MA Macroeconomics
3. Introducing the IS-MP-PC Model

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Beyond IS-LM

- We have reviewed the IS-LM and AS-AD models.
- We will now revisit some of the ideas from those models and expand on them in a number of ways:

    1. **More Realistic**: Rather than the traditional LM curve, we will describe monetary policy in a way that is more consistent with how it is now implemented, i.e. we will assume the central bank follows a rule that dictates how it sets nominal interest rates. We will focus on how the properties of the monetary policy rule influence the behaviour of the economy.
    2. **Real Interest Rates**: We will have a more careful treatment of the roles played by real interest rates.
    3. **Expectations**: We will focus more on the role of the public's inflation expectations.
    4. **The Zero Bound**: We will model the zero lower bound on interest rates and discuss its implications for policy.

A Model With Three Elements

- Our model will have three elements to it.

  1. **A Phillips Curve** describing how inflation depends on output.
  2. **An IS Curve** describing how output depends upon interest rates.
  3. **A Monetary Policy Rule** describing how the central bank sets interest rates depending on inflation and/or output.

- Putting these three elements together, I will call it the IS-MP-PC model (i.e. The Income-Spending/Monetary Policy/Phillips Curve model).
- We will describe the model with equations.
- We will also merge together the second two elements (the IS curve and the monetary policy rule) to give a new IS-MP curve that can be combined with the Phillips curve to use graphs to illustrate the model's properties.

Part I

The Phillips Curve

The Phillips Curve

- What are the tradeoffs facing a central bank? A 1958 study by the LSE's A.W. Phillips seemed to provide the answer.
- Phillips documented a strong negative relationship between wage inflation and unemployment: Low unemployment was associated with high inflation, presumably because tight labour markets stimulated wage inflation.
- A 1960 study by MIT economists Solow and Samuelson replicated these findings for the US and emphasised that the relationship also worked for price inflation.
- The Phillips curve tradeoff quickly became the basis for the discussion of macroeconomic policy.
- Policy faced a tradeoff: Lower unemployment could be achieved, but only at the cost of higher inflation.
- However, Milton Friedman's 1968 presidential address to the American Economic Association produced a well-timed and influential critique of the thinking underlying the Phillips Curve.

A. W. Phillips's Graph

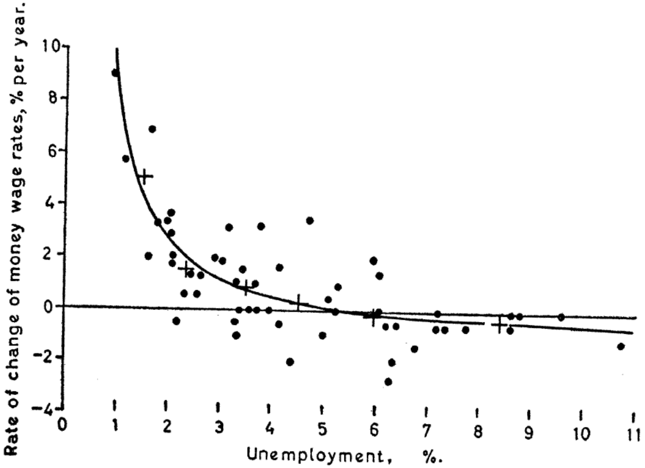


Fig.1. 1861 – 1913

Solow and Samuelson's Description of the Phillips Curve

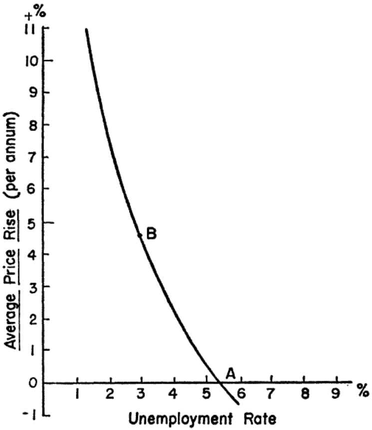


FIGURE 2

MODIFIED PHILLIPS CURVE FOR U.S.

This shows the menu of choice between different degrees of unemployment and price stability, as roughly estimated from last twenty-five years of American data.

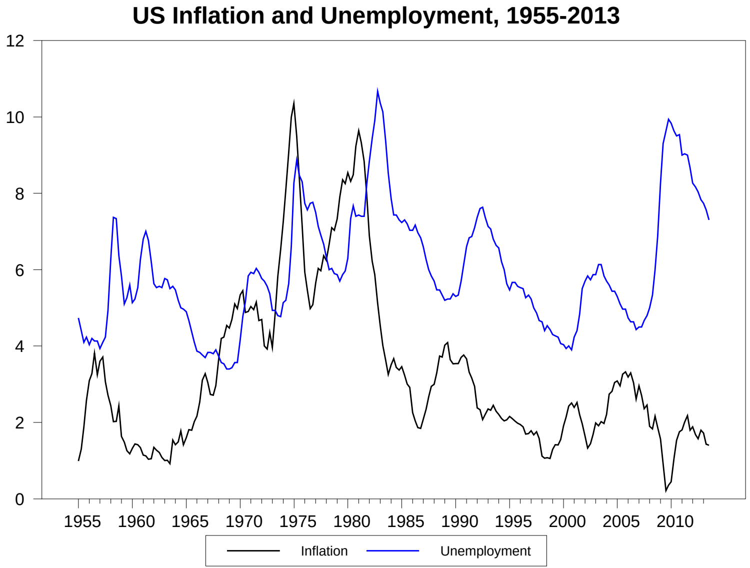
The Expectations-Augmented Phillips Curve

- Friedman pointed out that it was expected real wages that affected wage bargaining.
- If low unemployment means workers have strong bargaining position, then high nominal wage inflation on its own is not good enough: They want nominal wage inflation greater than price inflation.
- Friedman argued that if policy-makers tried to exploit an apparent Phillips curve tradeoff, then the public would get used to high inflation and come to expect it. Inflation expectations would move up and the previously-existing tradeoff between inflation and output would disappear.
- In particular, he put forward the idea that there was a **natural rate of unemployment** and that attempts to keep unemployment below this level could not work in the long run.

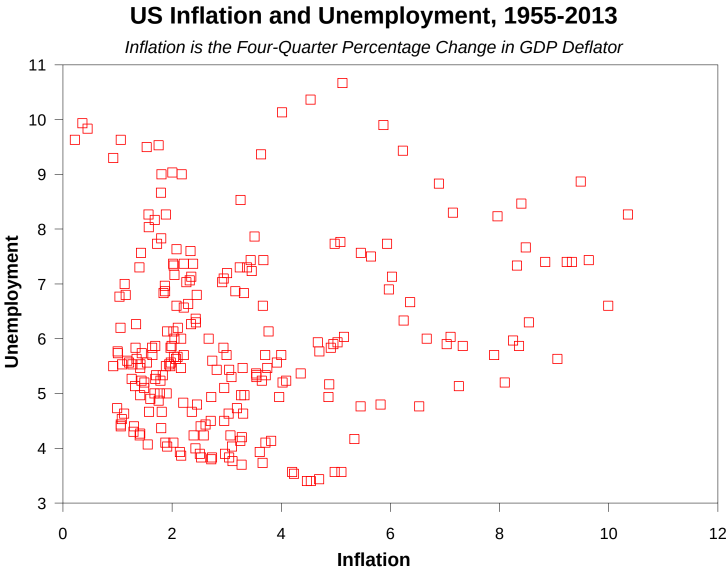
The Demise of the Basic Phillips Curve

- Monetary and fiscal policy in the 1960s were very expansionary around the world.
- At first, the Phillips curve seemed to work: Inflation rose and unemployment fell.
- However, as the public got used to high inflation, the Phillips tradeoff got worse. By the late 1960s inflation was still rising even though unemployment had moved up.
- This *stagflation* combination of high inflation and high unemployment got even worse in the 1970s.
- This was exactly what Friedman predicted would happen.
- Today, the data no longer show any sign of a negative relationship between inflation and unemployment. If fact, the correlation is positive: The original formulation of the Phillips curve is widely agreed to be wrong.

The Evolution of US Inflation and Unemployment



The Failure of the Phillips Curve



How to Read the Equations in this Course

- We will use both graphs and equations to describe the models in this class.
- I know many students don't like equations and believe they are best studiously avoided but it isn't as hard is it might look to start with.
- The equations in this class will often look a bit like this.

$$y_t = \alpha + \beta x_t$$

There are two types of objects in this equation.

1. The **variables**, y_t and x_t. These will correspond to economic variables that we are interested in (inflation for example). We interpret y_t as meaning "the value that the variable y takes during the time period t").
2. There are the **parameters** or **coefficients**. In this example, these are given by α and β. These are assumed to stay fixed over time. There are usually two types of coefficients: Intercept terms like α that describe the value that series like y_t will take when other variables all equal zero and coefficients like β that describe the impact that one variable has on another.

Squiggly Letters

- Some of you are probably asking what those squiggly shapes — α and β — are. They are Greek letters.
- While it's not strictly necessary to use these shapes to represent model parameters, it's pretty common in economics.
- So let me introduce them:
  1. α is alpha (Al-Fa)
  2. β is beta (Bay-ta)
  3. γ is gamma
  4. δ is delta
  5. θ is theta (Thay-ta)
  6. π naturally enough is pi.

Dynamics

- One of the things we will be interested in is how the variables we are looking at will change over time. For example, we will have equations along the lines of

$$y_t = \beta y_{t-1} + \gamma x_t$$

- Reading this equation, it says that the value of y at time t will depend on the value of x at time t and also on the value that y took in the previous period i.e. $t - 1$.
- By this, we mean that this equation holds in every period. In other words, in period 2, y depends on the value that x takes in period 2 and also on the value that y took in period 1.
- Similarly, in period 3, y depends on the value that x takes in period 3 and also on the value that y took in period 2.
- And so on.

Subscripts and Superscripts

- When we write y_t, we mean the value that the variable y takes at time t.
- Note that the t here is a **subscript** – it goes at the bottom of the y.
- Some students don't realise this is a subscript and will just write yt but this is incorrect (it reads as though the value t is multiplying y which is not what's going on).
- We will also sometimes put indicators above certain variables to indicate that they are special variables.
- For example, in the model we present now, you will see a variable written as π_t^e which will represent the public's expectation of inflation.
- In the model, π_t is inflation at time t and the e above the π in π_t^e is there to signify that this is not inflation itself but rather it is the public's expectation of it.

Model Element One: The Phillips Curve

- Our version of the Phillips curve is as follows:

$$\pi_t = \pi_t^e + \gamma \left(y_t - y_t^* \right) + \epsilon_t^\pi$$

- Here π represents inflation and by π_t we mean inflation at time t.
- The equation states that inflation depends on three factors.

1. **Inflation Expectations**:
    - This is given by the π_t^e term which represents the public's inflation expectations at time t.
    - A one point increase in inflation expectations raises inflation by exactly one point.
    - People bargain over real wages and higher expected inflation translates one-for-one into their wage bargaining, which in turn is passed into price inflation.

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2. **The Output Gap**:
   - This is $y_t - y_t^*$, the gap between y_t (GDP at time t) and y_t^* (the "natural" level of output).
   - The natural level of output is the level consistent with unemployment equalling its natural rate.
   - The coefficient γ describes exactly how much inflation is generated by a 1 percent increase in the gap between output and its natural rate.

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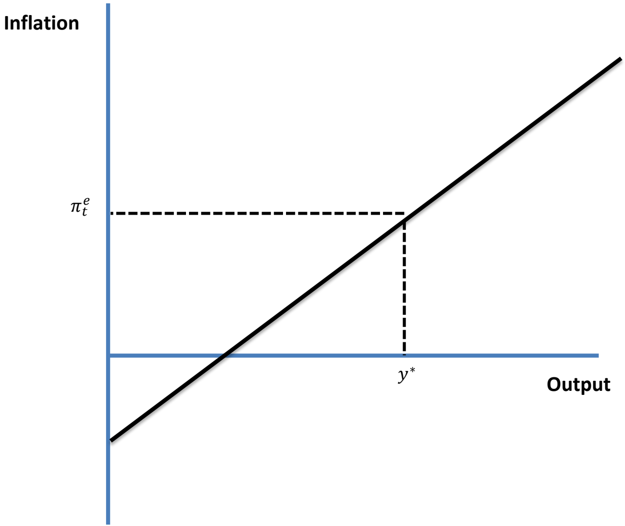
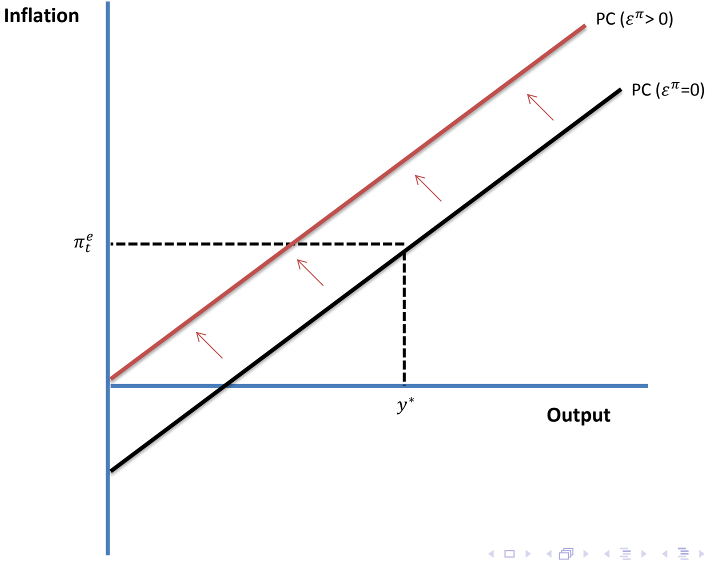
- The equation states that inflation depends on three factors.

3. **Inflationary Shocks**:
   - The ϵ_t^π term captures all factors beyond inflation expectations and the output gap that drive of inflation.
   - For example, "supply shocks" like a temporary increase in the price of imported oil can drive up inflation for a while. To capture these kinds of temporary factors, we include an inflationary "shock" term, ϵ_t^π.
   - The superscript π indicates that this is an inflationary shock and the t subscript indicates that these shocks change over time.

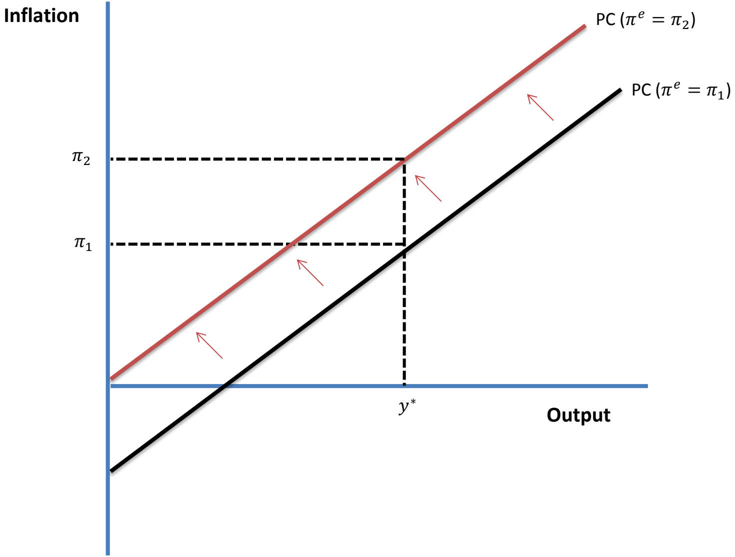
The Phillips Curve Graph with $\epsilon_t^\pi = 0$



The Phillips Curve as we move from $\epsilon_t^\pi = 0$ to $\epsilon_t^\pi > 0$ (An Aggregate Supply Shock)



The Phillips Curve as we move from $\pi_t^e = \pi_1$ to $\pi_t^e = \pi_2$



Part II

The IS-MP Curve

Model Element Two: The IS Curve

- The second element of the model is an IS curve relating output to interest rates. The higher interest rates are, the lower output is.
- The IS relationship is between output and **real interest rates**, not nominal rates. Real interest rates adjust the headline (nominal) interest rate by subtracting off inflation.
- Suppose the interest rate was 10 percent. Is this a high or low? It depends on inflation. Consider a person's decision to save.
  - If the interest rate if 5% but inflation is 2%, then you can buy 3% more stuff next year because you saved.
  - In contrast, if the interest rate if 5% but inflation is 8%, you can buy 3% less stuff next year even though you have saved.
- Similar for firms considering borrowing.
  - If inflation is 10%, then a firm can expect that its prices will increase by that much over the next year and a 10% interest rate won't seem so high.
  - But if prices are falling, then a 10% interest rate on borrowings will seem very high.

Our Version of the IS Curve

- Our version of the IS curve will be the following:

$$y_t = y_t^* - \alpha \left(i_t - \pi_t - r^* \right) + \epsilon_t^y$$

- Expressed in words, this equation states that the gap between output and its natural rate $y_t - y_t^*$ depends on two factors:

1. **The Real Interest Rate**:
   - The nominal interest rate at time t is i_t, so the real interest rate is $i_t - \pi_t$.
   - The real interest rate is the real rate at which output will, on average, equal its natural rate. This is denoted by r^*.
   - This is known as the *natural rate of interest*. When $\epsilon_t^y = 0$, a real interest rate of r^* will imply $y_t = y_t^*$.

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- Expressed in words, this equation states that the gap between output and its natural rate $y_t - y_t^*$ depends on two factors:

2. **Aggregate Demand Shocks, ϵ_t^y:**
   - ★ Many other factors beyond the real interest rate influence aggregate spending decisions.
   - ★ Fiscal policy, asset prices and consumer and business sentiment.
   - ★ We model these as temporary deviations from zero of an aggregate demand "shock" – this is ϵ_t^y.
   - ★ This shock has a superscript y to distinguish it from the "aggregate supply" shock ϵ_t^π that moves the Phillips curve up and down.

Monetary Policy: The LM Curve Approach

- So inflation depends on output and how output depends on interest rates.
- Complete the model by describing how interest rates are determined.
- Traditionally, this is where the LM curve is introduced. Links demand for the real money stock with nominal interest rates and output:

$$\frac{m_t}{p_t} = \delta - \mu i_t + \theta y_t$$

- Implies a positive relationship between output and interest rates:

$$y_t = \frac{1}{\theta}\left(\frac{m_t}{p_t} - \delta + \mu i_t\right)$$

- Combined with the negative relationship between these variables in the IS curve to determine unique values for output and interest rates.
- Illustrated with an upward-sloping LM curve and a downward-sloping IS curve. Central bank adjusts money supply m_t to set the position of the LM curve.
- The determination of prices is then described separately in an AS-AD model.

Monetary Policy: Our Approach

Instead of the LM curve approach, we will model monetary policy by assuming the central bank sets nominal interest rates according to a particular rule. There are three reasons for this appraoch.

1. **Realism 1**: Modern central banks do not implement monetary policy by setting a specified level of the monetary base.
2. **Realism 2**: The traditional approach uses a separate AS-AD model to describe the determination of prices (and thus, implicitly, inflation) separate from interest rates. However, rather than being determined independently of inflation, most modern central banks set interest rates with a very close eye on inflationary developments.
3. **Simplicity**: In simplifying the determination of output, inflation and interest rates down to a single model, this approach is also simpler than one that requires two different sets of graphs.

Model Element Three: The Monetary Policy Rule

- We first consider a monetary policy rule of the form:

$$i_t = r^* + \pi^* + \beta_\pi (\pi_t - \pi^*)$$

  We assume $\beta_\pi > 0$.

- Features of this rule:
  - Central bank adjusts i_t up when inflation, π_t, goes up and down when inflation goes down.
  - When $\pi_t = \pi^*$ real interest rates equal their natural level.
- Why is a rule like this a good idea?
  - If the public understands the central bank's target inflation rate, then on average we get $\pi_t^e = \pi^*$.
  - In this case, the Phillips curve tells us that, on average, inflation will equal π^* provided we have $y_t = y_t^*$.
  - And IS curve tells us that, on average, we will have $y_t = y_t^*$ when $i_t - \pi_t = r^*$.

The Full Model

- That's the model. It consists of three equations.

  1. The Phillips curve:

$$\pi_t = \pi_t^e + \gamma\left(y_t - y_t^*\right) + \epsilon_t^\pi$$

  2. The IS curve:

$$y_t = y_t^* - \alpha\left(i_t - \pi_t - r^*\right) + \epsilon_t^y$$

  3. The monetary policy rule:

$$i_t = r^* + \pi^* + \beta_\pi\left(\pi_t - \pi^*\right)$$

- I promised a graphical representation of this model. But this is a system of three variables which makes it hard to express on a graph with two axes.
- To make the model easier to analyse using graphs, we are going to reduce it down to a system with two main variables (inflation and output).
- Monetary policy rule makes interest rates are a function of inflation, so we can substitute this rule into the IS curve to get a new relationship between output and inflation that we will call the IS-MP curve.

The IS-MP Curve

- If we replace the term i_t in the IS curve with the formula from the monetary policy rule, we get

$$y_t = y_t^* - \alpha \left[r^* + \pi^* + \beta_\pi \left(\pi_t - \pi^* \right) \right] + \alpha \left(\pi_t + r^* \right) + \epsilon_t^y$$

- Now multiply out the terms in this equation to get

$$y_t = y_t^* - \alpha r^* - \alpha \pi^* - \alpha \beta_\pi \left(\pi_t - \pi^* \right) + \alpha \pi_t + \alpha r^* + \epsilon_t^y$$

- Canceling terms and re-arranging, this simplifies to

$$y_t = y_t^* - \alpha \left(\beta_\pi - 1 \right) \left(\pi_t - \pi^* \right) + \epsilon_t^y$$

- This is the IS-MP curve. It combines the information in the IS curve and the MP curve into one relationship.

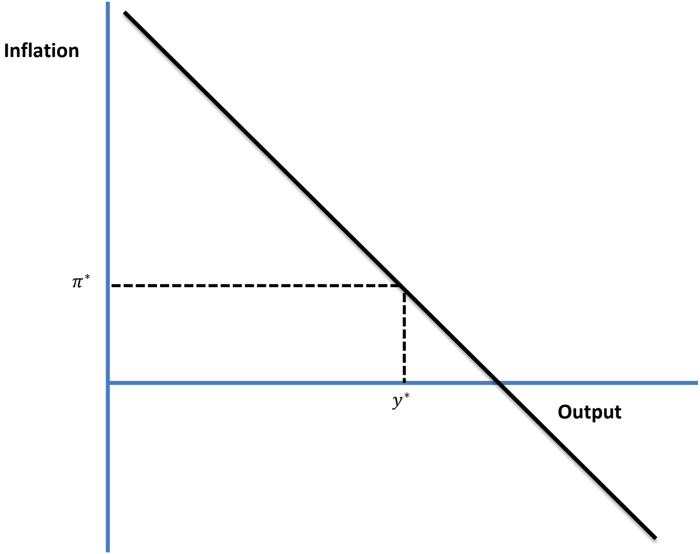
The IS-MP Curve Graph

- The IS-MP curve is

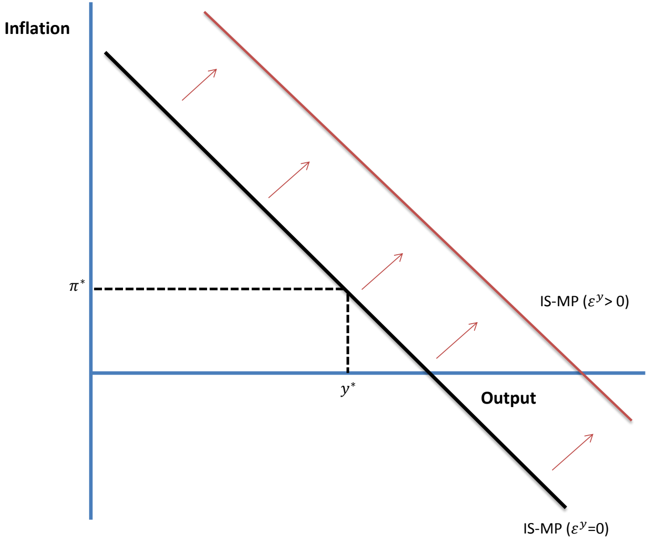
$$y_t = y_t^* - \alpha\left(\beta_\pi - 1\right)\left(\pi_t - \pi^*\right) + \epsilon_t^y$$

- How this curve looks in a graph depends especially on the value of β_π.
- An extra unit of inflation implies a change of $-\alpha\left(\beta_\pi - 1\right)$ in output.
- Is this positive or negative? We are assuming that $\alpha > 0$ so this combined coefficient will be negative if $\beta_\pi - 1 > 0$, i.e. the IS-MP curve will slope downwards if $\beta_\pi > 1$ and upwards if $\beta_\pi < 1$.
- Explanation: Increase in inflation of x will lead to an increase in nominal interest rates of $\beta_\pi x$ so real interest rates change by $\left(\beta_\pi - 1\right)x$. If $\beta_\pi > 1$ then an increase in inflation leads to higher real interest rates and, via the IS curve relation, to lower output.
- For now, we will assume that $\beta_\pi > 1$ so that we have a downward-sloping IS-MP curve but we will revisit this later.

The IS-MP Curve with $\epsilon_t^y = 0$



The IS-MP Curve as we move from $\epsilon_t^y = 0$ to $\epsilon_t^y > 0$



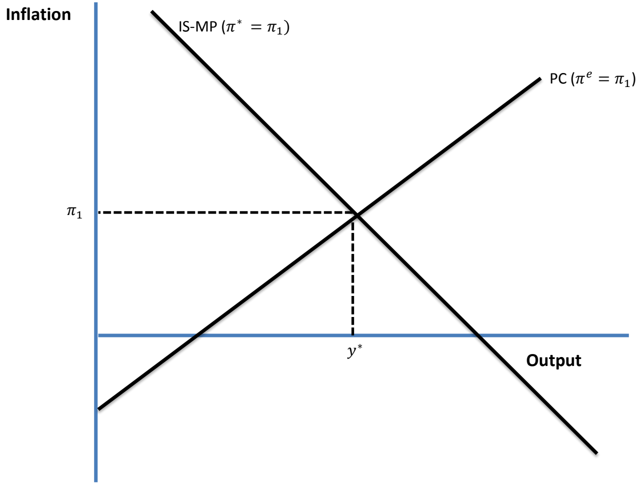
Part III

Putting the Pieces Together

The IS-MP-PC Model Graph

- We can now illustrate the full model in a single graph.
- The graph features one curve that slopes upwards (the Phillips curve) and one that slopes downwards (the IS-MP curve provided we assume that $\beta_\pi > 1$.)
- The next figure provides the simplest possible example of the graph. This is the case where both the temporary shocks, ϵ_t^π and ϵ_t^y equal zero and the public's expectation of inflation is equal to the central bank's inflation target.
- PC and IS-MP curves are labelled to indicate the expected and target rates of inflation are.
- In the next set of notes, we will analyse this model in depth, examining what happens when various types of events occur and focusing carefully on how inflation expectations change over time.

Expected Inflation Equals the Inflation Target



A More Complicated Monetary Policy Rule

- In a famous 1993 paper, John Taylor argued for a monetary policy rule in which the central bank adjusted interest rates in response to both inflation and the gap between output and an estimated trend.
- We can amend our monetary policy rule to be more like this "Taylor rule":

$$i_t = r^* + \pi^* + \beta_\pi (\pi_t - \pi^*) + \beta_y (y_t - y_t^*)$$

- Substituting this into the IS curve, we get

$$y_t = y_t^* - \alpha [r^* + \pi^* + \beta_\pi (\pi_t - \pi^*) + \beta_y (y_t - y_t^*)] + \alpha (\pi_t + r^*) + \epsilon_t^y$$

- This can be re-arranged to give

$$y_t - y_t^* = -\frac{\alpha (\beta_\pi - 1)}{1 + \alpha \beta_y} (\pi_t - \pi^*) + \frac{1}{1 + \alpha \beta_y} \epsilon_t^y$$

- Broadening the monetary policy rule to incorporate interest rates responding to the output gap doesn't change the essential form of the IS-MP curve.

Things to Understand From This Topic

1. The evidence on the Phillips curve.
2. The Phillips curve that features in our model and how to draw it.
3. Why real interest rates are what matters for aggregage demand.
4. The IS curve that features in our model.
5. The monetary policy that features in our model.
6. How to derive the IS-MP curve.
7. What determines the slope of the IS-MP curve.
8. How the IS-MP curve changes when the monetary policy rule takes the form of a "Taylor rule".