot be determined without more information

Solution: The IS curve gives combinations of the interest rate r and output Y that are equilibria in the goods market. When the interest rate changes, the equilibrium value of output changes (through the effect of the interest rate on investment). Because the IS is plotted with output Y on the horizontal axis and the interest rate r on the vertical axis, simultaneous changes in r and Y that maintain goods market equilibrium correspond to movements along the IS curve.

- **(A) Select.**

- (B) Do not select.
- (C) Do not select.
- (D) Do not select.

(d) When inflation expectations are unanchored, if output exceeds potential output, the inflation rate over time

◯ (A) remains stable

◯ (B) spirals downward

✓ **(C) increases**

◯ (D) decreases

Solution: When inflation expectations are unanchored, expected inflation π_t^e equals inflation in the previous period π_{t-1} The Phillips curve in this case is $\pi_t - \pi_{t-1} = \alpha(Y_t - Y^n)$. If output exceeds potential output, the output gap $(Y_t - Y^n)$ is positive. The Phillips curve then gives $\pi_t > \pi_{t-1}$, that is, inflation is increasing over time.

- (A) Do not select.
- (B) Do not select.
- **(C) Select.**
- (D) Do not select.

(e) In the IS-LM-PC model with anchored inflation expectations, starting from a medium-run equilibrium, the government increases taxes. After the increase in taxes, the resulting medium-run equilibrium has

◯ (A) higher output than in the original medium-run equilibrium

◯ (B) a higher real interest rate than in the original medium-run equilibrium

✓ **(C) an IS curve that is to the left of the IS curve of the original medium-run equilibrium**

◯ (D) the answer depends on whether the LM curve is flat or upward sloping

Solution:

- (A) Do not select. In the resulting medium-run equilibrium, output equals potential just as in the initial medium-run equilibrium. Potential remains unchanged because taxes do not affect potential output.
- (B) Do not select. Taxes do not shift the LM. With an upward-sloping LM, the interest rate falls endogenously; with a flat LM, the central bank must lower the interest rate to bring output back to potential. In both cases, the medium-run real interest rate ends up below the initial medium-run equilibrium.
- **(C) Select.** Higher taxes reduce equilibrium output for any level of the interest rate, so the IS curve shifts to the left.
- (D) Do not select. Same explanation as in (B).

(f) In the Phillips curve, which of the following changes is associated with an increase in the current inflation rate (keeping everything else fixed)?

○ (A) a decrease in the expected inflation rate

○ (B) an increase in the unemployment rate

○ (C) a lower natural rate of unemployment

✓ **(D) an increase in the markup**

Solution: We use that the Phillips curve is

$$\begin{aligned}\pi &= \pi^e + m + z - \alpha u \\ &= \pi^e - \alpha(u - u_n).\end{aligned}$$

- (A) Do not select. Lower expected inflation directly lowers current inflation.
- (B) Do not select. Higher unemployment reduces the bargaining power of workers relative to employers, causing the equilibrium nominal wage to go down. A lower nominal wage means the nominal marginal cost of production is lower. To keep the markup (profit rate) unchanged, firms reduce the price of goods they sell and the price level goes down. A lower price level means lower inflation (the price level in the previous period cannot change in the current period, so changes in the price level correspond

directly to changes in inflation).

- (C) Do not select. A lower natural rate of unemployment is deflationary. For any given rate of unemployment, a lower natural rate of unemployment increases the unemployment gap. The amount of people unemployed relative to the stable-inflation medium-run level is now higher. Workers' bargaining power is therefore lower, pushing the nominal wage and inflation down.

- **(D) Select.** In the Phillips curve relation $\pi = \pi^e + m + z - \alpha u$, a higher markup m increases current inflation, holding π^e, z, α and u fixed. The intuition is that to earn a higher markup at any given level of the nominal wage, firms increase the price of the goods they sell.

(g) Assume that the Phillips curve is given by

$$\pi_t = \pi_t^e + m + z - \alpha u_t.$$

Which of the following causes a reduction in the natural rate of unemployment?

○ (A) an increase in m

○ (B) an increase in z

✓ **(C) an increase in α**

○ (D) an increase in π_t^e

Solution: The natural rate of unemployment is the medium-run equilibrium level of unemployment. Using the medium-run condition $\pi_t = \pi_t^e$ in the Phillips curve and solving for u gives the natural rate of unemployment $u_n = (m + z)/\alpha$.

- (A) Do not select. An increase in m raises u_n.

- (B) Do not select. An increase in z raises u_n.

- **(C) Select.** An increase in α reduces u_n.

- (D) Do not select. π_t^e does not appear in the expression for u_n, so it has no effect on the natural rate.

(h) The price setting equation is $P = (1 + m)W$. When there is perfect competition, we know that

◯ (A) $m > 0$

✓ **(B)** $m = 0$

◯ (C) $m < 0$

◯ (D) the price setting equation does not hold

Solution: The markup m gives the profit rate of firms.

- (A) Do not select. A positive markup occurs under imperfect (monopolistic) competition, when firms use their monopoly power to earn positive profits.
- **(B) Select.** Under perfect competition, firms earn zero profits.
- (C) Do not select. A negative markup would mean firms sell below cost, which leads to bankruptcy and exit from the market.
- (D) Do not select. The price setting equation always holds; under perfect competition it simplifies to $P = W$.

(i) The natural rate of unemployment is the rate of unemployment that occurs when

◯ (A) the money market is in equilibrium

◯ (B) the markup is zero

✓ **(C) the economy is in a medium-run equilibrium**

◯ (D) none of the above

Solution: The natural rate of unemployment is defined as the medium-run equilibrium level of unemployment.

- (A) Do not select.
- (B) Do not select.
- **(C) Select.**
- (D) Do not select.

2. **True, False, or Uncertain**

For each statement below, answer true, false, or uncertain. Explain your answer. Use graphs or equations if useful.

(a) In the accounting identity $Y = C + I + G$, a simultaneous 1% increase in all three variables Y, C, and I can occur while $G > 0$ remains unchanged.

Solution: False. Writing the accounting identity $Y = C + I + G$ as

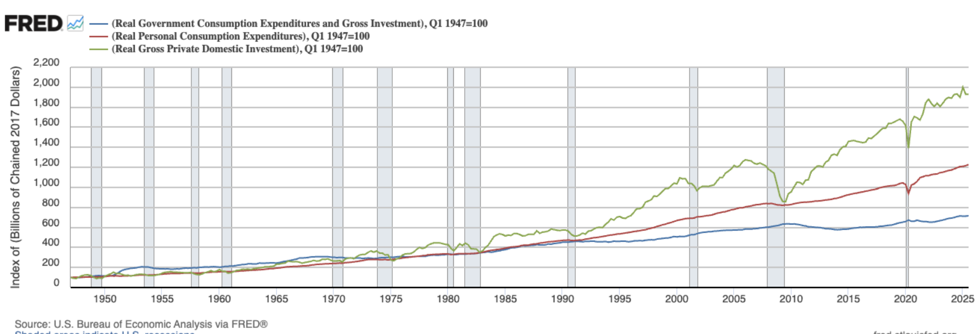
$$1 = \frac{C}{Y} + \frac{I}{Y} + \frac{G}{Y}$$

shows that a 1% increase in Y, C, and I leaves C/Y and I/Y unchanged. Therefore, for the identity to hold, G/Y must also remain unchanged. However, if $G > 0$, a fixed G and a higher Y imply a lower G/Y.

(b) In U.S. postwar data, real investment is substantially more volatile than real consumption and real government purchases.

<u>Hint</u>: Consult your intermediate macro textbook or plot the data using FRED.

Solution: True. Volatility here refers to cyclical fluctuations; investment has visibly larger cyclical swings. The plot below shows the evolution of real consumption, investment, and government purchases for the United States between 1947-Q1 and 2025-Q2 (index, 1947=100).



Source: `https://fred.stlouisfed.org/graph/?g=1QUNW`.

(c) In the IS-LM model, an increase in government spending raises output in the short run.

Solution: True. Higher government spending increases demand in the goods market at any given level of the interest rate. Higher demand, in equilibrium, is associated with higher output.

(d) Assume that investment is a function of output and the real interest rate. In the IS-LM model with an exogenous money supply, a decrease in government spending lowers investment.

Solution: Uncertain. Lower government spending reduces demand for goods. Equilibrium in the goods market then requires lower output for any given interest rate, so the IS shifts to the left. Lower output implies lower income. The decrease in income reduces the demand for money. But with an unchanged exogenous money supply, equilibrium in the money market requires money demand to also remain unchanged. The interest rate decreases so that money demand increases by an amount that exactly offsets the decrease caused by the lower income. The lower interest rate causes an increase in investment.
The overall effect on investment depends on the relative magnitude of the decline in investment caused by the initial drop in demand and the increase in investment caused by the lower interest rate. Without knowing the exact way in which investment responds to output and the interest rate, it is not possible to determine which of the two effects is stronger, making the behavior of equilibrium investment uncertain.

3. **A War Scare in the Short-Run IS-LM**

Consider the following closed-economy IS-LM model. The goods market equilibrium condition is

$$Y = C + I + \bar{G},$$

where Y is output, C is consumption, I is investment, and $\bar{G}$ is government spending. The behavioral equations for consumption and investment are

$$C = c_0 + c_1(Y - \bar{T}), \qquad I = b_0 - b_1 i,$$

where $\bar{T}$ denotes taxes, i is the nominal interest rate, and $c_0 > 0$, $0 < c_1 < 1$, $b_0 > 0$, and $b_1 > 0$ are parameters. Assume expected inflation is constant (so changes in the nominal interest rate i correspond one-for-one to changes in the real interest rate). The money market equilibrium condition is

$$\bar{M}^s = m_0 + m_1 Y - m_2 i,$$

where $\bar{M}^s$ is real money supply (we normalize the price level $P = 1$ so $\bar{M}^s/P = \bar{M}^s$), and $m_0 > 0$, $m_1 > 0$, and $m_2 > 0$ are parameters. The exogenous variables are $\bar{G}$, $\bar{T}$, $\bar{M}^s$, and the model parameters. The endogenous variables are Y, C, I, and i.

(a) Derive the IS curve and its slope.

Solution: The IS curve represents the combinations of interest rates and output that are consistent with equilibrium in the goods market. Using the behavioral equations for consumption and investment in the goods market equilibrium condition gives the IS relation:

$$\begin{aligned} Y &= C + I + \bar{G}, \\ &= c_0 + c_1(Y - \bar{T}) + b_0 - b_1 i + G. \end{aligned}$$

Solving for i gives the IS curve

$$i = \frac{c_0 + b_0 + \bar{G} - c_1 \bar{T}}{b_1} - \left(\frac{1 - c_1}{b_1}\right) Y,$$

which is the equation of a line (when plotting i as a function of Y) with slope

$$\text{slope of IS curve} = -\frac{1 - c_1}{b_1}.$$

(b) Derive the LM curve and its slope.

Solution: The LM curve represents the combinations of interest rates and output that are consistent with equilibrium in the money market.
Solving of i in the money market equilibrium condition gives the LM curve:

$$i = \frac{m_0 - \bar{M}^s}{m_2} + \left(\frac{m_1}{m_2}\right) Y,$$

which is the equation of a line (when plotting i as a function of Y) with slope

$$\text{slope of LM curve} = \frac{m_1}{m_2}.$$

(c) Solve for equilibrium output Y^* and the equilibrium interest rate i^*.

Solution: To make the algebra easier, write the IS from part (a) and the LM from part (b) as

$$\text{IS: } i = p - fY,$$
$$\text{LM: } i = q + gY,$$

where we have created the new auxiliary variables

$$p = \frac{c_0 + b_0 + \bar{G} - c_1\bar{T}}{b_1}, \qquad q = \frac{m_0 - \bar{M}^s}{m_2},$$
$$f = \frac{1 - c_1}{b_1}, \qquad g = \frac{m_1}{m_2}.$$

The IS and the LM are a system of two equations in the two unknowns Y and i. Solving the system gives

$$Y^* = \frac{p - q}{f + g},$$

and

$$i^* = \frac{gp + qf}{f + g},$$

or, in terms of the original variables

$$Y^* = \frac{m_2(c_0 + b_0 + \bar{G} - c_1\bar{T}) + b_1(\bar{M}^s - m_0)}{m_1 b_1 + m_2(1 - c_1)},$$

and

$$i^* = \frac{m_1(c_0 + b_0 + \bar{G} - c_1\bar{T}) + (1 - c_1)(m_0 - \bar{M}^s)}{m_1 b_1 + m_2(1 - c_1)}.$$

(d) Consider an increase in the money supply $\bar{M}^s$. What happens to Y^* and i^*? Explain using the IS-LM diagram.

Solution: Y^* goes up and i^* goes down. An increase in the money supply means a larger $\bar{M}^s$. For money markets to be in equilibrium, money demand must also increase. For people to have a higher money demand for a given level of income, the interest rate must go down so that bonds become less attractive, and people decide to sell bonds and hold more money. The LM curve shifts down.

The fall in the interest rate makes investment increase, pushing up the equilibrium level of output. The economy moves along the IS curve toward the new equilibrium with higher Y^* and lower i^*.

(e) Suppose a "war scare" raises precautionary demand for money, increasing m_0 to $m_0 + \Delta m_0$, where $\Delta m_0 > 0$. Find the new equilibrium level of output Y^{W}.

Solution: The new level of output Y^{W} can be found by replacing m_0 by $m_0 + \Delta m_0$ in the expression for Y^* from part (c):

$$Y^{\mathrm{W}} = Y^* - \frac{\Delta m_0}{m_2(f+g)},$$

with f and g defined as before.

(f) Under the war scare described in (e), how do the IS and LM curves shift? Explain the resulting movement in equilibrium Y and i.

Solution: The increase in money demand caused by the war scare makes the interest rate rise for any given level of output. The LM shifts up. The IS curve is unchanged, as are the slopes of both curves.

As people move away from bonds and toward money, the interest rate increases. A higher interest rate leads to lower investment and lower output. The fall in investment makes equilibrium output fall due to the war scare.

(g) Now suppose fiscal policy follows the rule

$$G = \bar{G} + g_1(Y - Y^*),$$

where Y^* is the original equilibrium output from (c). How does this rule affect the IS curve relative to the constant-$\bar{G}$ case?

Solution: Replace $\bar{G}$ by $\bar{G} + g_1(Y - Y^*)$ in the IS from part (a) to get

$$i = \frac{c_0 + b_0 + \bar{G} + g_1(Y - Y^*) - c_1\bar{T}}{b_1} - \left(\frac{1 - c_1}{b_1}\right) Y,$$

Using the same notation as in (c), we can rewrite this new IS as

$$i = p - \frac{g_1 Y^*}{b_1} - \left(f - \frac{g_1}{b_1}\right) Y.$$

The new intercept is

$$\text{new intercept of IS} = p - \frac{g_1 Y^*}{b_1},$$

and the new slope is

$$\text{new slope of IS} = -\left(f - \frac{g_1}{b_1}\right) = -\frac{1 - c_1 - g_1}{b_1}.$$

Compared to the IS from part (a), the new intercept is

- higher when $g_1 < 0$,
- the same when $g_1 = 0$,
- lower when $g_1 > 0$.

The new slope goes from negative to zero for values of g_1 increasing from negative to $(1 - c_1)$. When g_1 is higher than $(1 - c_1)$, the new slope is positive. Putting together the simultaneous changes in the intercept and slope, the effect of the fiscal rule is to rotate the IS around the equilibrium (Y^*, i^*) from (c).

(h) Using an IS-LM diagram, assess whether the fiscal policy rule in (g) stabilizes the economy after the war scare.

Solution: The war scare shifts the LM only, while the fiscal rule changes the IS only. In the figure below, the LM curve is shown in green and labeled LM^{W} (the W is for "war scare"). This is the LM curve after the war scare; it is unaffected by the fiscal rule since government spending does not enter the money market equilibrium.

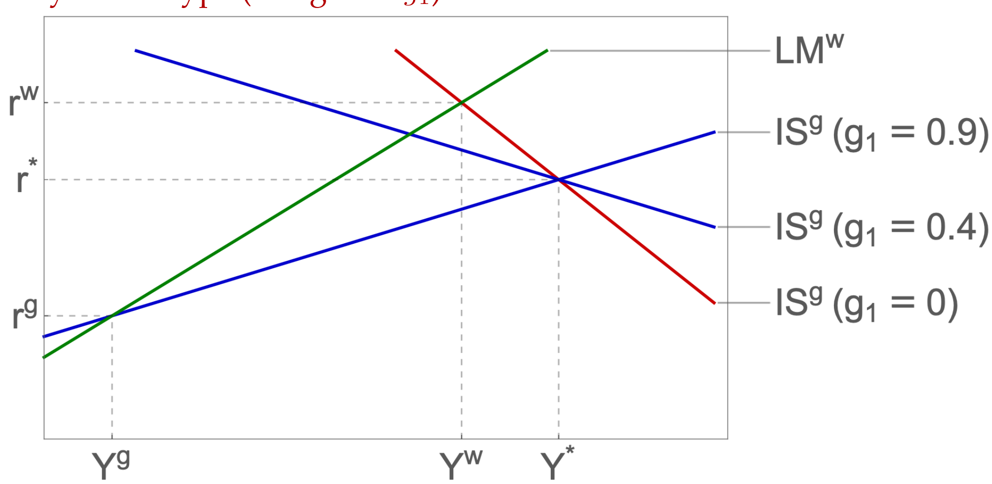
The red line, labeled $IS^g(g_1 = 0)$, is the IS curve before the war scare and also after the war scare. This red IS line is also the IS that would result from the government following the rule $G = \bar{G} + g_1(Y - Y^*)$ with $g_1 = 0$, which is equivalent to the policy $G = \bar{G}$ used in parts (a) through (f).

The two blue lines are two examples of IS curves that result for two different values of $g_1 > 0$. As g_1 increases from zero (the case of the red line) to positive values, it rotates counter-clockwise around (Y^*, i^*). For any positive values of g_1, equilibrium output is even further below the original equilibrium Y^* than it was under the war scare alone. The higher the g_1, the lower the levels of equilibrium output and the interest rate. For the case labeled $IS^g(g_1 = 0.9)$, we have equilibrium values (Y^g, i^g).

We conclude that when $g_1 > 0$, the fiscal policy pursued does not help stabilize the economy. On the contrary, it reduces output even below Y^W. The intuition is that with a positive g_1, when output goes down, government spending also goes down. The reduction in government spending reduces demand, which in turn reduces output. The policy amplifies the decline in Y.

A much better policy is to have a negative g_1 so that government spending increases as output decreases. The same analysis as before but with signs for g_1 reversed shows that fiscal policy makes the decline in output due to the war scare be smaller in magnitude than when G stays constant at $\bar{G}$.

A policy of this type (a negative g_1) is called an automatic stabilizer.



4. **An Endogenous Initial Price Level**

Consider a closed economy described by the following equations. The goods market is in equilibrium when

$$Y_t = C(Y_t - \bar{T}) + I(R_t) + \bar{G},$$

where Y_t is output, $C(\cdot)$ is the consumption function, $\bar{T}$ denotes taxes, $I(\cdot)$ is the investment function, R_t is the real interest rate, and $\bar{G}$ denotes government spending. Note that investment depends only on the interest rate R_t and does not depend on output Y_t. The money market is in equilibrium when

$$\frac{\bar{M}^s}{P_t} = \mathcal{L}(i_t, Y_t),$$

where $\bar{M}^s$ is the nominal money supply, P_t is the price level, $\mathcal{L}(\cdot,\cdot)$ is the real money demand function, and i_t is the nominal interest rate. The Fisher equation is

$$R_t = i_t - \pi^e,$$

where π^e is expected inflation. The labor market implies an aggregate supply relation of the form

$$P_t = (1+m)P_t^e F\left(1 - \frac{Y_t}{L}, z\right),$$

where m is the markup, P_t^e is the expected price level, L is the labor force, $u_t = 1 - \frac{Y_t}{L}$ is the unemployment rate, z is a catch-all variable for factors affecting the nominal wage other than P_t^e and u_t, and $F(\cdot,\cdot)$ is a function decreasing in its first argument and increasing in its second one. Assume the functional forms

$$C(Y - \bar{T}) = 1 + \frac{1}{2}(Y - \bar{T}),$$

$$I(R) = 2 - R,$$

$$\mathcal{L}(i, Y) = 2 + Y - 0.2i,$$

$$F(u, z) = 1 - \alpha u + z,$$

where $\alpha > 0$ is a parameter.

(a) Is the consumption function $C(\cdot)$ increasing or decreasing in its argument? Provide economic intuition.

Solution: The consumption function $C(\cdot)$ is increasing in disposable income $Y_D \equiv Y - \bar{T}$. Intuition: When households have higher disposable income, they consume more. This is a fundamental behavioral assumption: as people earn more (after taxes), they spend more on goods and services.

(b) Is the investment function $I(\cdot)$ increasing or decreasing in its argument? Provide economic intuition.

Solution: The investment function $I(\cdot)$ is decreasing in the real interest rate R_t. Intuition: The real interest rate represents the cost of borrowing for firms. When the real interest rate rises, it becomes more expensive for firms to finance investment projects, so they invest less. Equivalently, a higher real interest rate raises the required return on investment projects, making fewer projects profitable.

(c) Is the money demand function $\mathcal{L}(\cdot,\cdot)$ increasing or decreasing in each of its arguments? Provide economic intuition.

Solution: The money demand function $\mathcal{L}(i, Y)$ is decreasing in the nominal interest rate i and increasing in income Y. Intuition: When i goes up, people prefer to hold less money and more bonds, so money demand falls. The variable Y in this context plays the role of aggregate income. Higher income makes people want to buy more goods, which requires more transactions. To be able to conduct more transactions, people must hold more money.

(d) Derive the IS curve (when plotted with the nominal interest rate i_t on the vertical axis and output Y_t on the horizontal axis).

Solution: Substituting the functional forms into the goods market equilibrium:

$$Y_t = 1 + \frac{1}{2}(Y_t - \bar{T}) + 2 - R_t + \bar{G} = 1 + \frac{1}{2}(Y_t - \bar{T}) + 2 - (i_t - \pi^e) + \bar{G}.$$

Solving for i_t:

$$i_t = 3 - \frac{1}{2}\bar{T} + \bar{G} + \pi^e - \frac{1}{2}Y_t.$$

(e) Derive the LM curve (when plotted with the nominal interest rate i_t on the vertical axis and output Y_t on the horizontal axis).

Solution: From the money market equilibrium:

$$\frac{\bar{M}^s}{P_t} = 2 + Y_t - 0.2i_t.$$

Solving for i_t:

$$i_t = 5\left(2 + Y_t - \frac{\bar{M}^s}{P_t}\right) = 10 - 5\frac{\bar{M}^s}{P_t} + 5Y_t.$$

(f) Combine the IS and LM relations to eliminate i_t and obtain an aggregate demand relation of the form

$$Y_t = AD\left(\frac{\bar{M}^s}{P_t}, \bar{T}, \bar{G}, \pi^e\right),$$

where AD is a function increasing in $\bar{M}^s/P_t$, $\bar{G}$, and π^e, and decreasing in $\bar{T}$.

Hint: Your final expression should be linear in $\bar{M}^s/P_t$, $\bar{T}$, $\bar{G}$, and π^e, i.e., AD is a linear function.

Solution: Equating the i_t implied by the IS from part (d) to the i_t implied by the LM from part (e) gives

$$3 - \frac{1}{2}\bar{T} + \bar{G} + \pi^e - \frac{1}{2}Y_t = 10 - 5\frac{\bar{M}^s}{P_t} + 5Y_t.$$

Solving for Y_t:

$$Y_t = -\frac{14}{11} - \frac{1}{11}\bar{T} + \frac{2}{11}\bar{G} + \frac{2}{11}\pi^e + \frac{10}{11}\frac{\bar{M}^s}{P_t}.$$

(g) Find potential output, denoted Y^n, as a function of m, z, α, and L.

Solution: With $P_t^e = P_t$, the aggregate supply relation becomes:

$$P_t = (1+m)P_t F\left(1 - \frac{Y^n}{L}, z\right).$$

This simplifies to:

$$1 = (1+m)\left(1-\alpha\left(1-\frac{Y^n}{L}\right)+z\right).$$

Solving for Y^n:

$$Y^n = \left(1-\frac{1}{\alpha}\left(1-\frac{1}{1+m}+z\right)\right)L = \left(1-\frac{m+z(1+m)}{\alpha(1+m)}\right)L.$$

(h) Explain briefly why, in this model, potential output Y^n does not depend on monetary and fiscal policy variables such as $\bar{M}^s$, $\bar{T}$, and $\bar{G}$.

Solution: Y^n does not depend on $\bar{M}^s, \bar{T}, \bar{G}$ because in the medium run, the labor market determines output through the wage and price setting process. Monetary and fiscal policy can only affect output in the short run when prices are sticky; in the medium run, output is determined by real factors (technology, labor force, markup, labor market conditions).

(i) Assume the economy is in a medium-run equilibrium at $t = 0$, so $Y_0 = Y^n$ and $P_0^e = P_0$. Use the aggregate demand relation from (f) and the condition $Y_0 = Y^n$ to solve for the initial price level P_0 as a function of $\bar{M}^s$, $\bar{T}$, $\bar{G}$, π^e and the parameters m, z, α, and L.

Solution: Using the AD relation at time $t = 0$ and with $Y_0 = Y^n$:

$$Y^n = -\frac{14}{11} - \frac{1}{11}\bar{T} + \frac{2}{11}\bar{G} + \frac{2}{11}\pi^e + \frac{10}{11}\frac{\bar{M}^s}{P_0}.$$

Solving for P_0:

$$P_0 = \frac{10\bar{M}^s}{11Y^n + \bar{T} - 2\bar{G} - 2\pi^e + 14}.$$

Substituting $Y^n = \left(1-\frac{m+z(1+m)}{\alpha(1+m)}\right)L$ from (g):

$$P_0 = \frac{10\bar{M}^s}{11\left(1-\frac{m+z(1+m)}{\alpha(1+m)}L\right) + \bar{T} - 2\bar{G} - 2\pi^e + 14}.$$

(j) At time $t = 1$ the government announces an unexpected increase in taxes from $\bar{T}$ to $\bar{T} + \Delta T$, where $\Delta T > 0$. Assume that, in the short run, the price level is fixed at $P_1 = P_0$. Compute the short run equilibrium values of output Y_1 and the interest rate i_1. Express your answers in terms of $\bar{M}^s$, P_0, $\bar{T}$, $\bar{G}$, π^e, and ΔT.

Solution: Using the AD relation with $T_1 = \bar{T} + \Delta T$ and $P_1 = P_0$:

$$Y_1 = -\frac{14}{11} - \frac{1}{11}(\bar{T} + \Delta T) + \frac{2}{11}\bar{G} + \frac{2}{11}\pi^e + \frac{10}{11}\frac{\bar{M}^s}{P_0} = Y^n - \frac{1}{11}\Delta T,$$

where the second equality follows by using the expression for Y^n from (i). For i_1, use the LM relation:

$$i_1 = 10 + 5Y_1 - 5\frac{\bar{M}^s}{P_0} = 10 + 5Y^n - \frac{5}{11}\Delta T - 5\frac{\bar{M}^s}{P_0}.$$

(k) Assume the tax increase is permanent. Assume the economy eventually returns to a medium-run equilibrium with $Y = Y^n$ and $P^e = P$. Compute the new medium-run price level P_{MR} and compare it to P_0.

Solution: In the new medium run with $Y = Y^n$ and taxes at $\bar{T} + \Delta T$:

$$Y^n = \frac{10}{11}\frac{\bar{M}^s}{P_{\text{MR}}} - \frac{1}{11}(\bar{T} + \Delta T) + \frac{2}{11}\bar{G} + \frac{2}{11}\pi^e - \frac{14}{11}.$$

Solving for P_{MR}:

$$P_{\text{MR}} = \frac{10\bar{M}^s}{11Y^n + (\bar{T} + \Delta T) - 2\bar{G} - 2\pi^e + 14}.$$

Since $\bar{T} + \Delta T > \bar{T}$, the denominator is larger, so $P_{\text{MR}} < P_0$. The permanent tax increase leads to a lower price level in the medium run.

ECON 1550 — Problem Set 2 Answer Key

Spring 2026

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Submission:	Canvas or Gradescope

Chapter 2: National Income Accounting and the Balance of Payments

1. Import Restrictions Effects on the Current Account

Please answer Question 2 from Chapter 2 of the textbook, reproduced here for convenience:

> "Equation (2-2) tells us[1] that to reduce a current account deficit, a country must increase its private saving, reduce domestic investment, or cut its government budget deficit. Nowadays, some people recommend restrictions on imports from China (and other countries) to reduce the American current account deficit. How would higher U.S. barriers to imports affect its private saving, domestic investment, and government deficit? Do you agree that import restrictions would necessarily reduce a U.S. current account deficit?"

Solution: It is possible to tell stories in which the effect on the current account goes either way. There are many valid answers. Here, we focus on investment (as discussed in class), which empirically is often the key factor in determining whether the current account improves. Public and private saving can, of course, also change.

One direct channel through which investment can increase is through an increase in demand. When imported goods become more expensive or less available, consumers may switch to domestic substitutes. Another channel is through profits. If domestic producers' monopoly power increases because of the reduced competition from abroad, profits can increase. If profitability is expected to be persistent, it can induce domestic firms to invest to increase future production.

[1] Equation (2-2) is

$$S^p = I + CA - S^g = I + CA - (T - G) = I + CA + (G - T),$$

where S^p is private savings, I is investment, CA is the current account, S^g is government savings, T are taxes and G is government spending.

On the other hand, investment might fall in industries that face higher costs of imported intermediate goods, or higher costs of domestic substitutes.

Equation (2-2) is a powerful accounting identity: it must hold at all times and is therefore sufficient to rule out many common claims about the current account. In particular, it makes clear that tariffs affect the current account insofar as they also change private saving, domestic investment, or the government budget balance.

At the same time, the accounting identity alone cannot generate predictions about the direction or magnitude of specific variables, as evidenced by the examples above. Making such predictions requires additional assumptions—an explicit model with behavioral equations.

We will introduce and study those models later in the course.

2. **New Dynamics for American Primary Income**

Question 10 from Chapter 2 of the textbook states:

> "If you go to the BEA website for "U.S. International Transactions", table 1.1, you will find that in 2015, U.S. income receipts on its foreign assets were $ 775.85 billion (line 6), while the country's payments on liabilities to foreigners were $ 582.47 billion (line 14). Yet we saw in this chapter that the United States is a substantial net debtor to foreigners. How, then, is it possible that the United States received more foreign asset income than it paid out?"

In this question, we work through an updated version. There have been some interesting developments since 2015!

Go to FRED (Federal Reserve Economic Data) at `https://fred.stlouisfed.org` and plot the series "Balance on primary income" with series ID IEABCPI. Then answer the following:

(a) Give one concrete example that would contribute to the time series positively (make the balance on primary income larger) and one that would contribute negatively (make it smaller).

Solution: Here are a few examples (you only need one that contributes positively and one negatively for full credit).

Contribute positively:

- Wages paid to Prof. Duarte for teaching in France.

- Profits earned by Nike's subsidiary in Vietnam.
- Dividends received by a U.S. resident on shares of the Japanese firm Toyota.
- Interest received by U.S. residents on bonds they own that were issued by the Government of Mexico.
- Interest received by the Federal Reserve from the Banco Central do Brasil on dollars provided through a currency swap line during the Covid pandemic.

Contribute negatively:

- Dividends paid to a U.K. resident on shares of the U.S. company NVIDIA.
- Interest paid by Bank of America to an Australian resident on U.S. dollar deposits.
- Interest paid by the U.S. Treasury to the People's Bank of China on its holdings of U.S. Treasury securities.

(b) List all quarters in which the balance on primary income is negative.

Solution: There are only seven negative quarters in the entire dataset:

- Q3 2001: –$620 million
- Q4 2023: –$297 million
- Q1 2024: –$10,219 million
- Q2 2024: –$11,210 million
- Q3 2024: –$21,225 million
- Q1 2025: –$2,596 million
- Q2 2025: –$5,772 million

Additional information (not needed for full credit):
Here is the plot for the entire series, obtained from `https://fred.stlouisfed.org/series/IEABCPI`. The balance on primary income for each quarter is shown in the figure below. Quarters with negative values are marked with red dots.

(c) The United States is a substantial net debtor to foreigners. How, then, is it possible that the United States received more foreign asset income than it paid out?

Solution: Assets is a stock variable, while income is a flow variable[2]. That the value of foreign assets owned by the U.S. is less than the value of American assets owned by foreign countries (the U.S. is a net debtor) is a comparison between two stock variables. On any given quarter, the income flow generated by the smaller stock of foreign assets owned by the U.S. can be larger than the income flow generated by the larger stock of American assets owned by foreign countries. If bucket A has less water than bucket B, you can still pour more water out of bucket A than out of bucket B.

Income over one quarter equals assets at the beginning of the quarter multiplied by the return on those assets. Historically, the U.S. received a substantially higher rate of return on its foreign assets than other countries did on their U.S. assets. Key reasons include:

- U.S. foreign direct investment tends to earn higher returns than portfolio investment
- A substantial amount of foreign-held U.S. assets are Treasury securities, which have relatively low returns
- U.S. multinational corporations book profits in low-tax jurisdictions, inflating measured returns on foreign assets

The 2024 reversal suggests these advantages are no longer sufficient to offset the growing interest payments on the U.S.'s large net debtor position at the current relatively high level of interest rates.

[2] Stock: a variable that can be expressed as a quantity at a point in time (such as physical capital). Flow: a variable that can be expressed as a quantity per unit of time (such as investment).

(d) Go to the BEA website at `https://www.bea.gov/itable/` and find Table 1.1 U.S. International Transactions. For the year 2024, report the values of primary income receipts (line 6) and primary income payments (line 14). Compute the annual balance on primary income by subtracting payments from receipts. Compare this annual balance to the sum of the four quarterly values from the FRED series for 2024. Do they match? Are they expected to match?

Hint: Finding the numbers should take, at most, 5 minutes. The need to poke around a bit (rather than giving you the exact link) is built into this problem intentionally so that you gain some familiarity with international account statistics.

Solution: From BEA Table 1.1 for the year 2024:

- Line 6 (Primary income receipts): \$1,451,065 million
- Line 14 (Primary income payments): \$1,492,104 million
- Balance (Line 6 – Line 14): \$1,451,065 – \$1,492,104 = –\$41,039 million

Sum of quarterly IEABCPI values for 2024:

$$\begin{aligned}&\text{Q1 2024} + \text{Q2 2024} + \text{Q3 2024} + \text{Q4 2024}\\&\qquad = (-10{,}219) + (-11{,}210) + (-21{,}225) + 1{,}615\\&\qquad\qquad = -41,039 \text{ million.}\end{aligned}$$

The two values match exactly. The quarterly series comes from BEA Table 1.2 (Expanded Detail), while Table 1.1 is the summary table—but both contain the same primary income balance data.

(e) If you had taken this course in 2023, the textbook's 2015 framing would still have applied, with over two decades of positive values for the time series. The magnitude of the 2024-Q3 value (a deficit of \$21 billion) is particularly noteworthy. Do some research and try to pinpoint the causes behind this large deficit. Keep it short and concrete. This question will be graded on effort rather than correctness.

Solution: The textbook's assumption that the U.S. receives more on its foreign assets than it pays on its liabilities held true for over two decades but reversed starting in Q4 2023. Q4 2023 marked the first quarterly deficit since Q3 2001, and Q1–Q3 2024 plus Q1–Q2 2025 all had deficits (Q4 2024 was positive), with Q3 2024 being the largest at $-$21.2 billion.

In Q3 2024 specifically, primary income receipts (earnings from overseas investments) fell by $15.5 billion, or 4.3%, primarily driven by declining direct investment earnings, while primary income payments decreased only slightly (BEA Survey of Current Business, January 2025). The deterioration was broad-based, with declining balances across all three major categories: direct investment, portfolio investment, and other investment earnings.

This structural shift reflects several factors:

- Rising interest rates increased payments on U.S. debt held by foreigners (much of it in Treasury securities). Net external interest payments now reach 1.3% of GDP.
- The "low-for-long" era of near-zero interest rates ended, so the U.S. can no longer borrow as cheaply while earning high returns abroad. When this profit-shifting is excluded, the income advantage largely disappears.
- Returns on American assets, dominated by AI-related industries, became relatively more profitable than U.S. investments overseas, further eroding the traditional return differential.

Review of Intermediate Macro

3. **The Labor Market and Phillips Curve**

Consider the following model of the labor market:

Labor force	L
Employment	N
Wage setting	$W = P^e(1-u)$
Price setting	$P = (1+\mu)W(1+\tau)$
Production function	$Y = N$

In the equations above, W is the nominal wage, P^e is the expected price level, u is the unemployment rate, P is the price level, μ is the markup, τ is a labor tax, and Y is output.

The labor tax τ is paid by firms that hire workers. If firms hire workers for a nominal wage W, they must pay τW to the government.

In the short run, the exogenous variables are L, μ, τ, P^e, and Y, while the endogenous variables are N, W, u, P.

In the medium run, the exogenous variables are L, P, μ, and τ, while the endogenous variables are N, W, u, P^e, and Y. In the medium run, the expected price level P^e is determined by $P^e = P$.

(a) Write an equation for the unemployment rate, u, in terms of the labor force L and employment N. Is this equation an identity, a behavioral equation, or an equilibrium condition?

Solution: The unemployment rate is

$$u \equiv \frac{L - N}{L}.$$

This is an identity so we use $\equiv$ instead of $=$.

(b) Solve the model in the short run.

Hint: Recall that "solving the model" means to write all endogenous variables in terms of exogenous variables only.

Solution: The short-run solution is:

$$\begin{aligned} N &= Y \\ W &= P^e \frac{Y}{L} \\ u &= 1 - \frac{Y}{L} \\ P &= P^e (1 + \mu) \frac{Y}{L} (1 + \tau). \end{aligned}$$

We now show how to derive this answer. The production function gives the solution for N:

$$N = Y.$$

Using the answer from a) and $N = Y$, we get the solution for u:

$$u = \frac{L - N}{L} = \frac{L - Y}{L} = 1 - \frac{Y}{L}.$$

Combine the wage and price setting relationships:

$$P = P^e(1 + \mu)(1 - u)(1 + \tau).$$

Using the solution for u gives the solution for P:

$$\begin{aligned} P &= P^e(1 + \mu)(1 - u)(1 + \tau) \\ &= P^e(1 + \mu)\left(1 - \left(1 - \frac{Y}{L}\right)\right)(1 + \tau) \\ &= P^e(1 + \mu)\frac{Y}{L}(1 + \tau). \end{aligned}$$

Plugging the solution for P into the price setting relationship:

$$P^e(1 + \mu)\frac{Y}{L}(1 + \tau) = (1 + \mu)W(1 + \tau).$$

Simplifying and solving for W gives:

$$W = P^e\frac{Y}{L}.$$

(c) Solve the model in the medium run.

Solution: The medium-run solution is:

$$\begin{aligned} N &= \frac{L}{(1 + \mu)(1 + \tau)} \\ W &= \frac{P}{(1 + \mu)(1 + \tau)} \\ u &= 1 - \frac{1}{(1 + \mu)(1 + \tau)} \\ P^e &= P \\ Y &= \frac{L}{(1 + \mu)(1 + \tau)}. \end{aligned}$$

We now show how to derive this answer. First, we note that the equations that give the short-run solution obtained in part b) are valid equations in the medium run with $P = P^e$ (can you see why?). The short-run solution for P with $P = P^e$ gives:

$$1 = (1+\mu)\frac{Y}{L}(1+\tau).$$

Solving for Y gives:

$$Y = \frac{L}{(1+\mu)(1+\tau)}.$$

Plugging the last equation into the solutions for u and W from part b), and using $P = P^e$, we get:

$$u = 1 - \frac{Y}{L} = 1 - \frac{1}{(1+\mu)(1+\tau)},$$

$$W = \frac{P}{(1+\mu)(1+\tau)}.$$

(d) How do u, P, P^e, and Y respond to an increase in the labor tax τ in the short run? Give economic intuition for your answer.

Solution: Short run

Using the answers from part b), we can see that an increase in the labor tax τ leads to an increase in the price level P and no change in any of the other variables.

The intuition is as follows. Since output Y, the labor force L, and the expected price level P^e are exogenous, they are unchanged. To produce the same output as before the increase in tax, the production function implies that firms need to hire the same number of workers, so N remains unchanged. With N and L unchanged, the unemployment rate u also remains unchanged. The wage setting relation implies that the nominal wage W also stays the same: since the unemployment rate is unchanged, the bargaining power of workers and firms does not change, and since the expected price level is unchanged, the real standard of living that workers expect and the real wage bill that firms expect to pay both remain unchanged. By the price setting relation, higher labor taxes increase firms' marginal cost $W(1+\tau)$ even if wages have not changed. To keep earning the same markup μ as before the tax increase, firms increase the price

P at which they sell their goods.

(e) How do u, P, P^e, and Y respond to an increase in the labor tax τ in the medium run? Give economic intuition for your answer.

Solution: Medium run
Using the answers from part c), we can see that an increase in the labor tax τ leads to lower N, W and Y; higher u; and unchanged P^e.
The intuition is as follows. Since P did not change, the price that firms charge for the goods they sell is unchanged. By the price setting relation, to earn the same profit margin μ at the given price level P, firms keep the marginal cost $W(1+\tau)$ unchanged. For a given nominal wage W, the increase in tax τ makes marginal cost go up. To offset the increase in marginal cost caused by the higher tax rate, firms pay a lower nominal wage. In turn, a lower nominal wage W and an unchanged expected price level P^e leads to a lower expected real wage W/P^e. By the wage setting relation, the lower expected real wage leads to an increase in the unemployment rate u or, equivalently, a reduction in employment N, as workers' willingness to work declines. The production function then implies that the lower number of workers produce less output Y.

(f) We now introduce subscripts to keep track of the value of variables at different points in time. For a variable x, we denote its value at time t by x_t. For example, P_t is the price level at time t. We assume all variables can change over time (so we add time subscripts to all variables).

Inflation and expected inflation are defined by:

$$\pi_t \equiv \frac{P_t - P_{t-1}}{P_{t-1}},$$

$$\pi_t^e \equiv \frac{P_t^e - P_{t-1}}{P_{t-1}}.$$

The non-linear Phillips Curve. Using your answers from parts (a) and (b), give an expression for inflation π_t only as a function of π_t^e, μ_t, u_t, and τ_t.

Solution: In part b), we found that

$$P = P^e(1+\mu)\frac{Y}{L}(1+\tau).$$

Using the answer from part a), we can re-write the last equation as:

$$P = P^e(1+\mu)(1-u)(1+\tau).$$

Introducing time subscripts for all variables gives:

$$P_t = P_t^e\left(1+\mu_t\right)\left(1-u_t\right)\left(1+\tau_t\right).$$

Dividing both sides by P_{t-1}, we get:

$$\frac{P_t}{P_{t-1}} = \frac{P_t^e}{P_{t-1}}\left(1+\mu_t\right)\left(1-u_t\right)\left(1+\tau_t\right).$$

Using the definitions for inflation and expected inflation, we get:

$$1+\pi_t = \left(1+\pi_t^e\right)\left(1+\mu_t\right)\left(1-u_t\right)\left(1+\tau_t\right).$$

This is the *non-linear* Phillips curve (because inflation is not a linear function of π_t^e and u_t).

(g) Show that the expression you found in part (f) can be written as:

$$\frac{1+\pi_t}{1+\pi_t^e} = \frac{1-u_t}{1-u_t^n},$$

where u_t^n is the medium-run unemployment rate that you found in part (c), also called the natural rate of unemployment.

Solution: From c), we have that

$$u = 1 - \frac{1}{(1+\mu)(1+\tau)},$$

$$u_t^n = 1 - \frac{1}{\left(1+\mu_t\right)\left(1+\tau_t\right)}.$$

Substituting the last equation into the non-linear Phillips Curve from part f) and re-arranging, we find that

$$\frac{1+\pi_t}{1+\pi_t^e} = \frac{1-u_t}{1-u_t^n}.$$

(h) The Phillips Curve. Show that when π_t, π_t^e, u_t, and u_t^n are small enough, a good approximation to the expression given in part (g) is:

$$\pi_t = \pi_t^e - (u_t - u_t^n).$$

Hint: Use that when x and y are small enough,

$$\frac{1+x}{1+y} \approx 1 + x - y$$

is a good approximation.

Solution: Using the hint with $x = \pi_t$ and $y = \pi_t^e$ gives the approximation

$$\frac{1+\pi_t}{1+\pi_t^e} \approx 1 + \pi_t - \pi_t^e.$$

Using the hint with $x = -u_t$ and $y = -u_t^n$ gives the approximation

$$\frac{1-u_t}{1-u_t^n} \approx 1 - u_t + u_t^n.$$

Plugging the two approximations into the expression

$$\frac{1+\pi_t}{1+\pi_t^e} = \frac{1-u_t}{1-u_t^n}$$

found in part g) gives

$$1 + \pi_t - \pi_t^e = 1 - u_t + u_t^n.$$

Re-arranging, we get

$$\pi_t = \pi_t^e - (u_t - u_t^n).$$

This is the Phillips curve, which is a linear equation (inflation is a linear function of π_t^e and u_t).

(i) From now on, assume that the labor force is always $L = 1$.

Show that the Phillips Curve from part (h) can also be written as:

$$\pi_t = \pi_t^e + (Y_t - Y_t^n),$$

where Y_t^n is the medium-run level of output that you found in part (c), also called the natural level of output or potential output.

Solution: The answer from part a), the production function $Y = N$, and $L = 1$, imply

$$u = 1 - Y.$$

After adding time subscripts and the superscript n for the medium run, plugging the last equation into the Phillips Curve from part h) gives

$$\pi_t = \pi_t^e - ((1 - Y_t) - (1 - Y_t^n)).$$

Simplifying,

$$\pi_t = \pi_t^e + (Y_t - Y_t^n).$$

(j) Assume the economy is initially at its medium-run equilibrium with $P = 1$. Then, the government increases labor taxes from τ to τ^{new} (with $\tau < \tau^{new}$). Immediately after the increase in τ, the economy jumps to its short-run equilibrium. Keep assuming that $L = 1$ at all times. The variables μ, P^e, and Y that are exogenous in the short inherit their value from the initial medium-run equilibrium.

Is inflation π_t in the short-run equilibrium positive, negative, or zero? Give intuition for why.

Hint: Use your previous answers.

Solution: From part c), the initial medium-run equilibrium with $L = P = 1$ has

$$Y = Y^n = \frac{1}{(1+\mu)(1+\tau)},$$

$$P^e = P = 1.$$

The short-run solution from part b) with

$$L = 1,$$
$$Y = Y^n = \frac{1}{(1+\mu)(1+\tau)},$$
$$P^e = 1,$$

is

$$N = Y^n,$$
$$W = Y^n,$$
$$u = 1 - Y^n,$$
$$P = (1+\mu)\left(1+\tau^{new}\right)Y^n = \frac{1+\tau^{new}}{1+\tau} > 1.$$

Inflation in the short-run equilibrium is positive

$$\pi_t = \frac{\frac{1+\tau^{new}}{1+\tau} - 1}{1} = \frac{\tau^{new} - \tau}{1+\tau} > 0.$$

(k) Find expected inflation π_t^e in the short-run equilibrium. Is expected inflation positive, negative, or zero? Give intuition for why.

Hint: Use the Phillips Curve.

Solution: The new medium-run natural level of output after taxes increase from τ to τ^{new} is

$$Y^{n,new} = \frac{1}{(1+\mu)\left(1+\tau^{new}\right)}.$$

Plugging this $Y^{n,new}$ and the expressions for Y^n and π_t from part j) into the Phillips Curve

$$\pi_t = \pi_t^e + \left(Y^n - Y^{n,new}\right)$$

gives

$$\frac{\tau^{new} - \tau}{1+\tau} = \pi_t^e + \left(\frac{1}{(1+\mu)(1+\tau)} - \frac{1}{(1+\mu)\left(1+\tau^{new}\right)}\right).$$

Solving for π_t^e and simplifying,

$$\begin{aligned}\pi_t^e &= \frac{\tau^{new}-\tau}{1+\tau} - \left(\frac{1}{(1+\mu)(1+\tau)} - \frac{1}{(1+\mu)\left(1+\tau^{new}\right)}\right)\\ &= \frac{1}{(1+\mu)(1+\tau)}\left((\tau^{new}-\tau)(1+\mu) + \frac{1+\tau}{1+\tau^{new}} - 1\right).\end{aligned}$$

Expected inflation is positive:

$$\begin{aligned}&\implies \pi_t^e > 0\\ &\implies \frac{1}{(1+\mu)(1+\tau)}\left((\tau^{new}-\tau)(1+\mu) + \frac{1+\tau}{1+\tau^{new}} - 1\right) > 0\\ &\implies (\tau^{new}-\tau)(1+\mu) + \frac{1+\tau}{1+\tau^{new}} - 1 > 0\\ &\implies (1+\mu)(1+\tau^{new}) > 1.\end{aligned}$$

Where I have used that μ, τ, and τ^{new} are positive and that $\tau^{new} > \tau$.

ECON 1550 — Problem Set 3 Answer Key

Spring 2026

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Submission:	Canvas or Gradescope

1. **Multiple Choice**

Select only one answer.

(a) The carry trade

- ◯ (A) has positive average returns because the uncovered interest parity condition holds.
- ◯ (B) has a non-zero risk premium only when covered interest parity holds.
- ◯ (C) is risky because the difference between domestic and foreign interest rates fluctuates over time.
- ✓ **(D) earns a zero average risk premium when the uncovered interest parity condition holds.**

Solution:

- (A) Do not select. The carry trade has positive average returns because the uncovered interest parity condition does *not* hold empirically.
- (B) Do not select. The carry trade risk premium is about whether *uncovered* interest parity holds, not *covered* interest parity.
- (C) Do not select. The carry trade is risky because exchange rates fluctuate, not because interest rate differentials fluctuate.
- **(D) Select.** When UIP holds, expected returns from investing in foreign versus domestic bonds are equal, implying a zero average risk premium.

(b) Running a current account deficit is equivalent to

- ✓ **(A) net borrowing from the rest of the world.**
- ◯ (B) net lending to the rest of the world.

◯ (C) an increase in public savings.

◯ (D) an increase in private savings.

Solution:

- **(A) Select.** A current account deficit means imports exceed exports, so the country must finance the difference by borrowing from abroad (or selling assets to foreigners).
- (B) Do not select. Lending to the rest of the world corresponds to a current account *surplus*, not a deficit.
- (C) Do not select. An increase in public savings (larger government budget surplus or smaller deficit) would tend to improve the current account, not cause a deficit.
- (D) Do not select. An increase in private savings would also tend to improve the current account, not cause a deficit.

(c) If the government has a $100 million budget deficit, private saving is equal to $500 million, private investment is equal to $300 million, what is the value of the current account?

✓ **(A) $100 million surplus.**

◯ (B) $700 million surplus.

◯ (C) $100 million deficit.

◯ (D) $700 million deficit.

Solution:

- **(A) Select.** Using the identity $S^p + (T - G) = I + CA$, we have $500 + (-100) = 300 + CA$, so $CA = 100$ million surplus.
- (B) Do not select. This would require a different combination of savings, investment, and government balance.
- (C) Do not select. This has the wrong sign; the calculation yields a surplus, not a deficit.
- (D) Do not select. This has both the wrong sign and the wrong magnitude.

(d) Which of the following correctly shows the relationship between savings, the government budget balance, and the current account?

- ◯ (A) $S^p + CA = I + (T - G)$
- ◯ (B) $S^p + CA = I + (T + G)$
- ✓ **(C)** $S^p + (T - G) = I + CA$
- ◯ (D) $S^p + (T + G) = I + CA$

Solution:

- (A) Do not select. The terms are on the wrong sides of the equation.
- (B) Do not select. Both the placement and the sign of G are incorrect.
- **(C) Select.** This is the correct national income identity: private savings plus public savings (government budget balance $T - G$) equals investment plus the current account.
- (D) Do not select. The government budget balance should be $T - G$, not $T + G$.

(e) All else equal, if Canada raises its interest rates,

- ✓ **(A) the U.S. dollar depreciates.**
- ◯ (B) the U.S. demand for Canadian dollars decreases.
- ◯ (C) the Canadian supply of Canadian dollars increases.
- ◯ (D) the Canadian dollar will depreciate.

Solution:

- **(A) Select.** The symbol for the Canadian dollar is CAD. All else equal, higher Canadian interest rates increase demand for CAD-denominated bonds. To purchase these bonds, people need to use CAD, so demand for CAD increases. The CAD appreciates and the USD depreciates.
- (B) Do not select. U.S. demand for Canadian dollars *increases* as U.S. investors seek higher Canadian interest rates.
- (C) Do not select. Money supply does not enter UIP. Looking at the FX market in isolation says nothing about money supply. In the Canadian money

market, if money supply is exogenous, it does not change by assumption. If money supply is endogenous, higher Canadian interest rates lead to lower (not higher) money supply.

- (D) Do not select. The CAD appreciates (not depreciates). The explanation is the same as for choice (A).

2. **Chapter 3: Exchange Rates and the Foreign Exchange Market: An Asset Approach**

   (a) Please answer question 11 from Chapter 3 of the textbook, reproduced here for convenience:

   > "Suppose the dollar exchange rates of the euro and the yen are equally variable. The euro, however, tends to depreciate unexpectedly against the dollar when the return on the rest of your wealth is unexpectedly high, while the yen tends to appreciate unexpectedly in the same circumstances. As a U.S. resident, which currency, the euro or the yen, would you consider riskier?"

   Solution: The yen is riskier for you (equivalently, the euro is safer). When the return on the rest of your wealth is unexpectedly low, the euro tends to appreciate against the dollar, reducing your losses by giving you a relatively high payoff in terms of dollars. Conversely, losses on your euro assets tend to occur when they are least painful, that is, when the rest of your wealth is unexpectedly high. Holding the euro, therefore, reduces the variability of your total wealth, acting as a hedge (insurance) against bad outcomes (low wealth). The yen behaves in the opposite way and therefore is riskier.
   This logic showed up in lecture as one of the possible explanations for why the carry trade has a non-zero risk premium.

   (b) Consider our model of exchange rate determination through uncovered interest parity (UIP) for two time periods, t and $t+1$. Tables I and II summarize this two-period model. The behavioral equation for the expected exchange rate at $t+1$, E^e_{t+1}, is missing from Table II (the entry for that equation is '??'). Propose a reasonable behavioral equation for E^e_{t+1} such that an (exogenous) increase in E^e_t results in an increase in E_{t+1}. Explain the intuition for why E_{t+1} increases when E^e_t increases.

Hint: By reasonable, we mean reasonable to you. This is your own new model of exchange rate determination!

Table I: Exogenous variables

Variable	Description
R_t	Domestic interest rate at t
R_t^*	Foreign interest rate at t
E_t^e	Expected exchange rate at t
R_{t+1}	Domestic interest rate at $t+1$
R_{t+1}^*	Foreign interest rate at $t+1$

Table II: Endogenous Variables and Equations

Variable	Description	Equation	Type of equation
E_t	Exchange rate at t	$R_t = R_t^* + \frac{E_t^e - E_t}{E_t}$	Equilibrium condition
E_{t+1}	Exchange rate at $t+1$	$R_{t+1} = R_{t+1}^* + \frac{E_{t+1}^e - E_{t+1}}{E_{t+1}}$	Equilibrium condition
E_{t+1}^e	Expected exchange rate at $t+1$	??	Behavioral equation

Solution: We propose one particular answer, but of course there are many correct answers.

Irrespective of what equation we propose for E_{t+1}^e, the equilibrium at t looks like the standard equilibrium of the static (one-period) model we studied in class. For this standard model, we can solve the UIP condition for E_t to get

$$E_t = \frac{E_t^e}{1 + R_t - R_t^*}.$$

When E_t^e goes up, E_t goes up as well: at time t, the expectation of a future depreciation leads to an actual depreciation.

For E_{t+1} to also increase in response to the increase in E_t^e, we have to make E_{t+1}^e depend on E_t^e, E_t, or both. Let's try a behavioral equation for E_{t+1}^e given by:

$$E_{t+1}^e = E_t^e.$$

One way to justify this equation with economic intuition is to interpret the expected exchange rate for both t and $t+1$ as expectations for the value that the exchange rate will take "in the long run", many, many periods after t and $t+1$. To the extent that the long run looks the same from the perspectives of times t and $t+1$ (since one period is not a big difference when thinking about the far future), revisions in expectations about the long run at t should lead to an equal revision at $t+1$. The idea is that we will not change our mind about the long run in just one period.

$$E_{t+1} = \frac{E^e_{t+1}}{1 + R_{t+1} - R^*_{t+1}} = \frac{E^e_t}{1 + R_{t+1} - R^*_{t+1}}.$$

The expectation of a long-run depreciation at time t (E^e_t goes up) produces an equal expectation of a long run depreciation at $t+1$ (E^e_{t+1} goes up due to our behavioral equation $E^e_{t+1} = E^e_t$).

From here, the intuition is the one of the standard model.

Keeping the exchange rate E_{t+1} fixed at its initial value (before the change in E^e_t), an expected depreciation increases the domestic-currency return of investing in the foreign bond. After converting domestic currency into foreign currency at the given exchange rate E_{t+1} and earning the foreign interest rate R^*_{t+1}, the higher expected exchange rate E^e_{t+1} implies that the same amount of foreign currency earned by investing in the foreign bond is now exchanged into a larger amount of domestic currency.

The domestic-currency return of investing in the domestic bond, R_{t+1}, has not changed.

We have found that, at the initial exchange rate, the domestic-currency return on the foreign bond is higher than that of the domestic bond. But equilibrium requires that the two are equal.

To reduce the domestic-currency return of investing in the foreign bond, the exchange rate must depreciate today (E_{t+1} has to go up). When E_{t+1} goes up, the same amount of domestic currency results in a smaller amount of foreign currency that can be invested in the foreign bond. Even though the foreign-currency return on the foreign bond, R^*_{t+1}, has not changed, the smaller initial investment leads to a smaller payoff. When the reduction in payoff due to the higher exchange rate offsets the increase in payoff due to the higher expected exchange rate, equilibrium is reached.

(c) Question 18 from Chapter 3 of the textbook states:

"The interest rate on U.S. three-month Treasury bills dropped to very low levels at the end of 2008 and remained there for several years. Starting in January 2009 and ending in December 2019, find data on the three-month Treasury bill rate from Federal Reserve Economic Data (FRED) at the Federal Reserve Bank of St. Louis; find data on the exchange rate of the U.S. dollar against the Korean won from the Bank of Korea Economic Statistics System at http://ecos.bok.or.kr/flex/EasySearch_e.jsp; and from the same source, find data on the Korean 91-day Monetary Stabilization Bond interest rate. Imagine that you borrow dollars at the Treasury bill rate to invest in Korean stabilization bonds, thus doing a carry trade that exposes you to the risk of won/dollar exchange rate fluctuations. As in the Case Study in the text, calculate the total return on your carry trade for every month starting in February 2009 and ending in December 2019."

Please answer this question but end your analysis in July 2023 (rather than on the earlier date in the textbook's question). In addition to calculating the returns, please include a plot that shows the calculated total returns[1] (on the vertical axis) for each month (on the horizontal axis) assuming your initial investment was $100.

Note also that the link http://ecos.bok.or.kr/flex/EasySearch_e.jsp to find data from the Bank of Korea Economic Statistics System provided by the textbook is outdated and no longer works. The correct link is:

`https://ecos.bok.or.kr/#/SearchStat`

Be patient on the first load, it takes a while to load the page but works well after that.

Hint: You can review how to compute payoffs and returns for the carry trade in these lecture slides.

Solution: There are two steps to this question. The first step is getting the data, the second step is constructing the carry trade returns.

Step 1: Getting the data

- Bank of Korea

To get the Monetary Stabilization Bond (MSB) interest rate, go to:

[1] Total returns are the same as cumulative returns. For example, if your initial investment is $100 in January 2023 and the value of your portfolio is $120 in March 2023, then your total (cumulative) return is $120/100 - 1 = 0.2 = 20\%$. This 20% return can be achieved with different combinations of monthly (not cumulative) returns for the months of January, February, and March.

https://ecos.bok.or.kr/#/SearchStat
Then, in the Table Select pane, navigate to:

> 1. Monetary Financial Statistics > 1.3. Interest Rates > 1.3.2. Market Interest Rates > 1.3.2.2. Market Interest Rates (Monthly, Quarterly, Annual)

Once there, the Item Select pane will be populated with a list of rates. Turn off the Select All switch at the top of the pane, then from the list select Monetary stabilization bonds (91-day). At the bottom of the panel, click the Add to List button. Now the selected series appears on the Table Name pane.
To get the exchange rate, there are two equally correct options.

- Option 1. In the Table Select pane, navigate to:

  > 3. Exchange Rate/International Reserves and Trade > 3.1. Foreign Exchange Rate > 3.1.2 Average Period, End Period > 3.1.2.1. Arbitraged Rates of Major Currencies Against Won, Longer Frequency.

- Option 2. In the Table Select pane, navigate to:

  > 3. Exchange Rate/International Reserves and Trade > 3.1. Foreign Exchange Rate > 3.1.2 Average Period, End Period > 3.1.2.3. Exchange Rate of Won Against US Dollar, China Yuan Renminbi [...].

The exchange rates from the two options are very close to each other[2]. Then follow the same steps as before to add Won per United States Dollar (Close) to the Table Name pane. You can use either the Closing Rate or the Average Rate for the Won per United States Dollar (Close) series. They are both equally good options and very close to each other. In this answer, we use the Closing Rate from Option 1 above.
Last, at the bottom of the Table Name pane, click View List. A new screen will appear. Check the box for Mon (for monthly series) and select 2009.01 as the start date and 2023.07 as the end date. After selecting the dates, you have to click Search, otherwise the dates will not be updated. Finally, customize the format if desired (e.g., vertical view rather than horizontal) and click on Original Data Download.

- FRED

The three-month Treasury bill rate from FRED has code "TB3MS". However, the series "Market Yield on U.S. Treasury Securities at 3-Month Constant Maturity, Quoted on an Investment Basis" that has code "GS3M" is equally appropriate and gives essentially identical results. In this answer, we use "TB3MS".

The original spreadsheets with the downloaded data from the Bank of Korea can be found here (or in PDF) and from FRED it can be found here (or in PDF).

Step 2: Constructing carry trade returns

- Formula for returns

The carry trade returns are the same whether we compute US dollar (USD) returns or Korean won (KRW) returns. We compute USD returns.
We use the following notation:

$$
\begin{aligned}
E_t &= \text{USD / KRW exchange rate (dollars per won) in month } t, \\
R_t &= \text{Interest rate for the USD-denominated U.S. Treasury bill that accrues} \\
&\quad \text{between months } t \text{ and } t+1, \\
R_t^* &= \text{Interest rate for the KRW-denominated Korean bond that accrues} \\
&\quad \text{between months } t \text{ and } t+1.
\end{aligned}
$$

If you exchange 1 USD into KRW at the end of month t and use the resulting $1/E_t$ KRW to buy the Korean bond, at the end of month $t+1$, you have an amount of KRW equal to:

$$(1+R_t^*)\frac{1}{E_t}.$$

Converting this KRW-denominated payoff into USD using the $t+1$ exchange rate gives the USD-denominated payoff:

$$(1+R_t^*)\frac{E_{t+1}}{E_t}.$$

Thus, the USD-denominated net return earned by investing in the Korean bond between t and $t+1$ is:

$$(1+R_t^*)\frac{E_{t+1}}{E_t}-1.$$

By *net* return we just mean subtracting 1, so 1.05 is a *gross* return and 0.05 is a net return.
The USD-denominated net return earned between months t and $t+1$ by borrowing in the American bond is:

$$-R_t.$$

The negative sign is there because we are borrowing (short-selling the bond) rather than lending (buying the bond).
The returns on the carry trade strategy are therefore:

$$\begin{aligned} \text{returns}_{t+1} &= \left[(1+R_t^*)\frac{E_{t+1}}{E_t} - 1\right] - R_t \\ &= (1+R_t^*)\frac{E_{t+1}}{E_t} - (1+R_t). \end{aligned} \tag{1}$$

We can approximate to get an expression that looks the same as the formula for expected returns from lecture, but with E_{t+1} instead of E^e since we are constructing realized rather than expected returns. First, re-write the last equation as

$$\begin{aligned} \text{returns}_{t+1} &= (1+R_t^*)\frac{E_{t+1}}{E_t} - (1+R_t) \\ &= (1+R_t^*)\left(\frac{E_{t+1}}{E_t} - 1 + 1\right) - (1+R_t) \\ &= (1+R_t^*)\left[1 + \left(\frac{E_{t+1}}{E_t} - 1\right)\right] - (1+R_t) \\ &= (1+R_t^*) + (1+R_t^*)\left(\frac{E_{t+1}}{E_t} - 1\right) - (1+R_t) \\ &= (1+R_t^*) + \left(\frac{E_{t+1}}{E_t} - 1\right) + R_t^*\left(\frac{E_{t+1}}{E_t} - 1\right) - (1+R_t) \\ &= R_t^* + \left(\frac{E_{t+1}}{E_t} - 1\right) + R_t^*\left(\frac{E_{t+1}}{E_t} - 1\right) - R_t. \end{aligned}$$

The cross term

$$R_t^*\left(\frac{E_{t+1}}{E_t} - 1\right)$$

is much smaller than the other terms, so we ignore it and get

$$\begin{aligned}\text{Approximate returns}_{t+1} &= R_t^* + \left(\frac{E_{t+1}}{E_t} - 1\right) - R_t \\ &= R_t^* - R_t + \left(\frac{E_{t+1}}{E_t} - 1\right). \end{aligned} \tag{2}$$

The term $R_t^* - R_t$ is the *interest rate differential* and the term $E_{t+1}/E_t - 1$ is the *realized depreciation rate* of the USD with respect to the KRW.
Both the exact and the approximate returns can now be computed using the data on R_t^* and E_t downloaded from the Bank of Korea and the data on R_t downloaded from FRED.

- From monthly returns to cumulative returns

To compute cumulative returns, we take January 2009 to be month $t = 0$ and set the initial value of cumulative returns to be 100:

$$\text{Cumulative returns}_0 = 100. \tag{3}$$

For $t > 0$, we compute cumulative returns using the recursive formula:

$$\text{Cumulative returns}_t = (1 + \text{returns}_t)\,\text{Cumulative returns}_{t-1}. \tag{4}$$

We can alternatively use Approximate returns$_t$ instead of returns$_t$, which gives essentially identical results.

- Converting to the correct units

The formulas above use non-annualized decimal returns for the interest rates R and R^*, and dollars per won for the exchange rate E. For example, if $R = 0.02$, this means 2% returns over one month. And if $E = 2$, this means that we need 2 dollars to buy one won.
We have to make sure our numbers are the correct units before we plug them into the formula.

For interest rates, there are three dimensions of the data:

- Maturity of the bond: 3 months for both bonds

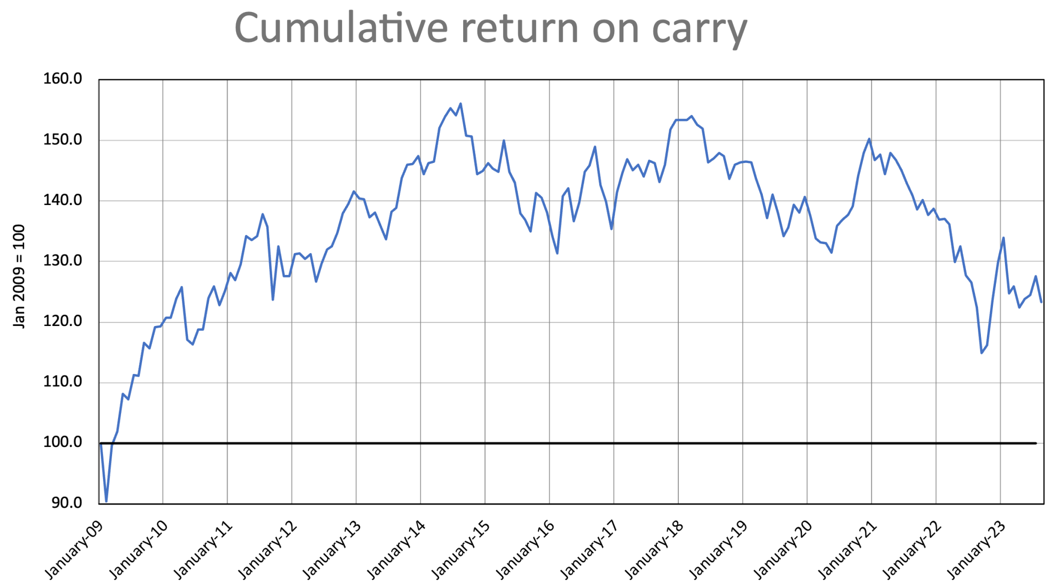
- Frequency of observation: monthly for both bonds
- Units: percent per annum for the Bank of Korea interest rate and decimal per annum for the FRED interest rate

Per annum here just means *annualized*. To convert to raw (non-annualized) values, we simply divide by 12 (because there are 12 months in a year). To convert percent to decimal, we divide by 100. For example, for January 2009, the Bank of Korea interest rate is reported as 2.26. This means that this bond provides a return of $2.26\%/12 = 0.1883\%$ over the next month or, in decimal, $0.1883/100 = 0.001883$. The FRED interest rate for the same month is reported as 0.13. Since FRED reports in annualized decimal units, the bond return over the next month is $0.13/12 = 0.01083$ in decimal, or 1.083%.

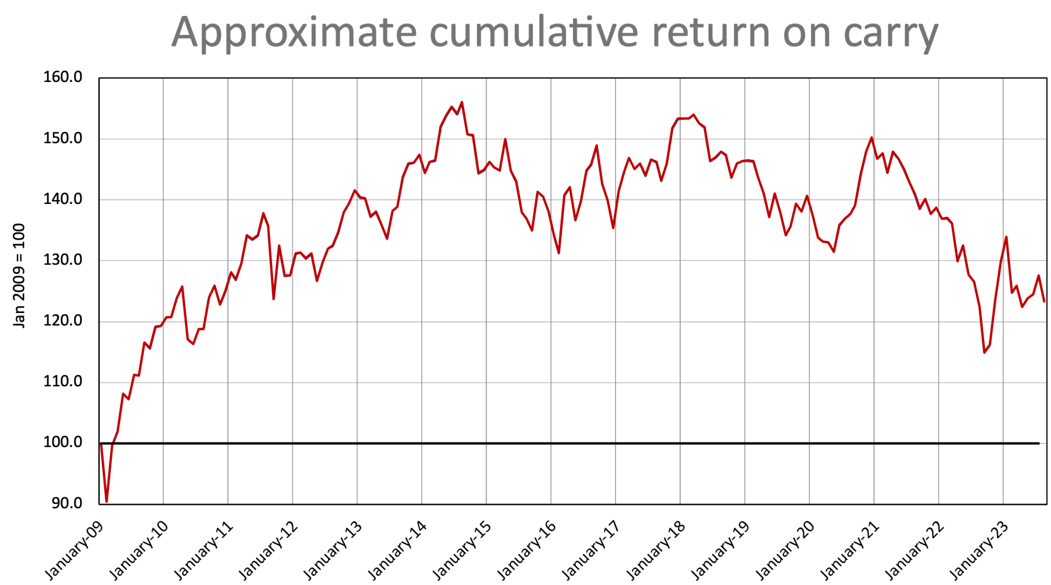
For the exchange rate, the Bank of Korea reports the KRW / USD (won per dollar) exchange rate. However, in our formulas E_t represents the USD / KRW exchange rate (dollars per won). Therefore, to convert the exchange rate we downloaded into E_t, we have to take its reciprocal. For example, for January 2009, the downloaded exchange rate value from the Bank of Kore is $1{,}368.5$ won per dollar. Then,

$$E_t = \frac{1}{1{,}368.5 \text{ KRW/USD}} = \frac{1}{1{,}368.5} \text{ USD/KRW} = 0.00073073 \text{ dollars per won.}$$

The plot below shows the time series of cumulative returns obtained by using equations (1), (3), and (4) with interest rates in non-annualized decimal units and the exchange rate in dollars per won. The cumulative returns in month t give the amount of money you would have in month t if you had invested \$100 in the carry trade strategy starting in January 2009.



If we use approximate returns in equation (2) rather than the exact returns from equation (1), we get essentially the same plot:



You can see all the calculations and plots in this Excel file.

[2] The exchange rate in Option 1 is the "basic exchange rate" and is determined as the transactions volume-weighted average of the rates applied in the previous business day's transactions between foreign exchange banks through brokers in an "over-the-counter" (OTC) market. The exchange rate in Option 2 is the closing-day exchange rate quoted in a trading exchange (a marketplace where prices are quoted openly).

ECON 1550 **Problem Set 4 Answer Key**

Spring 2026

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Submission:	Canvas or Gradescope

1. **Chapter 4: Money, Interest Rates, and Exchange Rates**

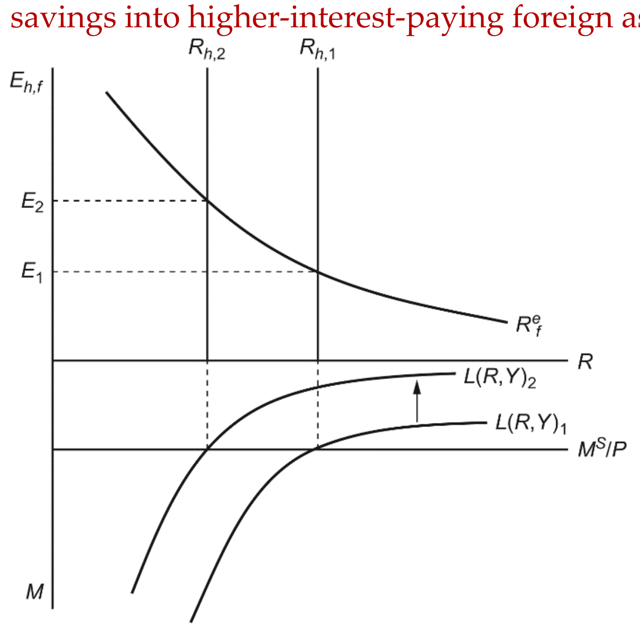
Answer the following questions about money, interest rates, and exchange rates from Chapter 4.

(a) Question 1 from Chapter 4 of the textbook is:

> "Suppose there is a reduction in aggregate real money demand, that is, a negative shift in the aggregate real money demand function. Trace the short- and long-run effects on the exchange rate, interest rate, and price level."

Answer this question **but only for the short run**. Treat the expected exchange rate and the price level as exogenous.

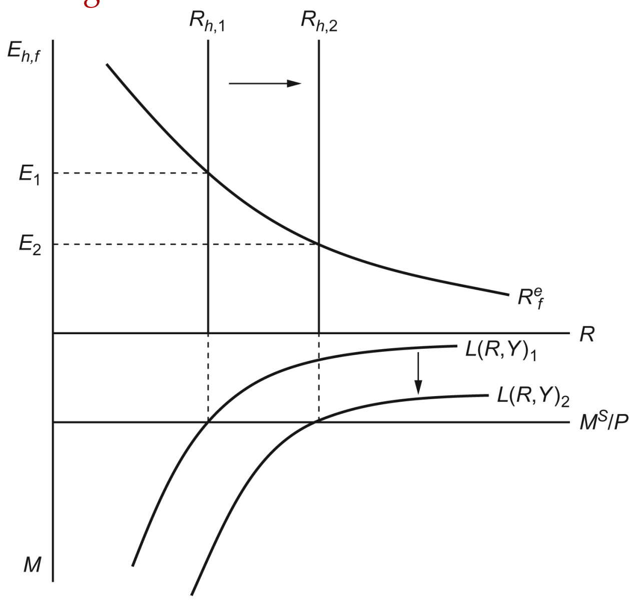
Solution: A reduction in the home money demand causes interest rates in the home country to fall from $R_{h,1}$ to $R_{h,2}$. With no change in expectations, there will be a depreciation of the home currency from E_1 to E_2 as investors shift their savings into higher-interest-paying foreign assets.



(b) Please answer question 4 from Chapter 4 of the textbook, reproduced here:

> What is the short-run effect on the exchange rate of an increase in domestic real GNP, given expectations about future exchange rates?

Solution: An increase in domestic real GNP will cause domestic real money demand to rise. This will cause domestic real interest rates to rise from $R_{h,1}$ to $R_{h,2}$ (see graph below). With no change in expectations, there will be an appreciation of the home currency from E_1 to E_2 as investors channel their savings into domestic assets.

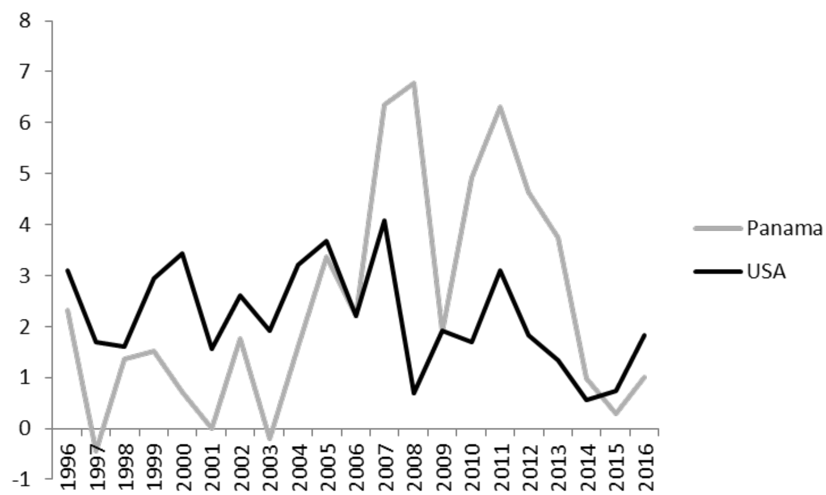


(c) Please answer question 13 from Chapter 4 of the textbook, reproduced here:

> "Since 1942, the small country of Panama has had no paper currency other than the U.S. dollar, which circulates freely internally. What would you expect to be true about the inflation rate in Panama compared to that in the United States, and why? Go to the International Monetary Fund's most recent World Economic Outlook database (accessible directly or through www.imf.org) and examine comparable consumer-price inflation rates for Panama and the United States. Do the inflation rates you see there conform to your earlier prediction? (After you have read Chapters 5 and 7, you should return to this question as you will then have a deeper understanding of the factors that determine the price level in a country like Panama.)"

Solution: Because Panama uses the US dollar as its currency, we would expect that, all else being equal, inflation in Panama and that in the United States should be identical. The chart below gives inflation rates in Panama and the United States over the past 20 years.

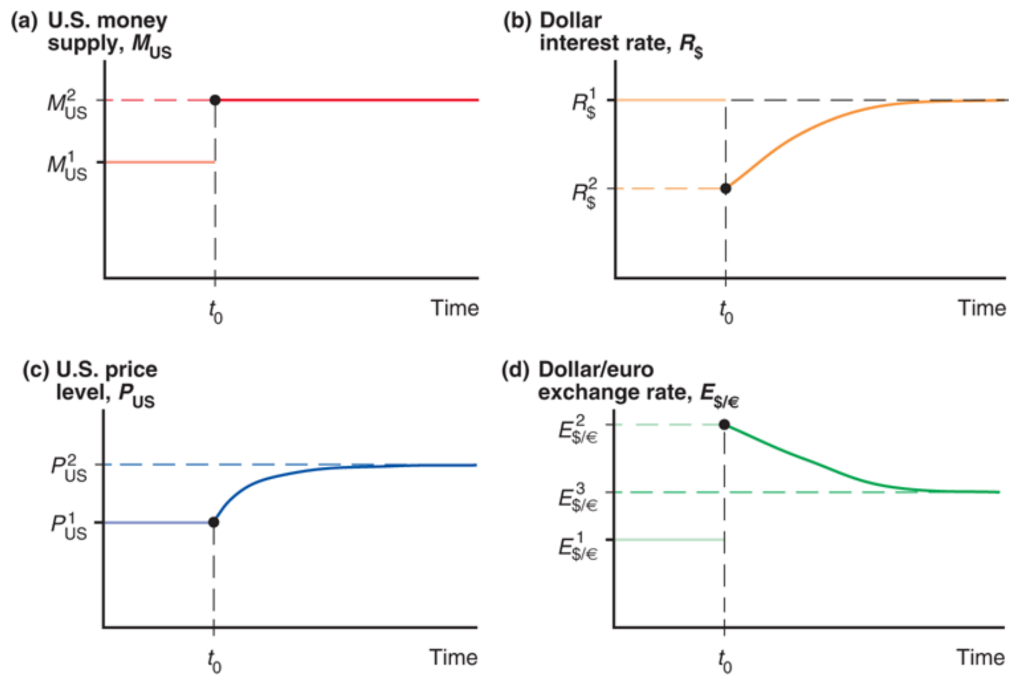
On the one hand, the inflation rates in the two countries tend to move together, as we would expect because they share the same money supply. That said, the inflation rates are not identical between the two countries. This is because prices (and thus inflation) are not determined by the money supply alone. Recall the long-run price level defined as $P = M^S/L(R, Y)$. Although Panama and the United States share the same money supply, the demand for money in each country may differ, allowing for differences in price levels.



2. **Overshooting and Carry Trade Returns**

Consider Figure 4-13 in Chapter 4 of the textbook:

Figure 4-13 Time Paths of U.S. Economic Variables after a Permanent Increase in the U.S. Money Supply



The figure was constructed under some specific assumptions explained in the textbook (the interest parity condition holds, $R_€ = R^1_\$$, expectations of exchange rates do not change during the adjustment of P_{US}, etc.). When you answer the questions below, please maintain the same assumptions made by the textbook.

(a) Plot the time-path of the expected exchange rate. What is its long-run value?

Solution: The textbook explained that the expected exchange rate jumps at t_0 and was assumed to remain constant at the new value after t_0.
To find the long-run value of E^e, we use that:

(i) $R_€ = R^1_\$$ (by assumption in the textbook)

(ii) The long-run value of $R_\$$ is $R^1_\$$

(iii) The long-run value of E is E^3

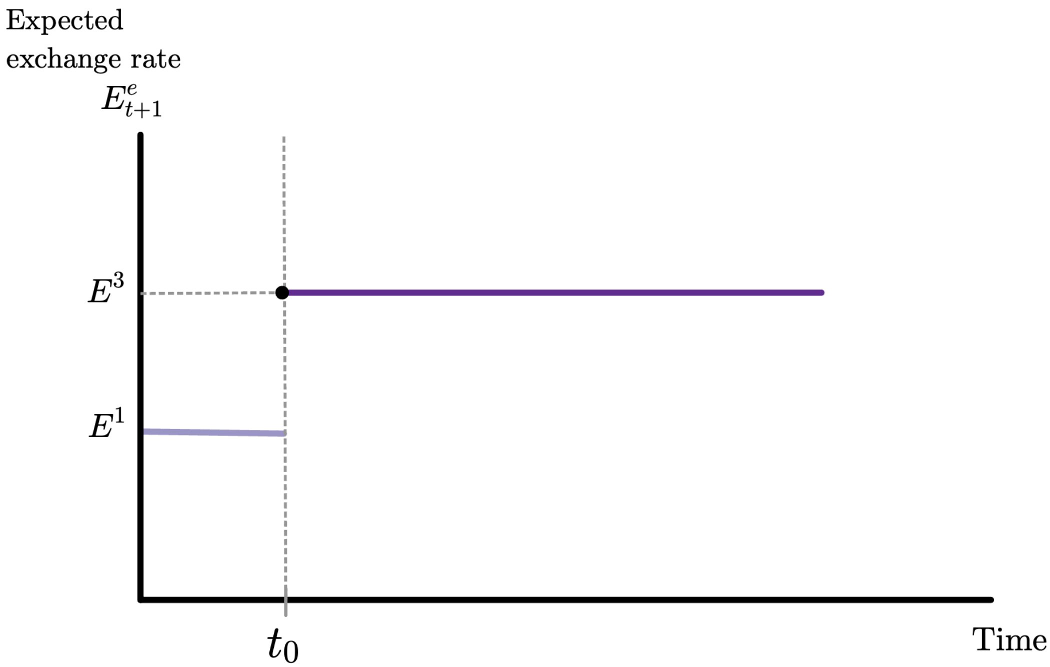
(iv) Since interest parity holds, in the long run:

$$0 = R_{\$} - R_{€} - \left(\frac{E^e}{E} - 1\right)$$

Using (i), (ii) and (iii) in the interest parity condition from (iv) we find that in the long run:

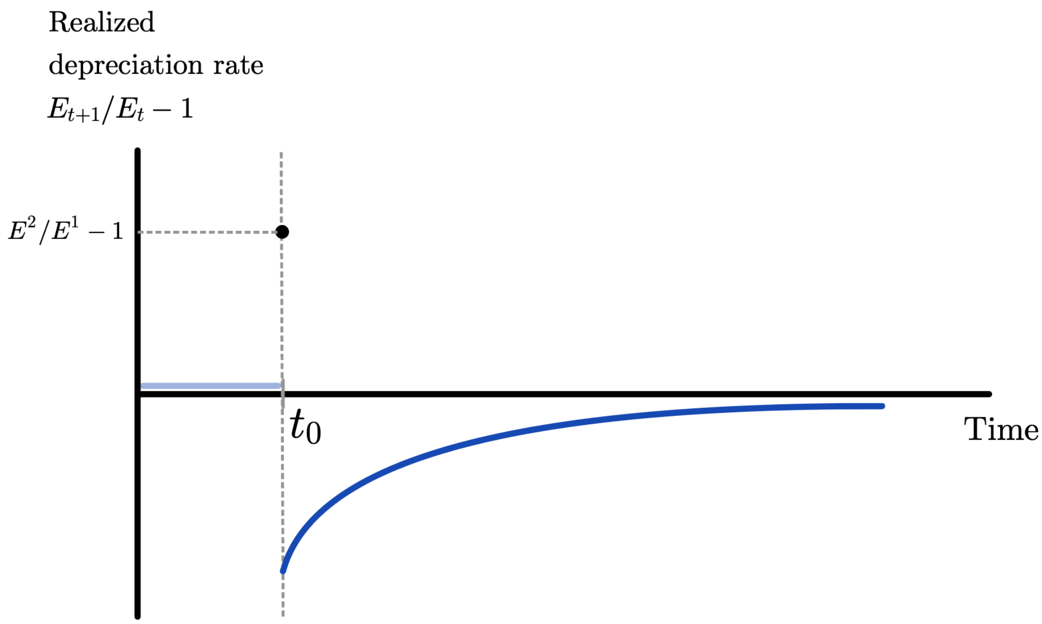
$$0 = R_{\$} - R_{€} - \left(\frac{E^e}{E} - 1\right) = R^1_{\$} - R^1_{\$} - \left(\frac{E^e}{E^3} - 1\right) = 1 - \frac{E^e}{E^3}$$

Therefore, $0 = 1 - E^e/E^3$, which gives $E^e = E^3$.



(b) Plot the time-path of the realized depreciation rate of the dollar with respect to the euro, $E_{t+1}/E_t - 1$ (where E is the number of dollars per euro).

Solution: The realized depreciation rate can be found by looking at the time-path of the exchange rate in panel (d) of the textbook's figure. At t_0, the exchange rate jumps from E^1 to E^2, so the initial depreciation rate is $E^2/E^1 - 1$. After t_0, the exchange rate decreases from E^2 to E^3, so the depreciation rate is negative. Eventually, the exchange rate converges, so the depreciation rate is zero in the long run.



Note that this solution requires the "Time" axis to be reported in terms of $t+1$ rather than t, i.e., [realized depreciation rate $]_{t+1} \equiv E_{t+1}/E_t - 1$. If we instead used [realized depreciation rate $]_t \equiv E_{t+1}/E_t - 1$, a depreciation at $t+1 = t_0$ would enter the realized depreciation rate at $t = t_0 - 1$, i.e., before the public had any knowledge of the coming money supply shock.

(c) Plot the time-path of realized returns for a carry trade that lends in dollars and borrows in euros. Give intuition for the behavior of the returns at t_0 and immediately after t_0.

Solution: We use R^* to denote the euro interest rate and R to denote the dollar interest rate. The realized carry trade returns are:

$$RET_{t+1} = R_t - \left[R_t^* + \left(\frac{E_{t+1}}{E_t} - 1\right)\right]$$

We will analyze the behavior of RET_{t+1} in three different stages: before t_0, exactly at t_0, and after t_0.

Before t_0

When $t+1 < t_0$, we have $RET_{t+1} = 0$ since E_{t+1} is constant and $R_t = R_t^*$.

Exactly at t_0

We found in part b) of this question that the realized depreciation rate $E_{t+1}/E_t - 1$ jumps up at $t+1 = t_0$, generating lower RET_{t+1}, so the carry trade returns go

down.
The dollar interest rate also drops to $R_{t_0} < R_{t_0-1}$, but this change isn't incorporated into returns realized at t_0: These returns depend only on interest rates set at $t_0 - 1$.
Since returns were zero before t_0, they are negative at exactly t_0.
After t_0
We start by analyzing what happens in the long run (as t grows to infinity).

- From part a) of this question, we know that in the long run, $R_t = R_t^*$.
- Additionally, panel (d) of the textbook's figure shows that the exchange rate eventually becomes constant and therefore, in the long run, $E_{t+1}/E_t - 1 = 0$.

Together, $R_t = R_t^*$ and $E_{t+1}/E_t - 1 = 0$ imply that, in the long run, we have $RET_{t+1} = 0$.
Now we show that $RET_{t+1} < 0$ between t_0 and the long run. First, note that for any $t + 1 > t_0$, we have:

$$E_{t+1} > E^3 \tag{1}$$

as can be directly seen in panel (d) of the textbook's figure. In addition, because the interest parity condition holds, we have $R_t - R_t^* = E^e_{t+1}/E_t - 1$.
Using the result from part b) that $E^e = E^3$ after t_0, we get:

$$R_t - R_t^* = \frac{E^3}{E_t} - 1 \tag{2}$$

Using equations (1) and (2),

$$RET_{t+1} = R_t - R_t^* - \left(\frac{E_{t+1}}{E_t} - 1\right) = \left(\frac{E^3}{E_t} - 1\right) - \left(\frac{E_{t+1}}{E_t} - 1\right) = \frac{E^3 - E_{t+1}}{E_t} < 0$$

Therefore, we know carry trade returns are always negative after t_0.
We now examine what happens *immediately* after t_0, i.e., at $t + 1 = t_0 + 1$.
From panel (d) of the textbook's figure, we see that depreciation maxes out at t_0; after that, the dollar only appreciates toward its long-run level. So, in $t_0 + 1$, realized depreciation contributes *positively* to returns: $E_{t_0+1} < E_{t_0}$, so $-(E_{t_0+1}/E_{t_0} - 1) > 0$.

But RET_{t_0+1} also depends on the dollar interest rate realized in t_0. From panel (b) in the textbook's figure, we know the dollar interest rate drops abruptly at t_0: $R_{t_0} < R_{t<t_0}$ contributes *negatively* to returns.
Combining these two pieces and drawing on our discussion of RET_{t+1} over the long run allows us to state $\Delta R_{t_0} < RET_{t_0+1} < 0$. But how does RET_{t_0+1} compare to RET_{t_0}?
Since $E_{t+1}/E_t = 1$ and $R_{t_0-1} = R^*_{t_0-1} \quad \forall t+1 < t_0$ in the long-run equilibrium preceding t_0, RET_{t_0} can be expressed in terms of E_{t_0}, the one variable that changes, as $-\Delta E_{t_0}/E_{t_0-1}$. Recalling our UIP condition

$$E_t = \frac{E^e}{1 + R_t - R^*_t}$$

lets us study ΔE_{t_0} in terms of $\Delta E^e_{t_0}$ and ΔR_{t_0} by evaluating the **total derivative** of E at t_0:

$$\begin{aligned}
\Delta E_{t_0} &= \frac{\partial E_{t_0-1}}{\partial E^e_{t_0-1}} \cdot \Delta E^e_{t_0} + \frac{\partial E_{t_0-1}}{\partial R_{t_0-1}} \cdot \Delta R_{t_0} \\
&= \frac{\Delta E^e_{t_0}}{1 + R_{t_0-1} - R^*_{t_0-1}} - \frac{E^e_{t_0-1} \cdot \Delta R_{t_0}}{(1 + R_{t_0-1} - R^*_{t_0-1})^2} \\
&= \Delta E^e_{t_0} - E^e_{t_0-1} \cdot \Delta R_{t_0}
\end{aligned}$$

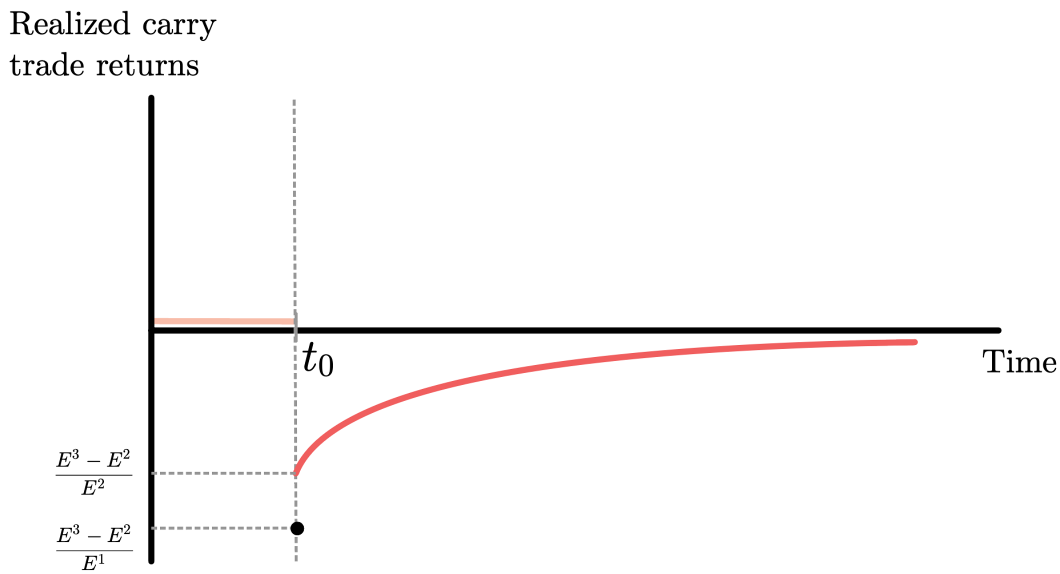
We therefore have

$$RET_{t_0} = -\frac{\Delta E^e_{t_0} - E^e_{t_0-1} \cdot \Delta R_{t_0}}{E_{t_0-1}} = -\frac{\Delta E^e_{t_0}}{E_{t_0-1}} + \frac{E^e_{t_0-1} \cdot \Delta R_{t_0}}{E_{t_0-1}}$$

The second term on the right-hand side simplifies to ΔR_{t_0} because $E^e_{t_0-1} = E_{t_0-1}$ in the long-run equilibrium that prevailed at $t_0 - 1$. The first term is negative because $\Delta E^e_{t_0}$ is positive: The expected exchange rate is permanently higher after the money supply shock at t_0. This gives us

$$RET_{t_0} = -\frac{\Delta E^e_{t_0}}{E_{t_0-1}} + \Delta R_{t_0} < \Delta R_{t_0} < RET_{t_0+1}$$

The reasoning above gives the following time path for realized carry trade returns:



The graph shows that carry trade returns jump up between t_0 and the instant immediately after t_0. This is a consequence of exchange rate overshooting, which induced a positive depreciation rate at t_0 but a negative one immediately after t_0, and of the interest parity condition, which guaranteed that the change in R did not perfectly offset the movements in returns caused by the exchange rate.

ECON 1550	**Problem Set 5 Answer Key**

Spring 2026

Instructor:	Fernando Duarte
Head TA:	Leo Zucker
Undergraduate TAs:	Eric Kim, Raisa Axenie, Nathalie Peña
Submission:	Canvas or Gradescope

1. **The Big Mac Index, Purchasing Power Parity, and the Exchange Rate**

The Big Mac index was invented by The Economist in 1986 as a lighthearted guide to whether currencies are at their "correct" level. Read the article about the Big Mac index (attached at the end of this problem set or online at https://www.economist.com/interactive/big-mac-index), and the box "Some Meaty Evidence on the Law of One Price" in Chapter 5 of the textbook, then please answer the following questions:

(a) How is Purchasing Power Parity (PPP) defined in the article from The Economist?

Solution: According to the article from The Economist, purchasing-power parity (PPP) is:

> "the notion that in the long run exchange rates should move towards the rate that would equalise the prices of an identical basket of goods and services (in this case, a burger) in any two countries."

(b) How is Purchasing Power Parity (PPP) defined in Chapter 5 of the textbook (and in class)?

Solution: From Chapter 5 of the textbook:

> "The theory of purchasing power parity states that the exchange rate between two countries' currencies equals the ratio of the countries' price levels."

Additional information (not part of the answer): This definition, correct as it is, fails to emphasize that the price levels for the two countries must be the prices of the *same* basket of goods.
We can also use a formula. If E is the exchange rate, P the domestic price (in units of domestic currency) of some reference basket of goods, and P^* the

foreign price (in units of foreign currency) of the same reference basket of goods, then PPP holds if

$$E = \frac{P}{P^*}$$

Last, in the textbook and in class, PPP is a long-run theory, which means that the relation $E = P/P^*$ is only supposed to hold in the long-run. Throughout this question, we use current values rather than long-run values as a simplified approximation.

(c) Measures of exchange rates and PPP for many countries can be downloaded from the OECD at this link. Observations are annual.

Data for the Big Mac index can be found at `https://github.com/TheEconomist/big-mac-data`. For this problem set, use the pinned file `big-mac-source-data-v2-pinned.csv`, which is based on the corresponding Economist source file. For some years, observations are annual. For other years, observations are semi-annual. When comparing Big Mac index data to OECD data, transform semi-annual data to annual by taking the average of the two semi-annual observations.

Explain how the OECD PPP measure relates to our definition of PPP from the textbook (and from class).

Hint: The OECD database links to this explanation of how their measure of PPP is constructed.

Solution: Question 1 in the link provided in the hint to the question explains that:

> "PPPs are the rates of currency conversion that equalize the purchasing power of different currencies by eliminating the differences in price levels between countries. In their simplest form, PPPs are simply price relatives that show the ratio of the prices in national currencies of the same good or service in different countries. PPPs are also calculated for product groups and for each of the various levels of aggregation up to and including GDP."

Therefore, in their "simplest form", the PPP measure from the OECD is the analog to the term P/P^* in the equation $E = P/P^*$, where P is in units of national currency and P^* is in US dollars.

(d) Pick any two countries that have data for 2024 or later in both the Big Mac index data and the OECD data. Using these two countries:

For the latest year available, construct P/P^* using the Big Mac data and the OECD data. Which of the two is closest to E? Do the two P/P^* measures agree on which of the two currencies is over/under-valued?

Solution: Using Argentina as the home country and the United States as the foreign country, the solution proceeds as follows. Results for a selection of other countries can be found here.

For Argentina, there are two semi-annual observations in 2024. The local price of a Big Mac in local currency (variable local_price) in Jan-2024 is 3,150 ARS and in Jul-2024 is 6,100 ARS, where ARS are Argentinean. We create a single annual observation for 2024 by taking the average of the two prices, which is 4,625.00 ARS.

For the United States, there are also two semi-annual observations for the local_price variable, but they are both the same and equal to 5.69 USD, so we use that value as the single annual observation for 2024.

The ratio of the two prices is:

$$\frac{\text{BigMac } P}{\text{BigMac } P^*} = \frac{4{,}625.00}{5.69} = 812.83$$

The OECD's PPP measure for Argentina in 2024 is 419.90. The PPP for the U.S. is 1 (as it is the reference currency). The ratio of the two PPP measures is:

$$\frac{P}{P^*} = \frac{419.90}{1} = 419.90$$

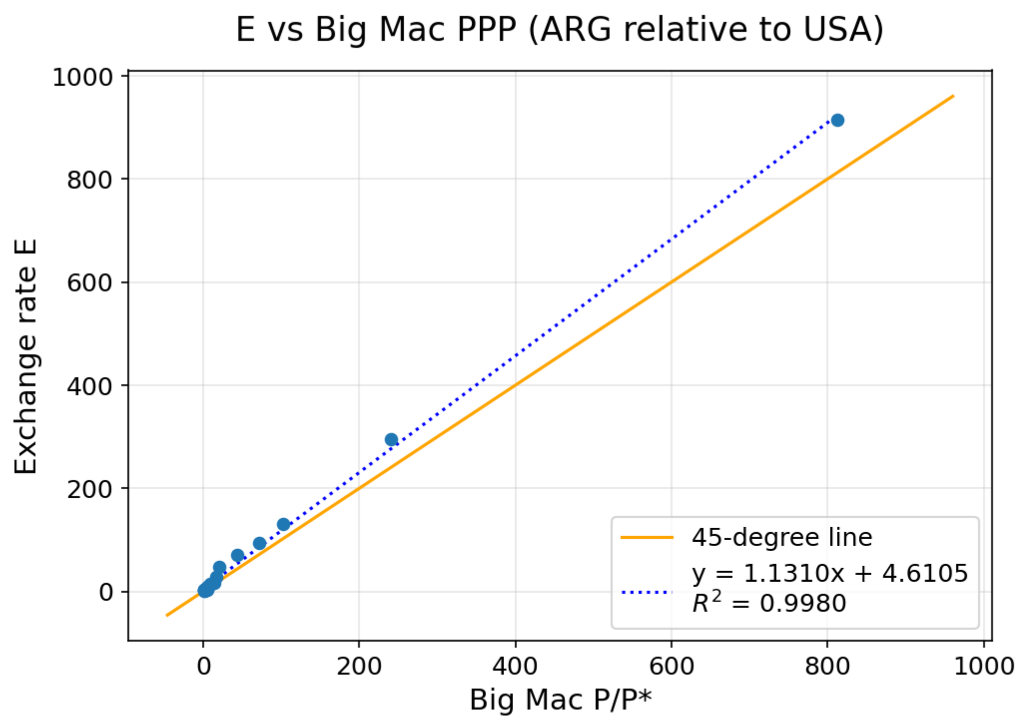
The exchange rate from the OECD data is:

$$E = 914.69 ARS/USD$$

The exchange rate predicted by the theory of PPP is $E_{\text{PPP}} = P/P^*$. The $E_{\text{PPP}} = 812.83$ using the Big Mac data is closer to the actual exchange rate $E = 914.69$ ARS/USD than the $E_{\text{PPP}} = 419.90$ using the OECD data. Both E_{PPP} measures are below E, so they agree in signaling an undervalued ARS. If the theory of PPP were true, then we would expect ARS to appreciate as time goes by, and to eventually reach E_{PPP} in the long run.

(e) Using all the years available, make a scatter plot of E against the Big Mac data's P/P^*. What should the scatter plot look like if PPP holds? What features of the scatter plot support the hypothesis that PPP holds? What features suggest the hypothesis that PPP holds is not true?

Solution: PPP holds when $E = P/P^*$. Therefore, if we plot E on one axis and P/P^* on the other, PPP holds exactly when the observations are on the line that goes through the origin and has a slope of 1, i.e., the 45-degree line that goes through the point (0,0).
A scatter plot using data between 2000 and 2024 gives:



The exchange rate E is on the vertical axis, and the PPP-implied measure of the exchange rate, $E_{\text{PPP}} = P/P^*$, is on the horizontal axis. Each dot represents the pair $(P/P^*, E)$ for a particular year, constructed exactly as in part (d). The orange line is the 45-degree line through the origin.
Features of the plot that support the theory of PPP are:

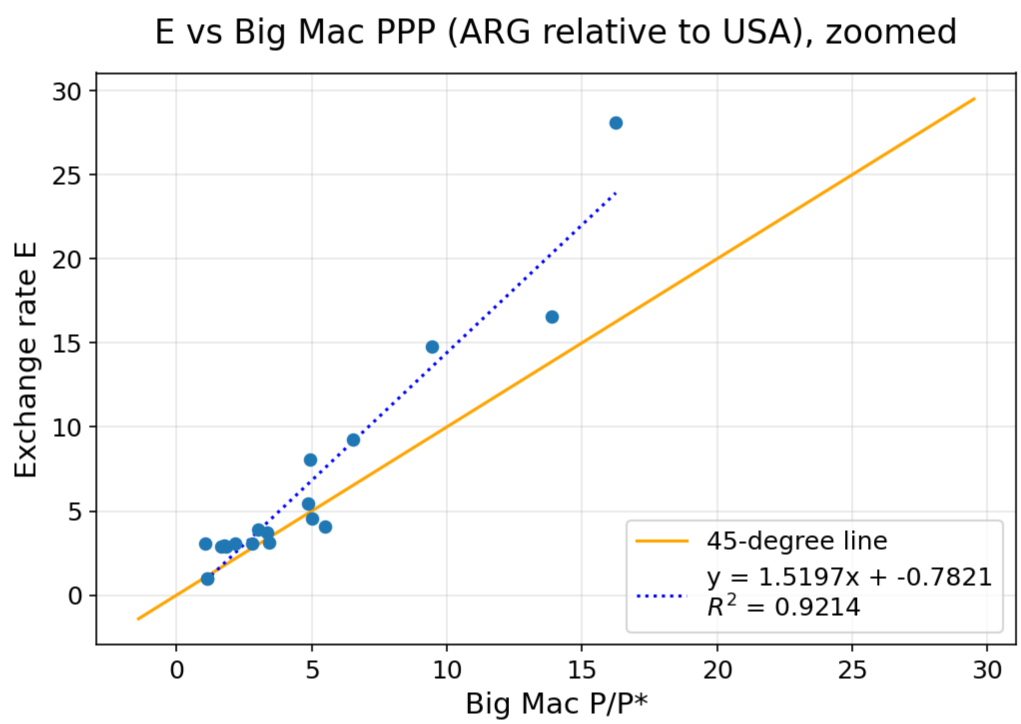
- The points align along a line (rather than along some other shape of curve)
- The slope of a line fitted to the points has a slope of 1.1310, which is close to the slope of 1 predicted by PPP.

Features of the plot against the theory of PPP are:

- The observations with high values of E are systematically above the 45-degree line. The fitted intercept of 4.6105 is small relative to the data range, but this systematic pattern shows that the deviations from PPP are not random.

- Even though the slope of 1.1310 is close to 1, the points fit the line with slope 1.1310 very well (with an R^2 of 0.9980). This tight fit means the slope is estimated precisely, so the deviation from the slope of 1 predicted by PPP is likely a genuine feature of the data rather than noise.

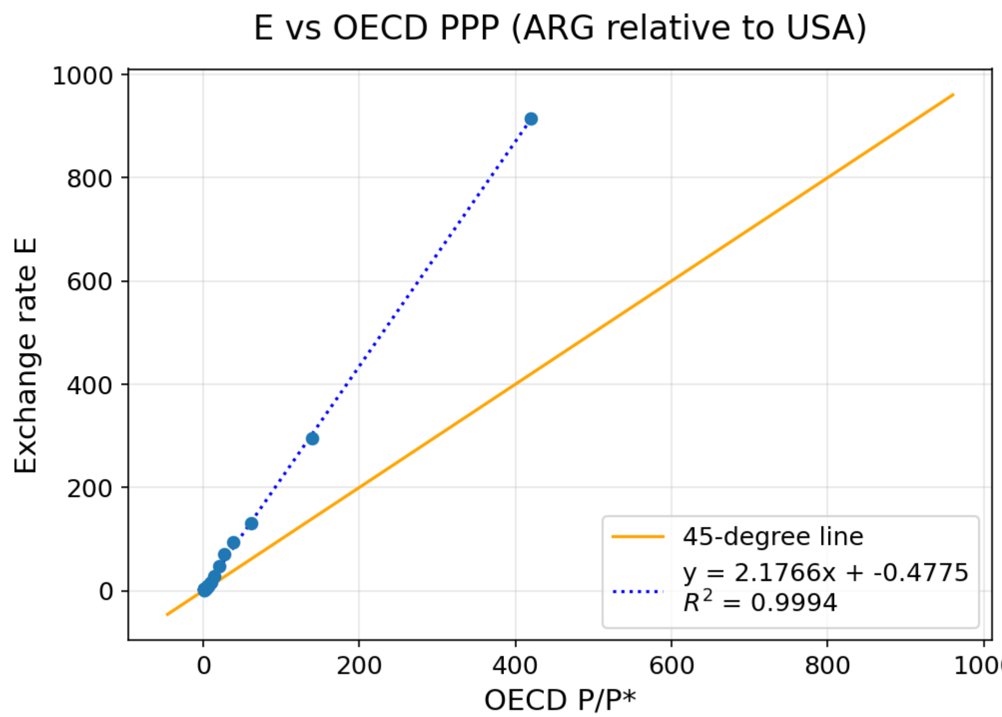
- The points with low E seem to fit the 45-degree line better, but it is hard to see in the figure above. The next figure zooms into lower values of E:



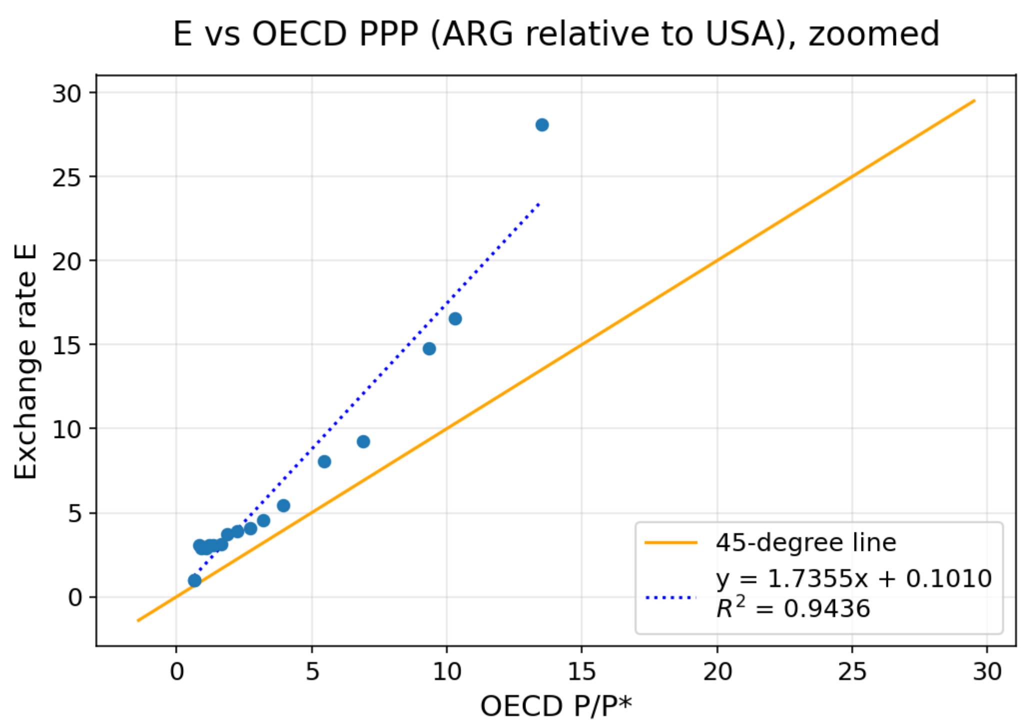
In this zoomed plot, the fitted line has slope 1.5197 and intercept -0.7821. We can more clearly see now that the low-E observations do not line up all that well with the 45-degree line.

(f) Answer the last question once again, but using OECD data to construct P/P^*.

Solution: The plot using the OECD data is:



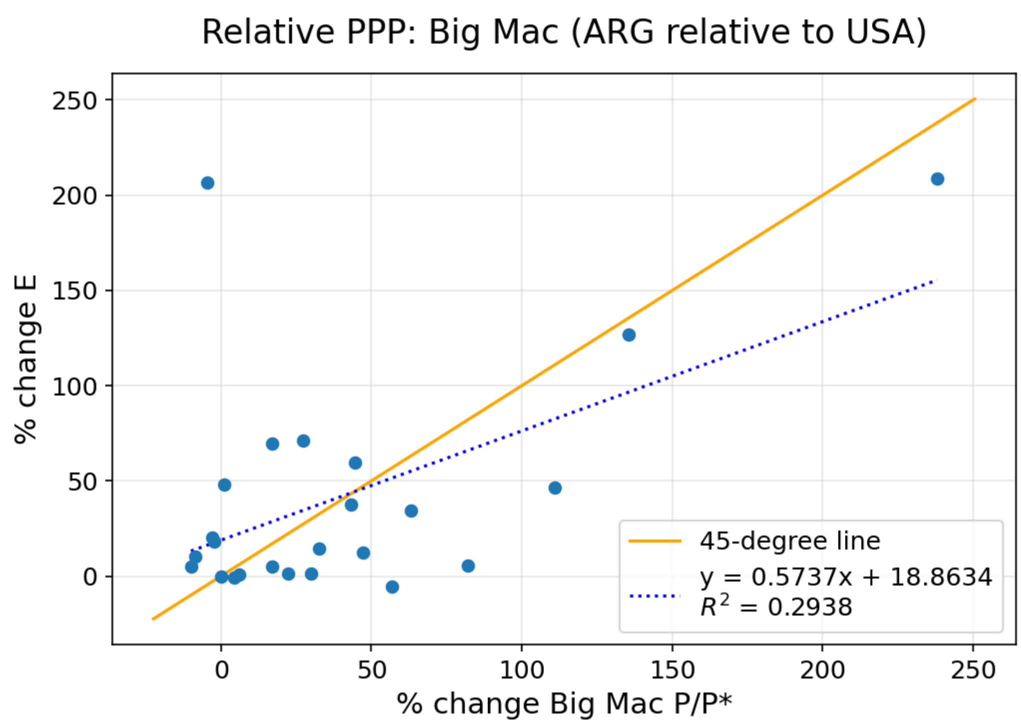
Zooming into small values:



In the full sample, the fitted line has slope 2.1766, intercept -0.4775, and $R^2 = 0.9994$. In the zoomed plot, the fitted line has slope 1.7355, intercept 0.1010, and $R^2 = 0.9436$. Similar to the Big Mac case from part (e), the points fit a line quite well when using the full sample (all the years), and not as well for low values of E. We conclude that the OECD-based PPP measure is strongly related to the exchange rate, but the relationship is still noticeably steeper than the 45-degree line predicted by PPP, has some noticeable deviations from being linear, and has an intercept different from zero.

(g) Repeat parts (e) and (f) but now assess relative PPP rather than absolute PPP.

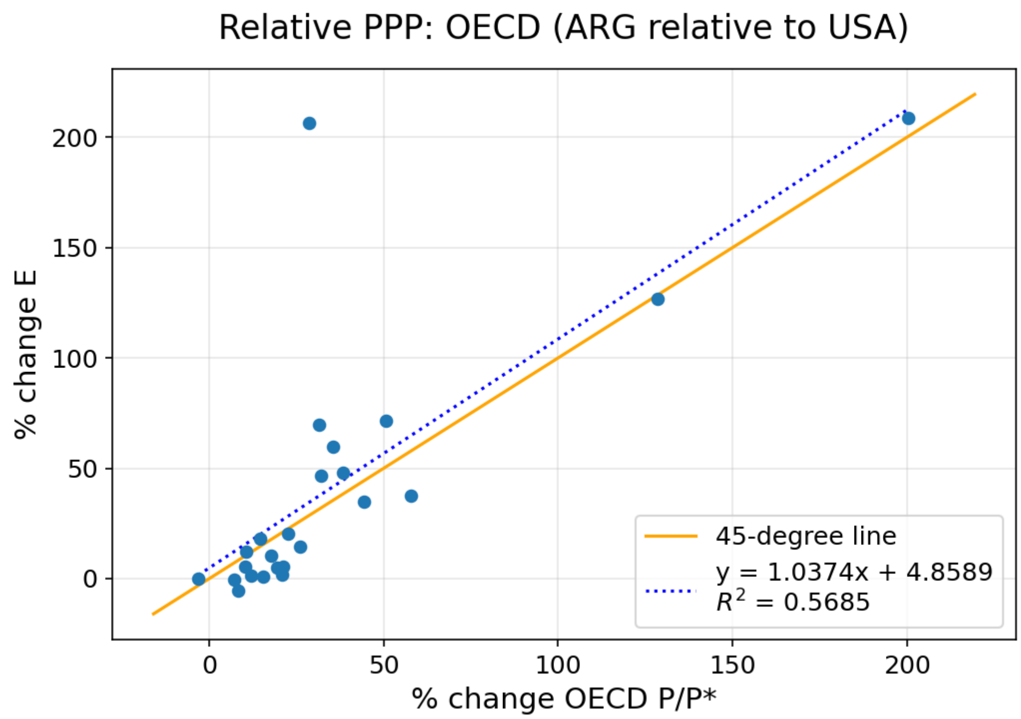
Solution: To assess relative PPP, we plot percentage changes in PPP and E rather than levels. For the Big Mac data, the plot is:



The scatterplot that uses the Big Mac data offers little support for relative PPP. The points are not neatly in a line, and the fitted line has slope 0.5737 with $R^2 = 0.2938$. In addition, the percentage change in E is often smaller than the percentage change in PPP. The outlier point labeled 2002 corresponds to the year 2002, when Argentina had its most severe financial crisis in its more than

200-year history.

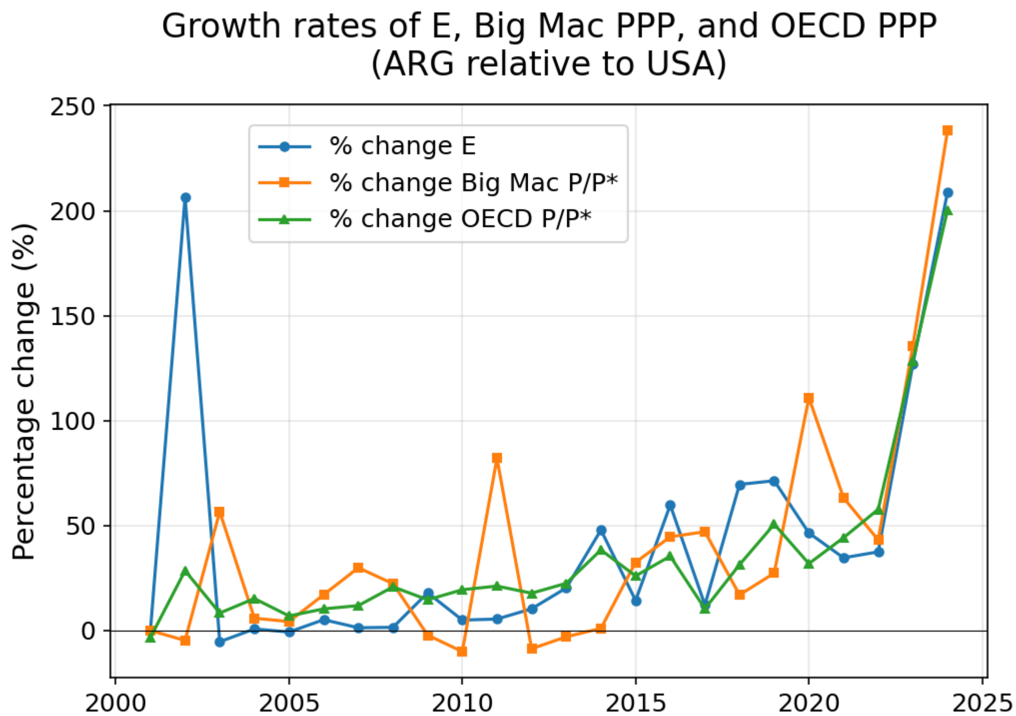
For the OECD data, we get:



The scatterplot that uses the OECD data offers more support for relative PPP than the Big Mac data. The fitted line has slope 1.0374, which is close to the slope of 1 predicted by relative PPP. Against the theory of PPP, the points do show noticeable dispersion and the R^2 is only 0.5685. The point corresponding to the 2002 financial crisis remains a clear outlier.

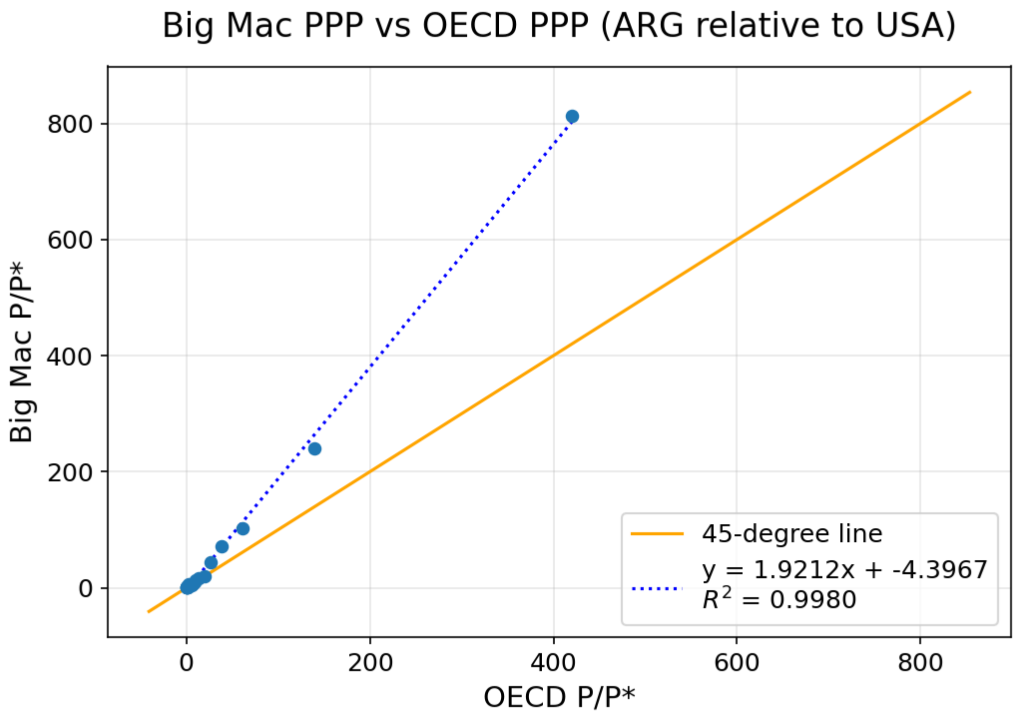
(h) In a single plot, show the time series of the growth rate of the two PPP measures and the growth rate of the exchange rate (that is, plot the year in the horizontal axis and the growth rates of the three variables on the vertical axis). Do the series move together over time? Describe one feature of the plot that provides evidence in favor and one feature that provides evidence against the hypothesis that relative PPP holds.

Solution: The series do move roughly together, although not in every year. If relative PPP held exactly, the exchange rate series E should lie exactly on top of the PPP series P/P^*. One feature in favor of relative PPP is that in 2023 and 2024, all three series jump sharply together, showing strong co-movement even if the exact magnitudes differ. A feature against relative PPP is in 2002, when the exchange rate depreciated more than what is implied by either of the two PPP measures.

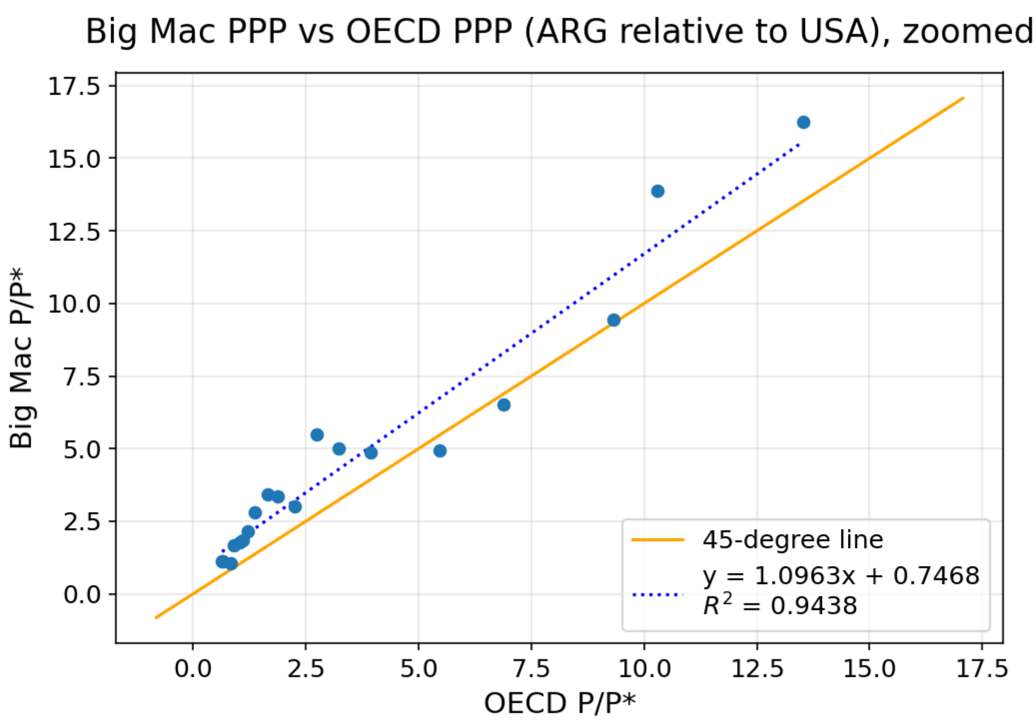


(i) Is the PPP implied by the Big Mac data close to the PPP from the OECD data? Give two reasons for why they are not supposed to perfectly agree.

Solution: The two PPP measures comove closely over time, with a correlation of 99.9%. A scatterplot of the two measures also shows relatively good agreement:



Zooming into smaller values,



Despite their closeness, they are far from identical. One reason is that the Big

Mac PPP measure uses an essentially identical basket of goods in Argentina and the U.S. (the Big Mac), while the GDP-based basket of goods for the OECD PPP measure is quite different for the two countries. In addition, the Big Mac itself has a composition of goods that is quite different from the GDP-based basket of goods of both Argentina and the U.S. The timing of when prices are measured within the year can also lead to noticeable differences, especially for prices in Argentina, which can be quite volatile in certain years.

(j) There are many criticisms of the Big Mac index as a measure of PPP. The Economist itself points out it is not meant to be a precise measure of PPP or currency valuation. On the other hand, there must be some advantages of the Big Mac index. List three advantages of the Big Mac index.

Solution: There are many correct answers. Only three are needed for full credit. We list four examples below, and many other answers would also be acceptable.

- Despite some local differences, the Big Mac is an incredibly uniform product across the world. It is likely much more uniform than any two representative or reference baskets of goods we can construct for two different countries.
- The concept of a Big Mac is much more tangible and easier to grasp than the more abstract concept of a "reference basket of goods" or a "representative basket of goods".
- There are likely many fewer data measurement errors than indices that rely on surveys or that must compile prices for thousands of goods.
- The Big Mac is not only uniform across countries, it is also remarkably uniform across time.

The Economist

Our Big Mac index shows how burger prices differ across borders

Using patty-power parity to think about exchange rates

Last updated on January 29th 2026

Raw index (January 2026)

Base currency: US dollar

Country	Currency	% Under/Over valued
Switzerland	Franc	+48.4
Uruguay	Peso	+43.1
Norway	Krone	+22.8
Sweden	Krona	+18.6
Denmark	Krone	+16.7
Britain	Pound	+15.7
Euro area	Euro	+15.3
Israel	Shekel	+4.0
Poland	Zloty	+2.2
Colombia	Peso	+1.5
Mexico	Peso	+0.8
United States	US$	*BASE*
Costa Rica	Colón	−1.3
Turkey	Lira	−3.5
Singapore	S$	−5.5
Australia	A$	−7.0

Country	Currency	% Under/Over valued
Canada	C$	−9.4
Argentina	Peso	−9.6
Czech Rep.	Koruna	−10.2
Chile	Peso	−11.4
Lebanon	Pound	−12.4
UAE	Dirham	−15.5
Saudi Arabia	Riyal	−17.2
Honduras	Lempira	−17.3
Peru	Sol	−17.8
Hungary	Forint	−18.4
New Zealand	NZ$	−19.3
Bahrain	Dinar	−22.0
Nicaragua	Córdoba	−22.4
Qatar	Riyal	−23.7
Kuwait	Dinar	−25.8
Brazil	Real	−27.3
Guatemala	Quetzal	−29.7
Thailand	Baht	−29.7
Moldova	Leu	−33.2
Venezuela	Bolívar	−33.9
Romania	Leu	−35.0
Oman	Rial	−35.1
Azerbaijan	Manat	−36.2
Pakistan	Rupee	−36.9
South Korea	Won	−38.9
China	Yuan	−40.2
Jordan	Dinar	−42.3

Country	Currency	% Under/Over valued
Malaysia	Ringgit	−44.6
South Africa	Rand	−45.1
Hong Kong	HK$	−47.6
Ukraine	Hryvnia	−47.8
Japan	Yen	−50.5
Vietnam	Dong	−52.7
Philippines	Peso	−53.6
Egypt	Pound	−56.8
Indonesia	Rupiah	−58.9
India	Rupee	−58.9
Taiwan	NT$	−59.6

Example: The British pound is 15.7% overvalued against the US dollar

A Big Mac costs £5.29 in Britain and US$6.12 in the United States. The implied exchange rate is 0.86. The difference between this and the actual exchange rate, 0.75, suggests the British pound is 15.7% overvalued.

About the Big Mac index

The Big Mac index was invented by *The Economist* in 1986 as a lighthearted guide to whether currencies are at their "correct" level. It is based on the theory of purchasing-power parity (PPP), the notion that in the long run exchange rates should move towards the rate that would equalise the prices of an identical basket of goods and services (in this case, a burger) in any two countries.

Burgernomics was never intended as a precise gauge of currency misalignment, merely a tool to make exchange-rate theory more digestible. Yet the Big Mac index has become a global standard, included in several economic textbooks and the subject of dozens of academic studies.

GDP-adjusted index

The GDP-adjusted index addresses the criticism that you would expect average burger prices to be cheaper in poor countries than in rich ones because labour costs are lower. PPP signals where exchange rates should be heading in the long run, as a country like China gets richer, but it says little about today's equilibrium rate. The relationship between prices and GDP per person may be a better guide to the current fair value of a currency.

Methodology note

In July 2022 we updated the Big Mac index to use a McDonald's-provided price for the United States. We also changed our methodology for how we calculate the GDP-adjusted index, the full history of which will now be adjusted whenever the IMF's historical GDP series are updated. The previously published versions of both indices are available in our archive.

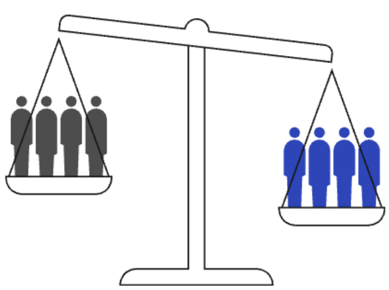
Note: All prices include tax.

Sources: McDonald's; LSEG Workspace; IMF; Eurostat; LebaneseLira.org; Banque du Liban; *The Economist*.

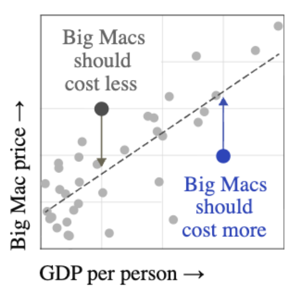
How it works

Raw index | GDP-adjusted

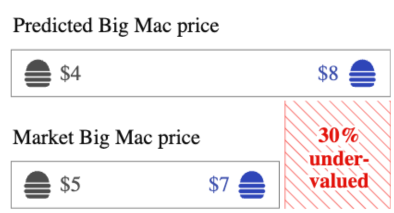
Varying labour costs and barriers to migration and trade may undermine purchasing-power parity



To control for this, our adjusted index predicts what Big Mac prices should be given a country's GDP per person



The difference between the predicted and the market price is an alternative measure of currency valuation

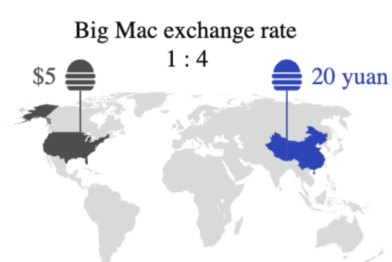


How it works

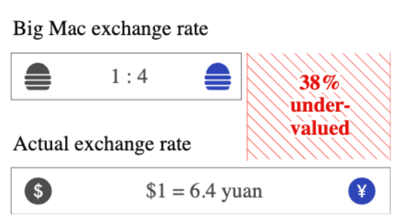
Raw index | GDP-adjusted

Purchasing-power parity implies that exchange rates are determined by the value of goods that currencies can buy

Differences in local prices – in our case, for Big Macs – can suggest what the exchange rate should be



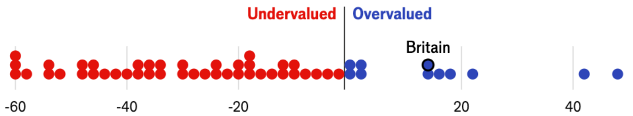
Using burgernomics, we can estimate how much one currency is under- or over-valued relative to another



ADJUST TO ACCOUNT FOR GDP PER PERSON

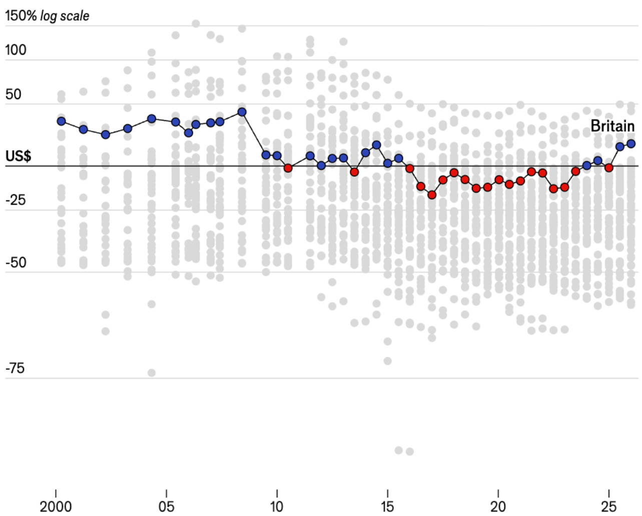
Raw index	GDP-adjusted

Jan 2026 | **The British pound is 15.7% overvalued against the US dollar**



A Big Mac costs **£5.29** in Britain and **US$6.12** in **the United States**. The implied exchange rate is **0.86**. The difference between this and the actual exchange rate, **0.75**, suggests the British pound is **15.7% overvalued**.

2000-2025

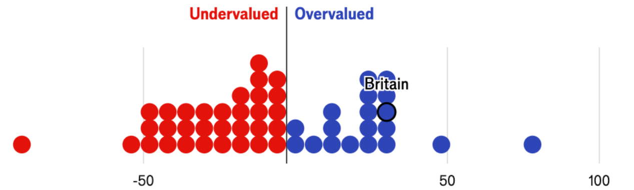


Sources: McDonald's; LSEG Workspace; IMF; Eurostat; LebaneseLira.org; Banque du Liban; *The Economist*

ADJUST TO ACCOUNT FOR GDP PER PERSON

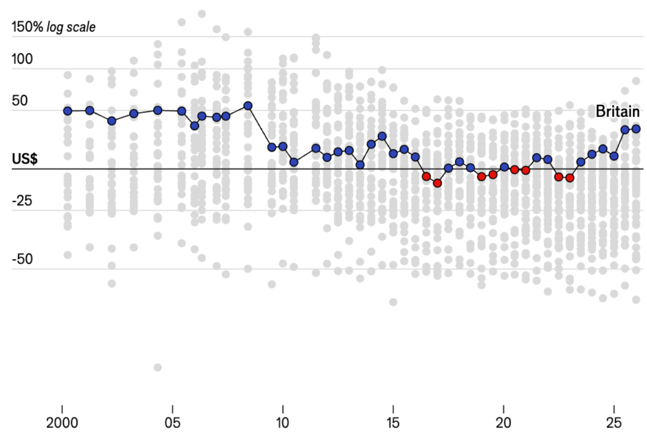
Raw index	GDP-adjusted

Jan 2026 | **The British pound is 31.9% overvalued against the US dollar**



A Big Mac costs **15.7% more** in **Britain** (**US$7.08**) than in **the United States** (**US$6.12**) at market exchange rates. Based on differences in GDP per person, a Big Mac should cost **12.3% less**. This suggests the British pound is **31.9% overvalued**.

2000-2025



Sources: McDonald's; LSEG Workspace; IMF; Eurostat; LebaneseLira.org; Banque du Liban; *The Economist*

ECON 1550	**Problem Set 6 Answer Key**
Spring 2026	
Instructor:	Fernando Duarte
Head TA:	Leo Zucker
Undergraduate TAs:	Eric Kim, Raisa Axenie, Nathalie Peña
Submission:	Canvas or Gradescope

1. **A Conditional Carry Trade**

(a) Consider the price level in the United States at time t, $P_{\text{US},t}$, the price level in Korea at time t, $P_{\text{Korea},t}$, and the U.S. Dollar (USD) per Korean Won (KRW) exchange rate at time t, E_t. Write the equation for relative PPP between the United States and Korea.

> **Solution:** As shown in equation (5-2) in the textbook, relative PPP between the United States and Korea is
>
> $$\frac{E_t - E_{t-1}}{E_{t-1}} = \pi_{\text{US},t} - \pi_{\text{Korea},t}$$
>
> where $\pi_{\text{US},t}$ is U.S. inflation and $\pi_{\text{Korea},t}$ is Korean inflation.

(b) When

$$\frac{P_{\text{US},t}}{P_{\text{Korea},t}} - E_t > 0,$$

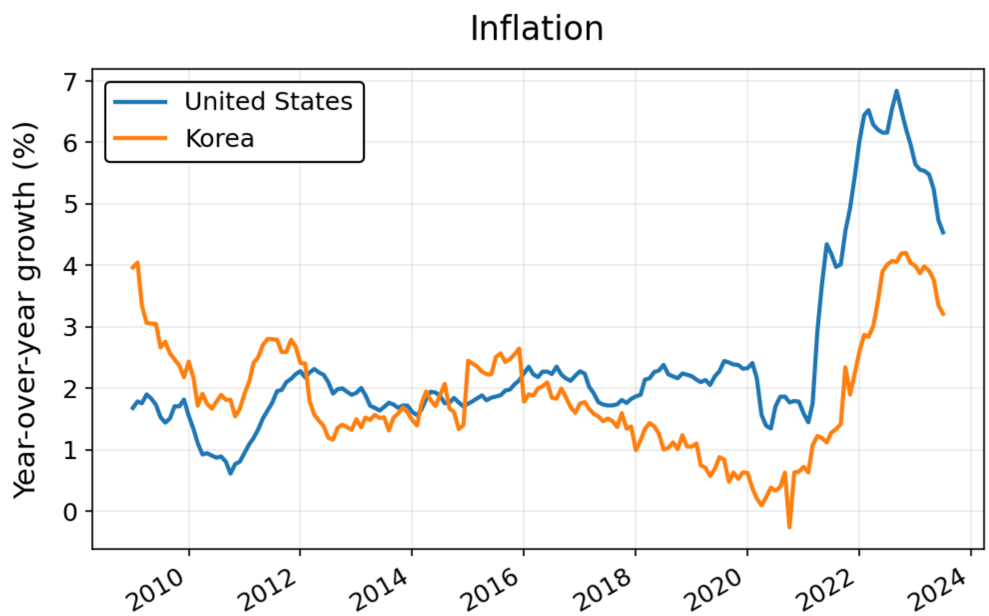
the theory of absolute PPP suggests that USD is overvalued compared to KRW. Write an analogous condition that suggests that USD is overvalued compared to KRW according to *relative* PPP.

> **Solution:** The condition using relative PPP is
>
> $$\pi_{\text{US},t} - \pi_{\text{Korea},t} - \left(\frac{E_t - E_{t-1}}{E_{t-1}}\right) > 0$$

(c) Download the inflation rate for the United States and the inflation rate for Korea from FRED for all months between February 2009 and July 2023 and show both series in a single plot that has time on the horizontal axis and the inflation rates on the vertical axis.

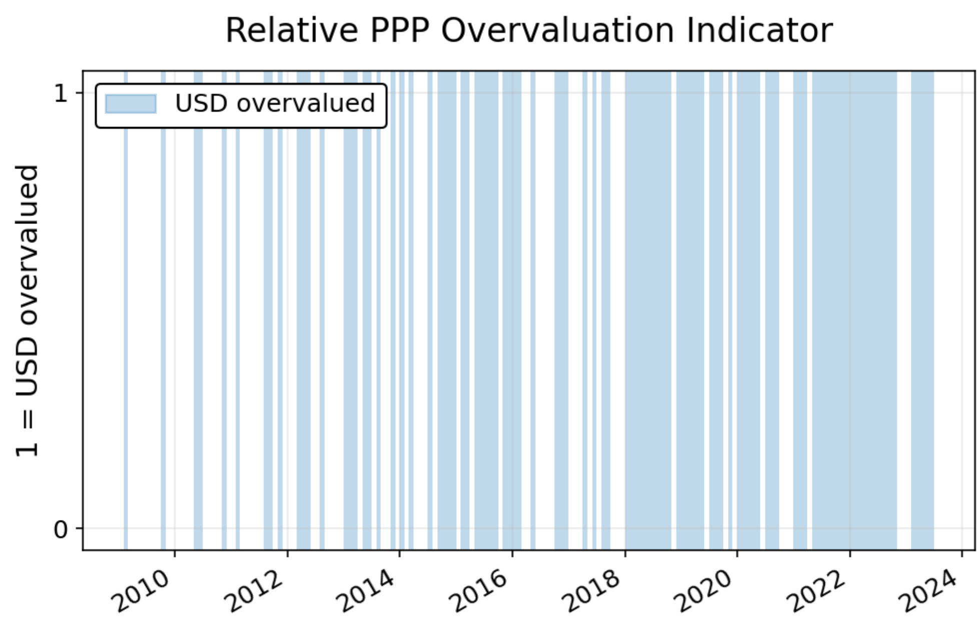
Hint: The links should already display the correct dates, but double check and adjust them if needed. Likewise, the link should already show the consumer price index in units of "Growth rate same period previous year", but make sure it is the case before downloading.

Solution: The plot with both inflation rates is:



(d) Combine the data from (c) with the carry trade data you constructed in Problem Set 3, question 2, part (c), and compute the relative PPP overvaluation condition from part (b). Now construct an indicator variable that is equal to 1 when the overvaluation condition is true, and equal to zero otherwise. Plot this indicator variable with time on the horizontal axis and the indicator on the vertical axis.

Solution: The plot for the indicator variable is:

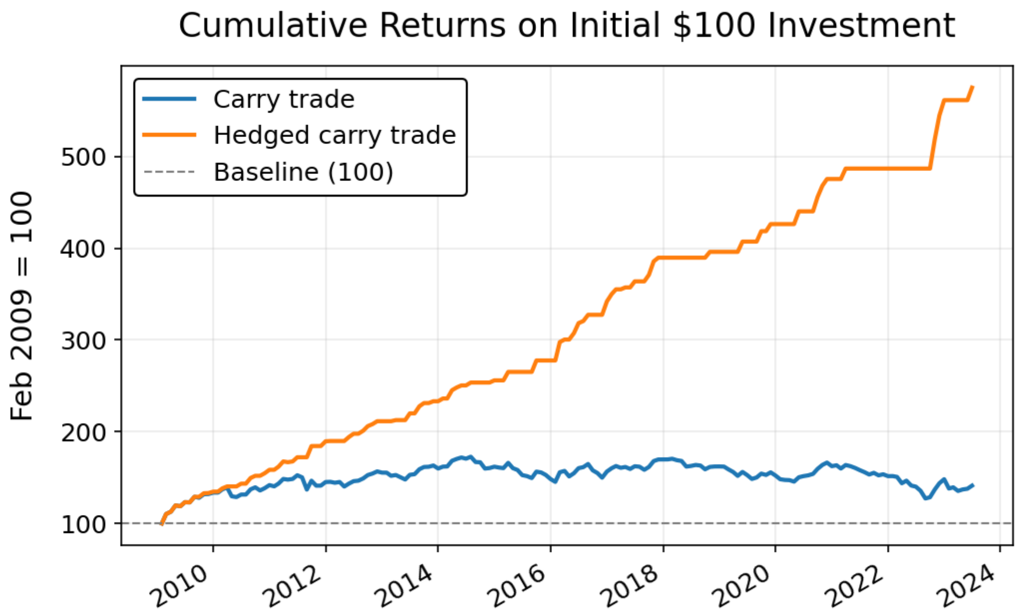


The *hedged carry trade* is a trading strategy where, for each month, you check if the relative PPP overvaluation condition you constructed in (d) signals an overvalued USD. If the signal is for an overvalued USD, invest nothing for that month and earn a monthly return of zero. If the signal is not for an overvalued USD, invest in the standard carry trade and earn the same monthly return that you computed in Problem Set 3, question 2c.

(e) Show the cumulative returns for the hedged carry trade and the standard carry trade together in one plot, with time on the horizontal axis and the cumulative returns on the vertical axis.

By the end of the sample, which strategy has higher cumulative returns? Is the difference in cumulative returns between the two strategies evidence in favor or against the idea that relative PPP holds in the long run?

Solution: The plot with cumulative returns for both strategies is:



By the end of the sample, the hedged carry trade has cumulative returns that are more than eleven times larger than the standard carry trade. This difference does provide some support to the idea that PPP holds in the long run. When relative PPP signals an overvalued dollar, the standard carry tends to have negative returns over the long run. The hedged carry trade has zero returns on those months. Since the standard carry trade borrows in dollars, the negative returns following the overvaluation signal suggest that the dollar depreciates in those periods, at least on average over our relatively long sample.

On the other hand, it could be possible that the negative returns are not due to a depreciation of the dollar but due to a reduction in the dollar-won interest rate differential. Whether the reduction in interest rate differential is evidence in favor or against relative PPP depends on how interest rates interact with inflation.

A spreadsheet with the data, calculations, and plots can be downloaded here.

2. **Long-Run Theories of the Exchange Rate Determination**

Consider the model of the long run given by:

$(PPP):$	$E = P/P^*$
$(MS = MD):$	$M^s/P = \mathrm{L}(R, Y)$
$(MS^* = MD^*):$	$M^{s*}/P^* = \mathrm{L}(R^*, Y^*)$

In class, we referred to this model as "Model 1".

(a) Explain the name of the equations PPP, $MS = MD$, and $MS^* = MD^*$.

> **Solution:** PPP means purchasing power parity. $MS = MD$ and $MS^* = MD^*$ mean (real) money supply equal to (real) money demand in the domestic and foreign countries, respectively.

(b) Identify the exogenous and endogenous variables.

Hint: Consult these slides if you need a reminder.

> **Solution:** The exogenous variables are: $R, Y, M^s, R^*, Y^*, M^{s*}$. The endogenous variables are: E, P, P^*.

(c) Assume that the function $\mathrm{L}(\cdot, \cdot)$ is given by $\mathrm{L}(R, Y) = Y/R$ and $\mathrm{L}(R^*, Y^*) = Y^*/R^*$. Solve for the endogenous variables as a function of the exogenous variables.

> **Solution:** Solve for P and P^* in the domestic and foreign money market equations to get: $P = M^s R/Y$ $P^* = M^{s*}R^*/Y^*$. Plugging into the PPP equation we get
>
> $$E = \frac{\frac{M^s R}{Y}}{\frac{M^{s*}R^*}{Y^*}} = \frac{M^s}{M^{s*}}\frac{R}{R^*}\frac{Y^*}{Y}$$

(d) Consider a one-time permanent increase in M^s. Explain how all endogenous variables respond immediately when the change in M^s occurs and in the long run.

> **Solution:** After a one-time permanent increase in M^s, P goes up, P^* remains unchanged and E goes up (there is a nominal depreciation). The changes in the short run and long run are identical, that is, immediately after the change in M^s we have a one-time permanent increase in P and E.

To the above monetary model, we add the following equations:

Relative output demand:	$Y/Y^* = q$
Relative output supply:	$Y/Y^* = \bar{Y}$
Definition of real exchange rate:	$q \equiv EP^*/P$

The exogenous variables are the same as before and, in addition, $\bar{Y}$. Assume $\bar{Y} = 1$. The endogenous variables are the same as before and, in addition, q and Y/Y^*.

The first equation, labeled Relative output demand, is a behavioral equation that captures the idea that if domestic goods become cheaper relative to foreign goods (q goes up, a real depreciation), then demand for domestic goods will increase relative to demand for foreign goods (the "relative output demand" Y/Y^* goes up).

The second equation, labeled Relative output supply, says that the relative supply of domestic and foreign goods, Y/Y^*, is equal to an exogenous variable $\bar{Y}$.

The third equation is the definition of the real exchange rate q.

In equilibrium, relative output supply must equal relative output demand.

(e) Consider a one-time permanent increase in M^s. Explain how all endogenous variables respond to the change in M^s in the short run (immediately after the change in M^s) and in the long run.

Hint: If you need help understanding the model, Section 5.6 of Chapter 5 of the textbook has a longer discussion.

Solution: From (d), we know that P^* remains unchanged. We also found that P and E increase permanently in the short run and remain at their new levels in the long run.
In equilibrium, relative output demand equals relative output supply and hence $Y/Y^* = q = \bar{Y}$. Because PPP is imposed in Model 1, $q = EP^*/P = 1$; therefore equilibrium in the added block requires $\bar{Y} = 1$ in levels. The key comparative-static result is that Y/Y^* and the real exchange rate q remain unchanged after the increase in M^s.

ECON 1550 Problem Set 7 Answer Key

Spring 2026

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Submission:	Canvas or Gradescope

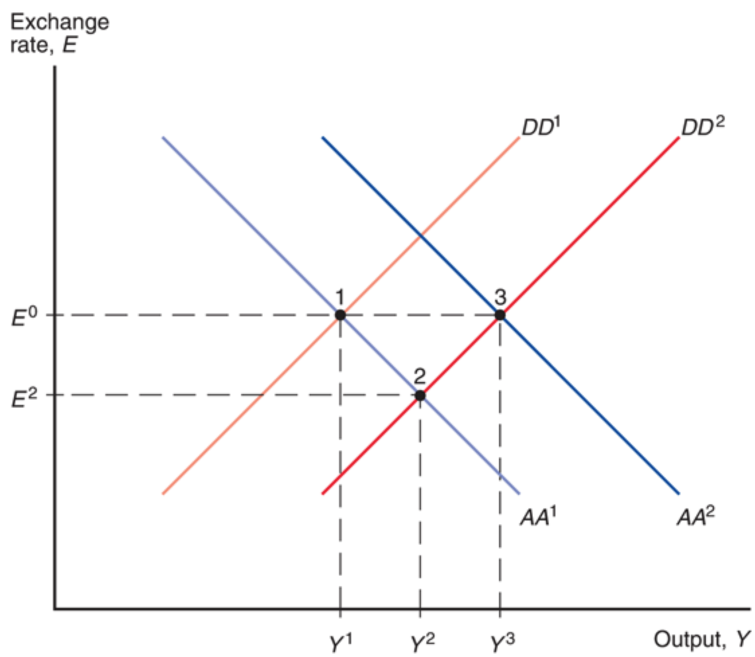
1. **Chapter 6: Output and the Exchange Rate in the Short Run**

The following questions analyze fiscal and monetary policy using the AA-DD model.

(a) If a government initially has a balanced budget but then cuts taxes, it is running a deficit. Suppose the government finances its deficit by printing the extra money it now needs to cover its expenditures, that is, by increasing the money supply enough to finance the deficit. Assume that the tax cuts and the increase in the money supply are both temporary and occur at the same time. According to the AA-DD model, how does the nominal exchange rate respond to this simultaneous change in taxes and money supply in the short run?

Solution: A temporary tax cut raises disposable income and consumption, so the DD curve shifts to the right. A temporary increase in the money supply shifts the AA curve to the right. Because both policies are expansionary, output rises unambiguously.

The initial equilibrium is point 1. The tax cut alone shifts the DD curve from DD^1 to DD^2, with the equilibrium moving from point 1 to point 2. Adding the temporary monetary expansion shifts the AA curve from AA^1 to AA^2, moving the equilibrium from point 2 to point 3.



In the figure, the shifts in AA and DD are such that the exchange rate at point 1 is the same as the exchange rate at point 3. In general, however, the effect on the exchange rate is ambiguous. If the DD shift is relatively large, the new equilibrium can have a lower exchange rate than E^0. If the AA shift is relatively large, the new equilibrium can have a higher exchange rate than E^0.
Summing up, the combined temporary tax cut and temporary monetary expansion raise output, while the effect on the exchange rate is ambiguous.

(b) A new government is elected and announces that once it is inaugurated, it will permanently increase the money supply. Use the AA-DD model to study the economy's response at the moment the announcement is made. Do not analyze what happens later, when the new government is inaugurated and the policy is implemented.

Solution: The expansionary money supply announcement causes a depreciation in the expected exchange rate and shifts the AA curve to the right. This leads to an immediate increase in output and an immediate currency depreciation. The effects of the anticipated policy action thus precede the policy's actual implementation.

During the last few years, and especially after the COVID-19 pandemic, there have been many calls to "buy American". Imagine the government implements a "buy American" program in which any new government spending is constrained to only purchase domestic goods. Use the AA-DD model to answer the following questions:

(c) Does a *permanent* increase in U.S. government spending constrained by "buy American" restrictions have a bigger effect on U.S. output than unconstrained U.S. government spending? Why or why not? Make sure you consider both the short and long run effects on output.

Solution: A "buy American" provision results in a larger permanent rightward shift in the DD curve than an unconstrained increase in government spending because there is a greater demand for U.S. goods than if some imported goods are purchased with the stimulus funds.

In both cases, the short-run expected exchange rate declines, shifting the AA curve down so that it intersects the DD curve at the point where output equals its full-employment level, that is, $Y = Y^f$. Since the short-run equilibrium has $Y = Y^f$, the AA and DD curves do not shift after the short run, so the long-run equilibrium coincides with the short-run equilibrium.

We conclude that the buy American provision and the unconstrained government spending case result in the same $Y = Y^f$ level of output in the short run and in the long run.

Because the buy American provision shifts the DD more than the unconstrained spending, the shift in the AA required to have $Y = Y^f$ is also larger for the buy American provision, and the currency appreciates more.

Additional information (not part of the answer): Because the buy American provision shifts the DD curve farther to the right than unconstrained government spending, keeping equilibrium at $Y = Y^f$ requires a larger downward shift in the AA curve. As a result, the domestic currency appreciates more under the buy American provision than under unconstrained government spending.

(d) Now assume the government spending is temporary. Do "buy American" restrictions have a bigger effect on U.S. output than unconstrained U.S. government spending? Why or why not? Make sure you consider both the short and long run effects on output.

Solution: When spending is temporary, a "buy American" provision has a larger effect on output in the short run, since the AA curve does not shift because

exchange rate expectations remain unchanged.
In the long run, the economy returns to $Y = Y^f$ in both cases, making the long-run effect on output the same with and without "buy American" provisions.

2. **Import Tariffs in the AA-DD Model**

Use the standard AA-DD model from class and from the textbook, with the following functional forms:

$$C(Y-T) = \frac{1}{2}(Y-T),$$
$$EX(q, Y^*) = \frac{1}{4} + \frac{1}{10}q + \frac{1}{10}(Y^*-1),$$
$$IM(q, Y-T) = \frac{5+2(Y-T)}{20} - \frac{1}{10}q,$$
$$L(R, Y) = \frac{Y}{1+R}.$$

Throughout this question, use

$$T = 0, \quad I = \frac{1}{5}, \quad G = \frac{1}{5}, \quad M^s = 1, \quad P^* = 1, \quad R^* = 0, \quad Y^* = 1.$$

It will also be useful to write imports as

$$IM(q, Y-T) = qV(q, Y-T),$$

where
$$V(q, Y-T) = \frac{5+2(Y-T)}{20q} - \frac{1}{10}$$
is the volume of imports measured in units of foreign goods.

(a) Explain the price effect and the volume effect of an increase in q on imports. Then, using the functional forms and values given above, verify that the volume effect dominates.

Solution: Write imports as

$$IM(q, Y-T) = qV(q, Y-T).$$

The price effect is that when q rises, each imported unit costs more in terms of domestic goods, which tends to raise IM for a given import volume. The volume effect is that when q rises, domestic residents buy fewer imported units, which tends to lower IM.

In this model,

$$V(q, Y-T) = \frac{5+2(Y-T)}{20q} - \frac{1}{10}.$$

Holding $Y-T$ fixed, a rise in q lowers the term $\frac{5+2(Y-T)}{20q}$, so import volume is decreasing in q.

Imports (expressed in units of domestic goods) are:

$$IM(q, Y-T) = q\left(\frac{5+2(Y-T)}{20q} - \frac{1}{10}\right) = \frac{5+2(Y-T)}{20} - \frac{q}{10}.$$

Since IM is decreasing in q, the fall in import volume more than offsets the higher price per imported unit. In this model, the volume effect dominates the price effect.

(b) Derive the DD curve explicitly. Explain what points on the DD curve represent. In a graph with E on the vertical axis and Y on the horizontal axis, is the DD curve increasing or decreasing? Give intuition.

Solution: From part (a),

$$IM = \frac{5+2Y}{20} - \frac{q}{10} = \frac{1}{4} + \frac{Y}{10} - \frac{q}{10},$$

because $T = 0$, so $Y - T = Y$.

Exports are

$$EX = \frac{1}{4} + \frac{q}{10},$$

because $Y^* = 1$.

So the current account is

$$CA = EX - IM = \left(\frac{1}{4} + \frac{q}{10}\right) - \left(\frac{1}{4} + \frac{Y}{10} - \frac{q}{10}\right) = \frac{q}{5} - \frac{Y}{10}.$$

Aggregate demand for domestic goods is

$$D = C + I + G + CA = \frac{1}{2}Y + \frac{1}{5} + \frac{1}{5} + \frac{q}{5} - \frac{Y}{10} = \frac{2}{5}Y + \frac{2}{5} + \frac{q}{5}.$$

Goods-market equilibrium requires $Y = D$, so

$$Y = \frac{2}{5}Y + \frac{2}{5} + \frac{q}{5}.$$

Re-arranging,

$$\frac{3}{5}Y = \frac{2}{5} + \frac{q}{5},$$

so

$$q = 3Y - 2.$$

Because $q = EP^*/P$ and $P^* = 1$, the DD curve is

$$E = P(3Y - 2).$$

Points on the DD curve are pairs (E, Y) that are consistent with equilibrium in the market for domestic goods.
In this version of the model, DD is a straight line. Its slope is $3P$, and its vertical intercept is $-2P$.
The DD curve is increasing. A higher level of output raises disposable income, consumption, and imports. To keep the market for domestic goods in equilibrium, the real exchange rate must depreciate (higher q) so that exports rise and imports fall enough to offset the increase in domestic absorption. With P and P^* fixed, a higher q requires a higher nominal exchange rate E.

(c) Repeat part (b) for the AA curve.

Solution: The money market is

$$\frac{1}{P} = \frac{Y}{1 + R},$$

because $M^s = 1$.
So

$$1 + R = PY,$$

and therefore

$$R = PY - 1.$$

Uncovered interest parity is

$$R = \frac{E^e}{E} - 1,$$

because $R^* = 0$.

Substitute the money-market expression for R into uncovered interest parity:

$$PY - 1 = \frac{E^e}{E} - 1.$$

So

$$PY = \frac{E^e}{E},$$

which implies

$$E = \frac{E^e}{PY}.$$

This is the AA curve.

Points on the AA curve are pairs (E, Y) that are consistent with asset-market equilibrium, meaning equilibrium in the money market together with equilibrium in the foreign-exchange market.

The AA curve is decreasing. If Y rises, people want to hold more money. With the money supply fixed, the interest rate must rise to make people willing to hold the available money. A higher domestic interest rate makes domestic bonds more attractive. For uncovered interest parity to continue to hold, the domestic currency must be more appreciated today, which means a lower E.

For the remaining parts of the question, add a Phillips curve:

$$\pi = \pi^e + \alpha(Y - Y^f),$$

where π is inflation, π^e is expected inflation, α is the slope, and Y^f is full-employment output. Set $\pi^e = 0$, $\alpha = 1$, and $Y^f = 1$.

(d) Solve for the initial long-run equilibrium.

Solution: With the given parameter values, the Phillips curve becomes

$$\pi = Y - 1.$$

In the long run, output equals full-employment output:

$$Y_0 = Y^f = 1.$$

So inflation is

$$\pi_0 = Y_0 - 1 = 0.$$

In the long run, expected and actual exchange rates are equal:

$$E_0^e = E_0.$$

Uncovered interest parity then gives

$$R_0 = R_0^* + \frac{E_0^e}{E_0} - 1 = 0 + 1 - 1 = 0.$$

The money market gives

$$\frac{1}{P_0} = \frac{Y_0}{1 + R_0} = \frac{1}{1},$$

so

$$P_0 = 1.$$

The DD relation from part (b) is

$$q = 3Y - 2.$$

At $Y_0 = 1$,

$$q_0 = 1.$$

Since $q_0 = E_0/P_0$ and $P_0 = 1$,

$$E_0 = 1.$$

Therefore

$$E_0^e = 1.$$

The remaining endogenous variables are

$$Y_0 - T = 1, \quad C_0 = \frac{1}{2}, \quad EX_0 = \frac{7}{20},$$

$$IM_0 = \frac{1}{4}, \quad CA_0 = \frac{1}{10}, \quad D_0 = 1.$$

So the initial long-run equilibrium is

$$Y_0 = 1, \quad E_0 = 1, \quad q_0 = 1, \quad R_0 = 0, \quad P_0 = 1, \quad \pi_0 = 0.$$

Now add an exogenous *ad valorem* (proportional) import tariff τ. The tariff raises the domestic-currency price of imported goods from q to $(1+\tau)q$ in the volume of imports:

$$IM(q, \tau, Y - T) = qV((1+\tau)q, Y - T).$$

Treat tariff revenue as negligible so that T and G remain unchanged.

(e) Keeping the real exchange rate, output, and taxes fixed, does a higher tariff lead to a higher or a lower current account? Explain why.

Solution: With the tariff,

$$V((1+\tau)q, Y) = \frac{5 + 2Y}{20(1+\tau)q} - \frac{1}{10},$$

because $T = 0$, so $Y - T = Y$.

Imports are therefore

$$IM(q, \tau, Y) = qV((1+\tau)q, Y) = q\left(\frac{5 + 2Y}{20(1+\tau)q} - \frac{1}{10}\right) = \frac{5 + 2Y}{20(1+\tau)} - \frac{q}{10}.$$

So the current account is

$$CA(q, \tau, Y) = \left(\frac{1}{4} + \frac{q}{10}\right) - \left(\frac{5 + 2Y}{20(1+\tau)} - \frac{q}{10}\right).$$

Holding q and Y fixed, a higher tariff makes the term $\frac{5+2Y}{20(1+\tau)}$ smaller. So imports fall and the current account rises.

The intuition is simple. At a fixed real exchange rate and a fixed level of output, the tariff makes imported goods more expensive for domestic buyers. Domestic residents therefore buy fewer imports, and that improves the current account.

(f) Find the DD curve when the tariff is present. How do tariffs change the DD curve? Comment on both the slope and the intercept. Give intuition.

Solution: From part (e),

$$IM = \frac{5 + 2Y}{20(1+\tau)} - \frac{q}{10}.$$

Exports are unchanged by the home import tariff:

$$EX = \frac{1}{4} + \frac{q}{10}.$$

So the current account is

$$CA = EX - IM = \frac{1}{4} - \frac{1}{4(1+\tau)} + \frac{q}{5} - \frac{Y}{10(1+\tau)}.$$

Aggregate demand for domestic goods is

$$D = \frac{1}{2}Y + \frac{1}{5} + \frac{1}{5} + \frac{1}{4} - \frac{1}{4(1+\tau)} + \frac{q}{5} - \frac{Y}{10(1+\tau)}.$$

So

$$D = \frac{1}{2}Y + \frac{13}{20} - \frac{1}{4(1+\tau)} + \frac{q}{5} - \frac{Y}{10(1+\tau)}.$$

Set $Y = D$:

$$Y = \frac{1}{2}Y + \frac{13}{20} - \frac{1}{4(1+\tau)} + \frac{q}{5} - \frac{Y}{10(1+\tau)}.$$

Move the Y-terms to the left:

$$\left(\frac{1}{2} + \frac{1}{10(1+\tau)}\right)Y = \frac{13}{20} - \frac{1}{4(1+\tau)} + \frac{q}{5}.$$

So

$$\frac{6+5\tau}{10(1+\tau)}Y = \frac{8+13\tau}{20(1+\tau)} + \frac{q}{5}.$$

Solving for q,

$$q = \frac{(12+10\tau)Y - 8 - 13\tau}{4(1+\tau)}.$$

Because $q = EP^*/P$ and $P^* = 1$, the DD curve with tariffs is

$$E = P\left[\frac{12+10\tau}{4(1+\tau)}Y - \frac{8+13\tau}{4(1+\tau)}\right].$$

This is again a straight line. Its slope is

$$m_{DD}(\tau) = P\frac{12+10\tau}{4(1+\tau)} = P\frac{6+5\tau}{2(1+\tau)},$$

and its vertical intercept is

$$b_{DD}(\tau) = -P\frac{8+13\tau}{4(1+\tau)}.$$

Without tariffs, the slope is $3P$ and the intercept is $-2P$. With a positive tariff, the slope is smaller because

$$\frac{6+5\tau}{2(1+\tau)} < 3,$$

and the intercept is lower because

$$\frac{8+13\tau}{4(1+\tau)} > 2.$$

So in an E-against-Y graph, the tariff DD curve is flatter and lies below the no-tariff DD curve. That is the same as saying DD shifts to the right.

If you solve instead for Y as a function of E, you get

$$Y = \frac{2(1+\tau)}{P(6+5\tau)}E + \frac{8+13\tau}{2(6+5\tau)}.$$

Both the slope and the intercept in that version are higher than in the no-tariff case, which makes the rightward shift especially easy to see.

The intuition is that the tariff already reduces imports. Because domestic demand is redirected away from foreign goods and toward domestic goods, the economy needs less depreciation to keep the market for domestic goods in equilibrium.

(g) Find the AA curve. How do tariffs change the AA curve? Give intuition.

Hint: The AA curve is not a straight line, so you don't need to talk about its slope and intercept. A qualitative explanation, or a sketch of the AA curve before and after the tariff is imposed, is enough.

Solution: The tariff does not enter the money market or uncovered interest parity. So the AA curve is the same as before:

$$E = \frac{E^e}{PY}.$$

AA is not a straight line. So it does not have one constant slope or a finite vertical intercept.

If a tariff change leaves E^e unchanged, then AA is unchanged. That means the curve keeps exactly the same shape.

This is what happens for a temporary tariff increase. In that case, the long-run exchange rate is unchanged, so E^e is unchanged, and the whole AA curve stays where it was.

A permanent tariff increase is different. It changes the long-run exchange rate, so it changes E^e. Here the permanent tariff lowers the long-run exchange rate. So every point on

$$E = \frac{E^e}{PY}$$

is multiplied by a smaller number. The whole AA curve shifts down, but its downward shape is unchanged.

The intuition is that the AA curve comes from equilibrium in asset markets. Current tariffs work through the goods market, not directly through money demand or interest parity. AA moves only if the tariff changes the expected future exchange rate.

(h) Consider a temporary increase in the tariff from 0 to $1/3$ in the short run, and a return to zero tariffs $\tau = 0$ immediately after and in the long run. Sketch in an AA-DD diagram the initial equilibrium, the short-run equilibrium, the long-run equilibrium, and the transition from the short run back to the long run. A qualitatively correct sketch is enough. Explain in words how and why the curves shift, or do not shift, at each point in time.

Solution: Since the shock is transitory, the long-run equilibrium after the temporary tariff shock is the initial long-run equilibrium:

$$Y_{LR} = 1, \quad E_{LR} = 1, \quad q_{LR} = 1, \quad P_{LR} = 1.$$

So on impact,

$$E^e_{SR} = E_{LR} = 1.$$

The short-run price level is fixed at the initial value:

$$P_{SR} = P_0 = 1.$$

On impact, AA is unchanged because the shock is temporary and E^e is unchanged:

$$AA_{SR}: \quad E = \frac{1}{Y}.$$

The DD curve shifts to the right. With $\tau = 1/3$ and $P = 1$, the tariff DD curve is

$$DD_{SR}: \quad E = \frac{46Y - 37}{16}.$$

The short-run equilibrium solves

$$\frac{46Y_{SR} - 37}{16} = \frac{1}{Y_{SR}},$$

so

$$46Y_{SR}^2 - 37Y_{SR} - 16 = 0.$$

The positive solution is

$$Y_{SR} = 1.116.$$

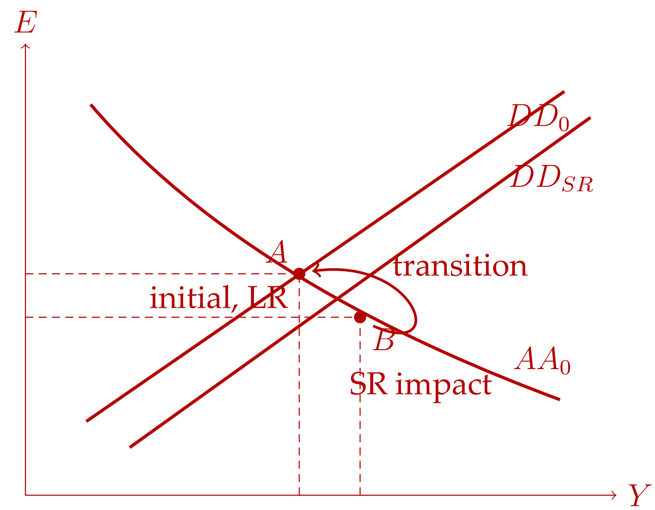
Therefore

$$E_{SR} = \frac{1}{Y_{SR}} = 0.896, \quad q_{SR} = \frac{E_{SR}}{P_{SR}} = 0.896.$$

So on impact the economy moves from the initial point A to the short-run point B, with higher Y and lower E. The tariff shifts spending toward domestic goods. That raises output and the exchange rate appreciates.
Because $Y_{SR} > Y^f = 1$, short-run inflation is positive:

$$\pi_{SR} = Y_{SR} - 1 = 0.116.$$

Immediately after the impact, the tariff returns to zero. So the economy begins to transition back toward the original long-run equilibrium. Because this temporary tariff affects the economy only at the impact instant, the short-run shift in the DD immediately reverses after the short run. The equilibrium at all times after the short run is the same as the initial long-run equilibrium. A qualitatively correct sketch therefore shows the original equilibrium A, the short-run impact point B, and a return from B back to A.



(i) Plot the time paths of E, q, Y, P, π, CA, EX, and IM for the temporary tariff increase. A qualitatively correct path is enough.

Solution: At the initial long-run equilibrium,

$$E_0 = 1, \quad q_0 = 1, \quad Y_0 = 1, \quad P_0 = 1,$$
$$\pi_0 = 0, \quad CA_0 = \frac{1}{10}, \quad EX_0 = \frac{7}{20}, \quad IM_0 = \frac{1}{4}.$$

At the short-run equilibrium from part (h),

$$Y_{SR} = 1.116, \quad E_{SR} = 0.896, \quad q_{SR} = 0.896, \quad P_{SR} = 1, \quad \pi_{SR} = 0.116.$$

The external variables at SR are

$$EX_{SR} = \frac{1}{4} + \frac{1}{10} q_{SR} = 0.340,$$

$$IM_{SR} = \frac{5 + 2Y_{SR}}{20(1 + 1/3)} - \frac{q_{SR}}{10} = 0.182,$$
$$CA_{SR} = EX_{SR} - IM_{SR} = 0.158.$$

In the long run, the temporary tariff is gone and the economy returns to the initial long-run equilibrium:

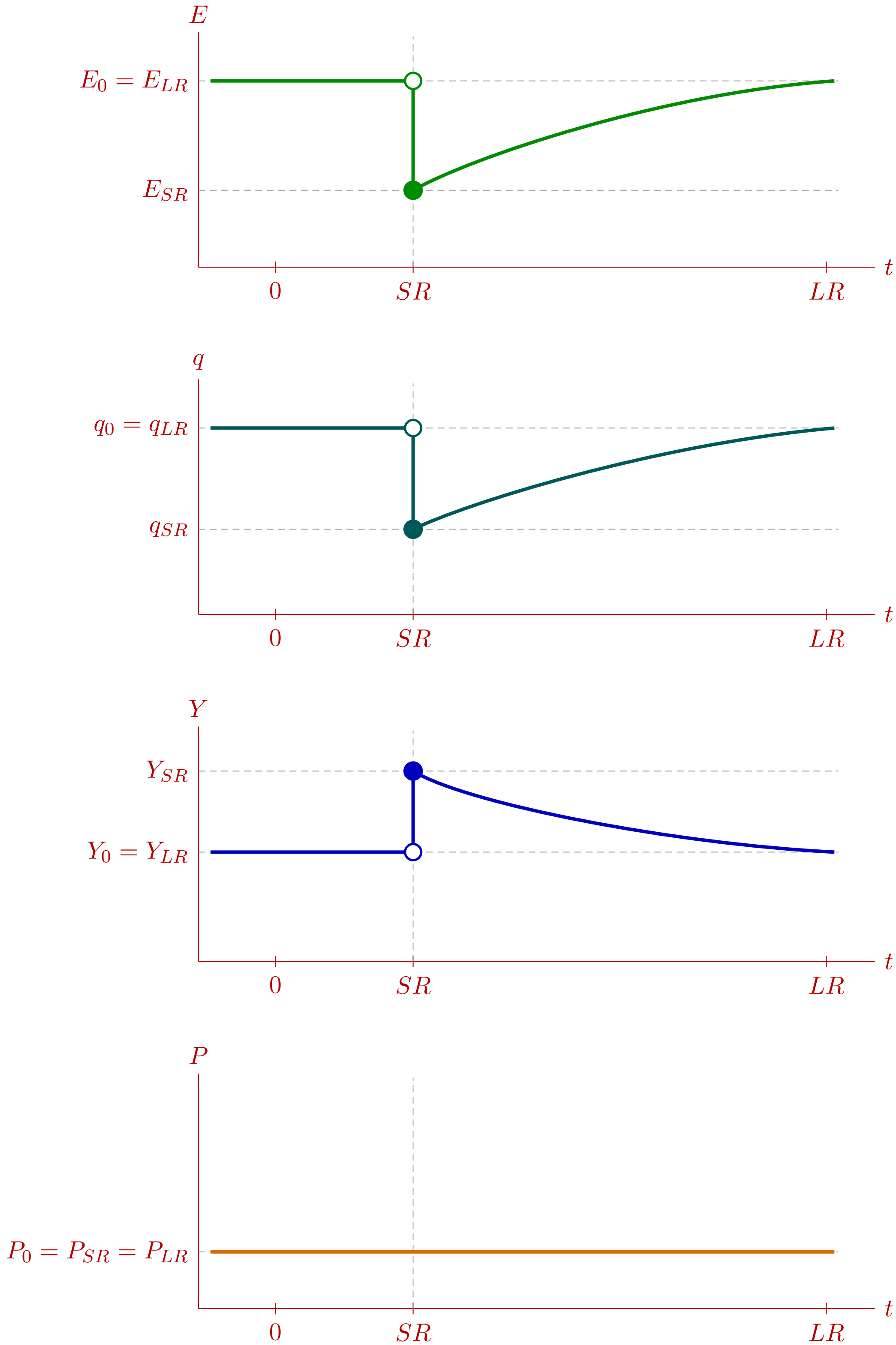
$$E_{LR} = 1, \quad q_{LR} = 1, \quad Y_{LR} = 1, \quad P_{LR} = 1,$$
$$\pi_{LR} = 0, \quad CA_{LR} = \frac{1}{10}, \quad EX_{LR} = \frac{7}{20}, \quad IM_{LR} = \frac{1}{4}.$$

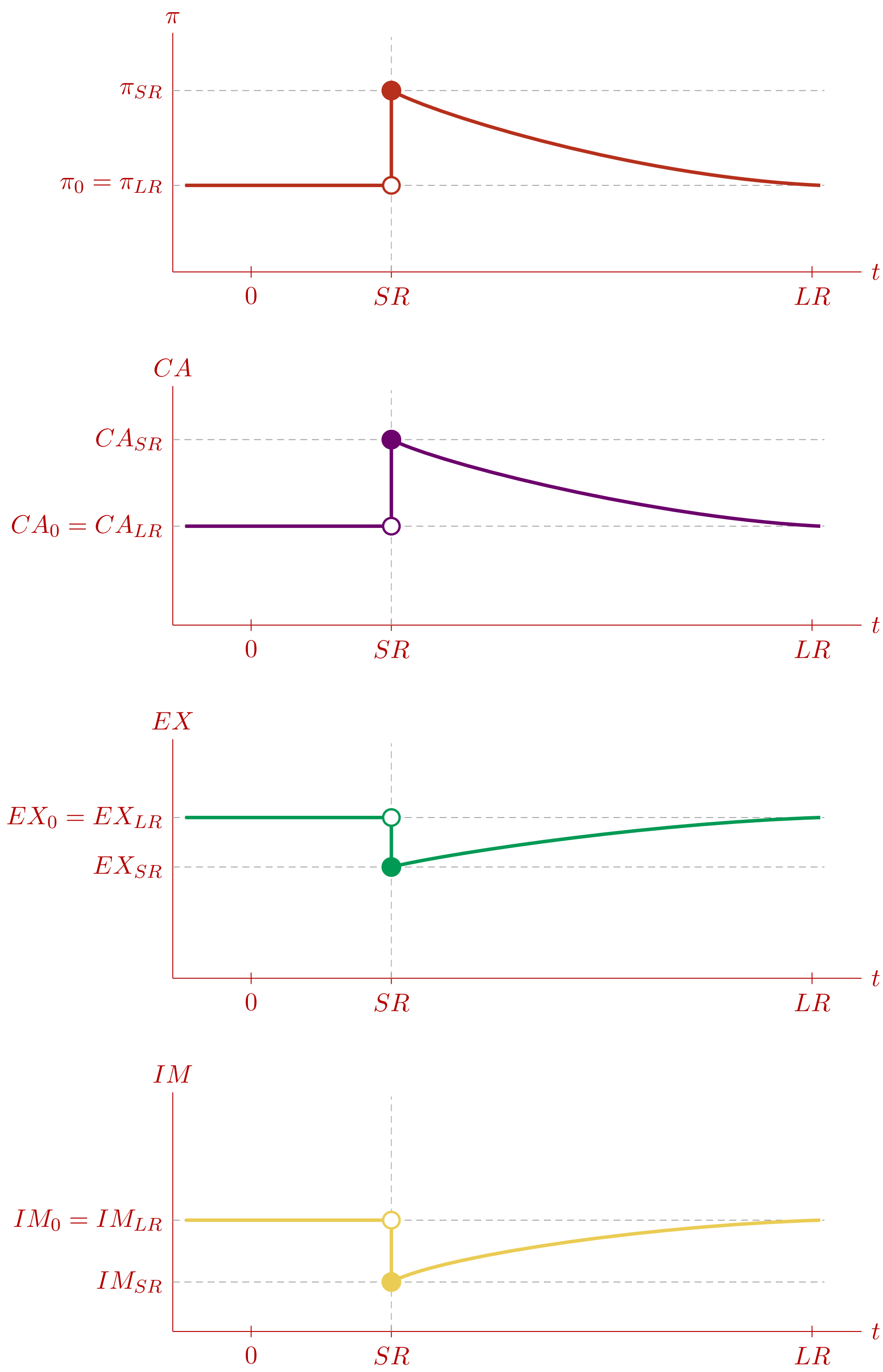
A convenient summary table for the values at 0, SR, and LR is

Variable	0	SR	LR
E	1.000	0.896	1.000
q	1.000	0.896	1.000
Y	1.000	1.116	1.000
P	1.000	1.000	1.000
π	0.000	0.116	0.000
CA	0.100	0.158	0.100
EX	0.350	0.340	0.350
IM	0.250	0.182	0.250

Because the temporary tariff is treated as a short-run impact only, each variable jumps to its impact value at SR and then jumps back to the initial equilibrium's value immediately after. So E and q jump down and then rise back, Y jumps up and then falls back, P is unchanged at the impact instant and stays at its original level, π jumps up and then falls back to zero, CA jumps up and then falls back, and both EX and IM jump down and then rise back to their original values.

One set of qualitatively correct paths is shown below.


E
$E_0 = E_{LR}$
E_{SR}
t
0
SR
LR
q
$q_0 = q_{LR}$
q_{SR}
t
0
SR
LR
Y
Y_{SR}
$Y_0 = Y_{LR}$
t
0
SR
LR
P
$P_0 = P_{SR} = P_{LR}$
t
0
SR
LR



(j) Repeat part (h) for a permanent increase in the tariff that changes it from 0 to $1/3$ in the short run, the long run, and the transition between the short run and the long run.

Solution: Now the tariff stays at $1/3$ in both the short run and the long run:

$$\tau_{SR} = \tau_{LR} = \frac{1}{3}.$$

In the long run, output is still at full employment:

$$Y_{LR} = 1.$$

The money supply, foreign interest rate, and full-employment output are unchanged, so the long-run money market still gives

$$P_{LR} = 1, \quad R_{LR} = 0.$$

Use the tariff DD relation from part (f):

$$q = \frac{(12 + 10\tau)Y - 8 - 13\tau}{4(1 + \tau)}.$$

At $Y = 1$ and $\tau = 1/3$,

$$q_{LR} = \frac{46 - 37}{16} = \frac{9}{16}.$$

Since $P_{LR} = 1$, the long-run exchange rate is

$$E_{LR} = q_{LR} = \frac{9}{16}.$$

So on impact,

$$E^e_{SR} = E_{LR} = \frac{9}{16}.$$

The short-run price level is still fixed at

$$P_{SR} = P_0 = 1.$$

With $\tau = 1/3$, the DD curve on impact is

$$DD_{SR}: \quad E = \frac{46Y - 37}{16}.$$

The AA curve on impact is

$$AA_{SR}: \quad E = \frac{9}{16Y}.$$

Solve for the short-run equilibrium:

$$\frac{46Y_{SR} - 37}{16} = \frac{9}{16Y_{SR}}.$$

So

$$46Y_{SR}^2 - 37Y_{SR} - 9 = 0.$$

This factors as

$$(Y_{SR} - 1)(46Y_{SR} + 9) = 0.$$

The positive solution is

$$Y_{SR} = 1.$$

Therefore

$$E_{SR} = \frac{9}{16}, \quad q_{SR} = \frac{9}{16}, \quad R_{SR} = 0.$$

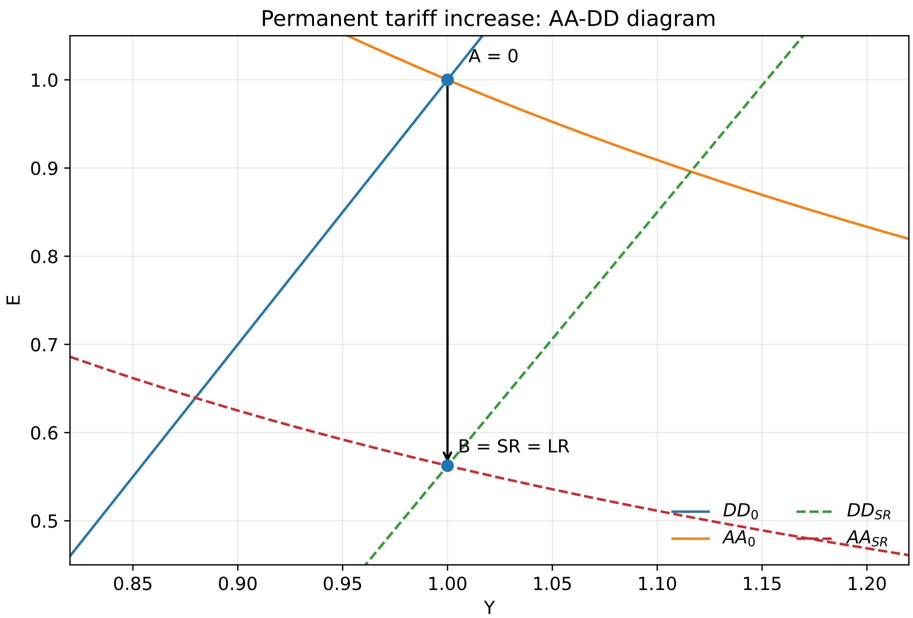
Because $Y_{SR} = Y^f = 1$, inflation is zero:

$$\pi_{SR} = 0.$$

So the price level does not change and the short-run equilibrium is already the long-run equilibrium.

In words, DD shifts to the right because the tariff reduces imports. AA shifts down because the permanent tariff lowers the expected future exchange rate. Those two shifts exactly offset each other in terms of output. The new equilibrium has the same Y as before, but a lower E.

The figure below shows one correct diagram.



(k) Repeat part (i) for the permanent tariff increase.

Solution: From part (j), the short-run and long-run equilibria are the same:

$$Y_{SR} = Y_{LR} = 1, \quad P_{SR} = P_{LR} = 1,$$
$$E_{SR} = E_{LR} = \frac{9}{16}, \quad q_{SR} = q_{LR} = \frac{9}{16}, \quad \pi_{SR} = \pi_{LR} = 0.$$

Exports and imports are

$$EX_{SR} = EX_{LR} = \frac{1}{4} + \frac{1}{10}\frac{9}{16} = \frac{49}{160} = 0.306,$$

$$IM_{SR} = IM_{LR} = \frac{5+2}{20(1+1/3)} - \frac{1}{10}\frac{9}{16} = \frac{33}{160} = 0.206.$$

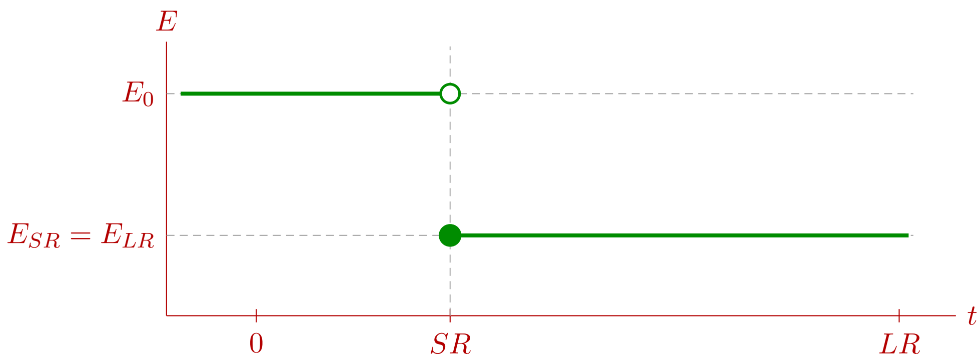
So

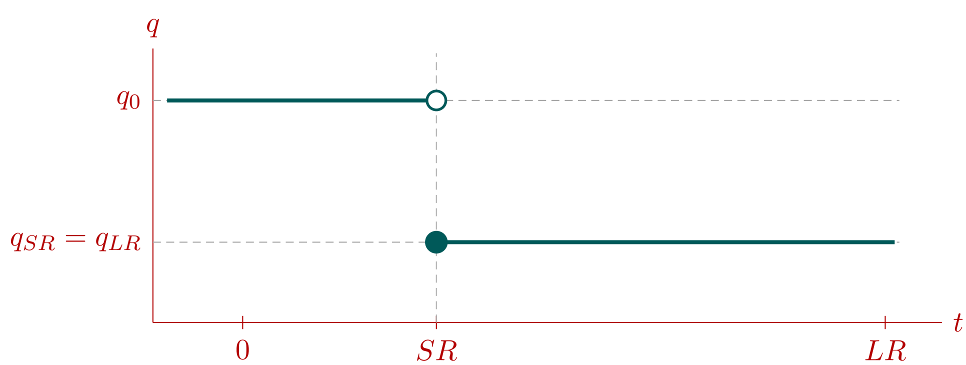
$$CA_{SR} = CA_{LR} = EX_{SR} - IM_{SR} = \frac{1}{10} = 0.100.$$

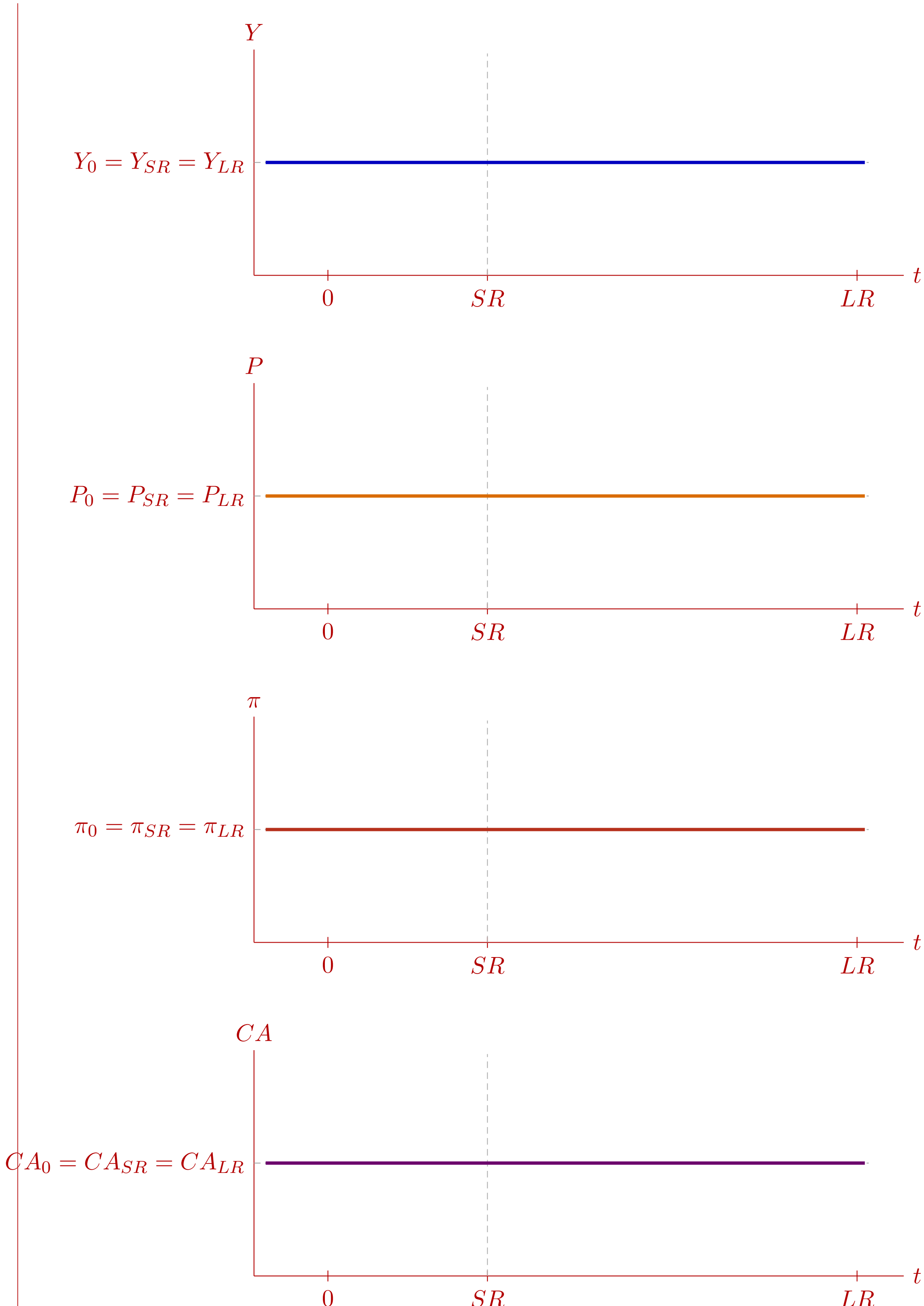
A convenient summary table is

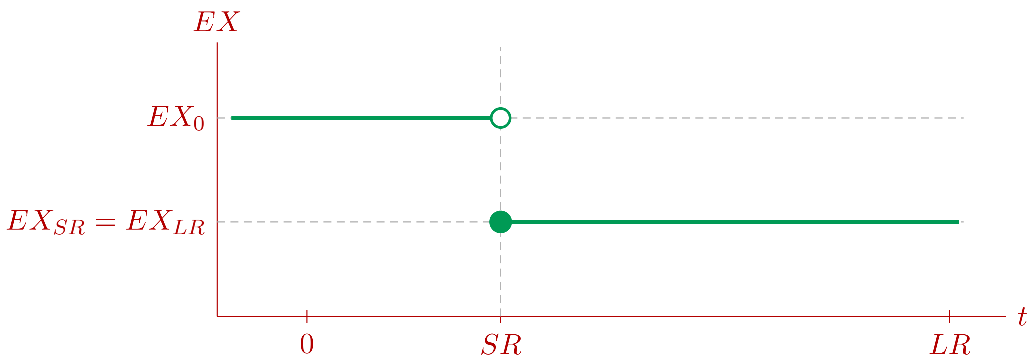
Variable	0	SR	LR
E	1.000	0.5625	0.5625
q	1.000	0.5625	0.5625
Y	1.000	1.000	1.000
P	1.000	1.000	1.000
π	0.000	0.000	0.000
CA	0.100	0.100	0.100
EX	0.350	0.306	0.306
IM	0.250	0.206	0.206

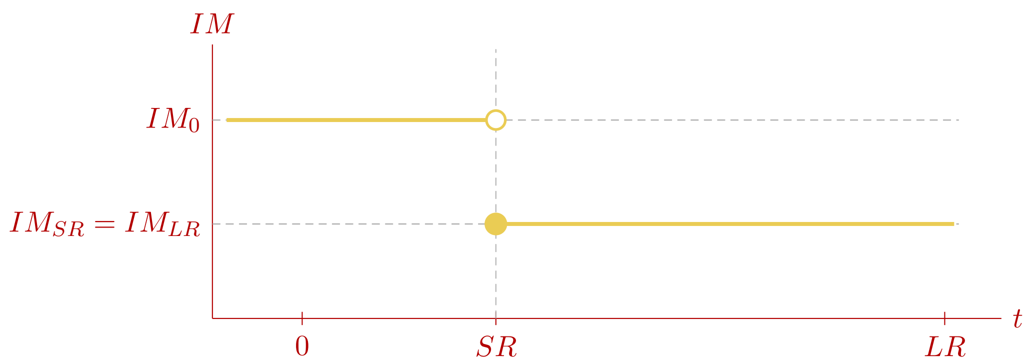
A correct set of time paths is shown below. Because the permanent tariff moves the economy directly to the new long-run equilibrium, every path is flat after the impact jump at SR.






Y
$Y_0 = Y_{SR} = Y_{LR}$
t
0
SR
LR
P
$P_0 = P_{SR} = P_{LR}$
t
0
SR
LR
π
$\pi_0 = \pi_{SR} = \pi_{LR}$
t
0
SR
LR
CA
$CA_0 = CA_{SR} = CA_{LR}$
t
0
SR
LR





The reason CA does not change is that the permanent appreciation offsets the expenditure-switching effect of the tariff. The tariff reduces imports, but the appreciation also reduces exports by exactly enough to leave the current account unchanged in this numerical example.