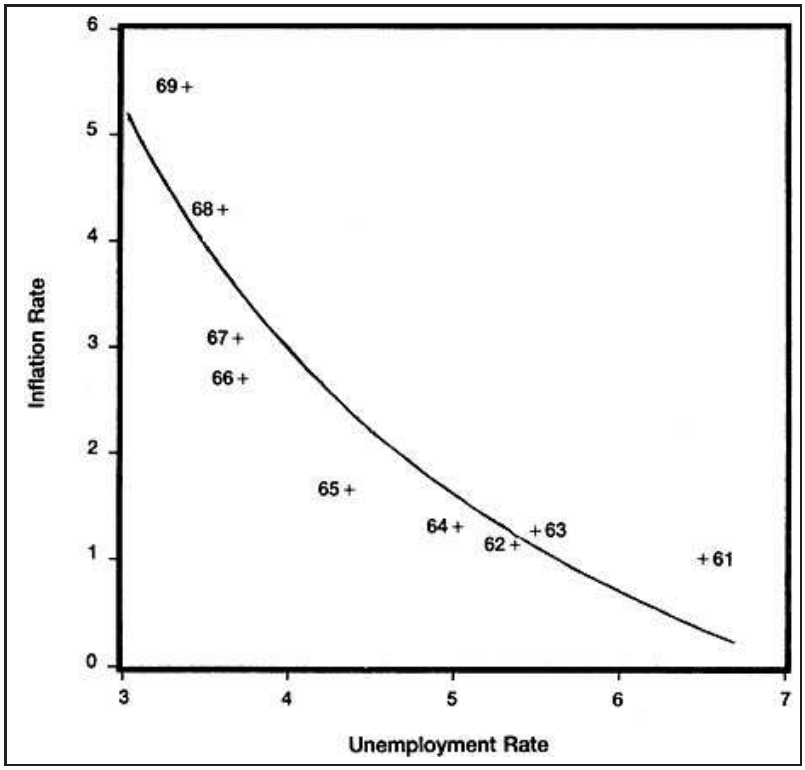
I The Phillips Curve in the Data

A The Original Phillips Curve

Definition 36 *The PHILLIPS CURVE is the relationship between unemployment (or sometimes output) and inflation.*

Phillips, an economist in Britian, plotted inflation vs. unemployment in Britian in the 1960's. The result was a negative correlation:



Relationship appeared to be so strong that policy choices were made on the curve. Some central banks favored low unemployment at the expense of higher inflation and some the reverse.

Next, output and unemployment are closely negatively correlated. As output increases, say in an economic boom, more workers are needed to produce the higher output, and thus unemployment falls.

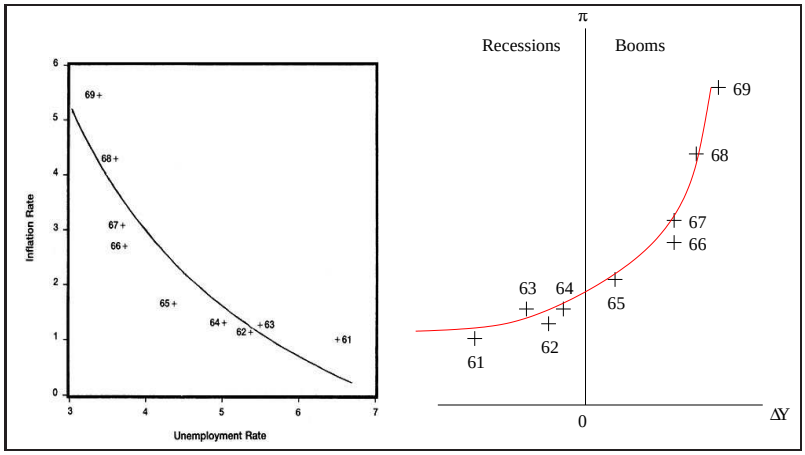
Definition 37 *OKUN'S LAW: Output and Unemployment are negatively correlated.*

We will use the following version of Okun's law:

$$U = NR - k\Delta Y \tag{70}$$

Here NR is the natural rate of unemployment or the long run average.

If inflation and unemployment have a negative correlation, then inflation and output have a postive correlation.

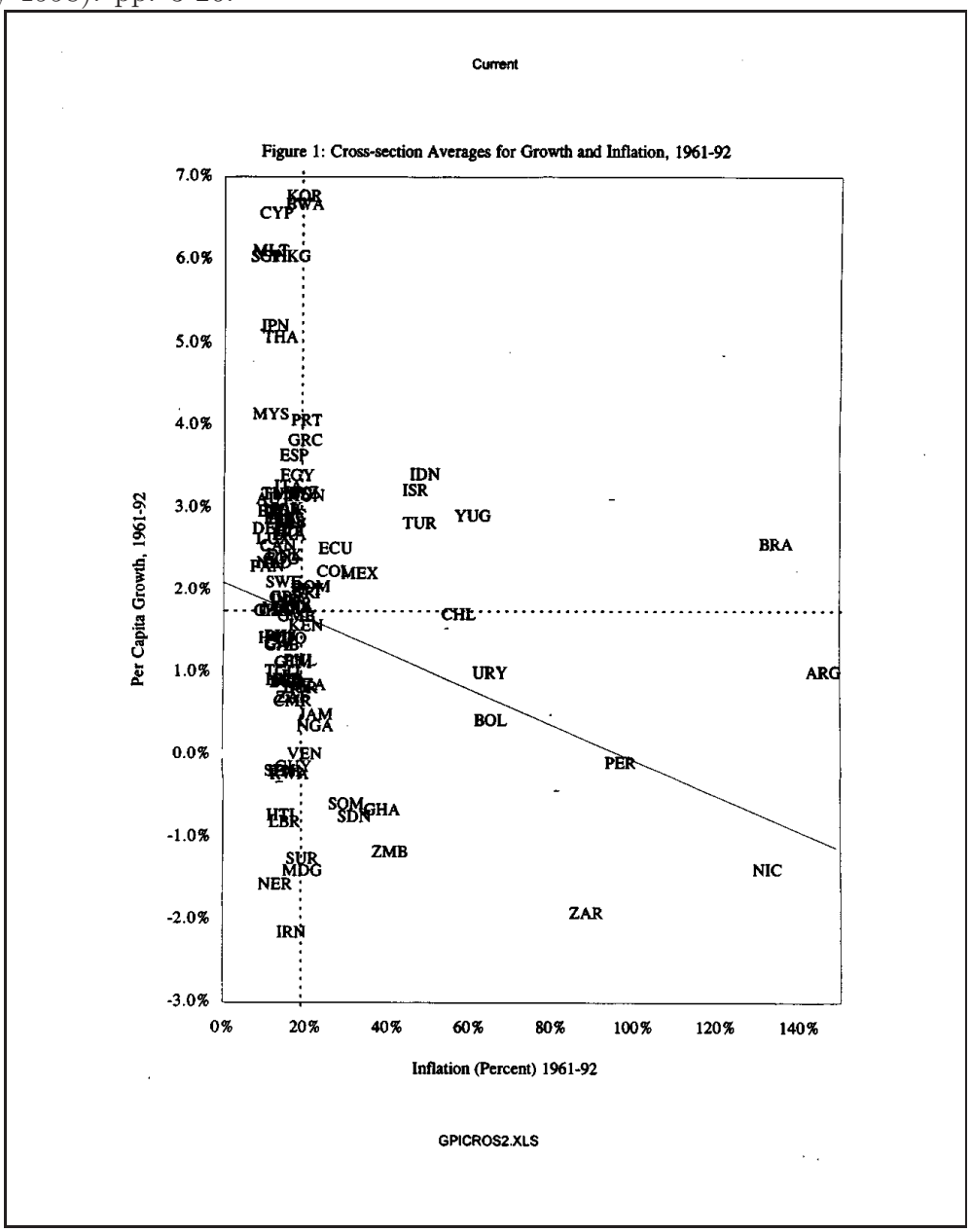


Usually the Phillips curve relates inflation and unemployment, but we will sometimes use the output and inflation version as well.

B Modern Phillips Curves in the Data

Primarily the data given by Phillips is just a few periods in the 1960s. Over longer periods, the data looks quite different. For example here is the data across countries.

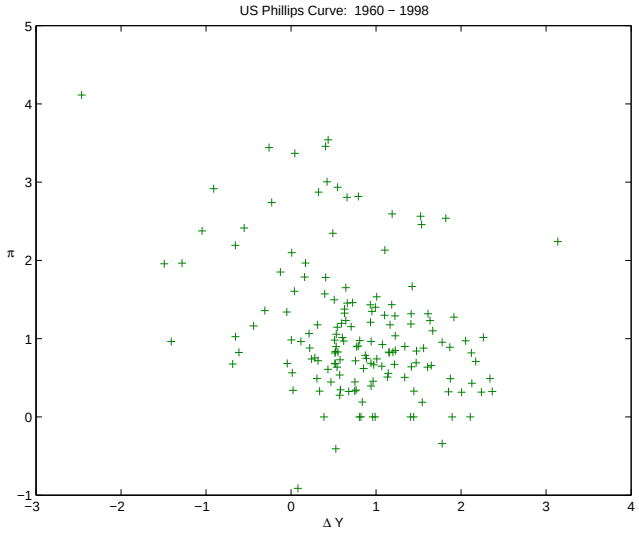
Figure 29: Inflation and long run growth. Graph is Figure (1) from Bruno, M. and William Easterly "Inflation Crises and Long Run Growth," *Journal of Monetary Economics*, vol. 41 (February 1998): pp. 3-26.

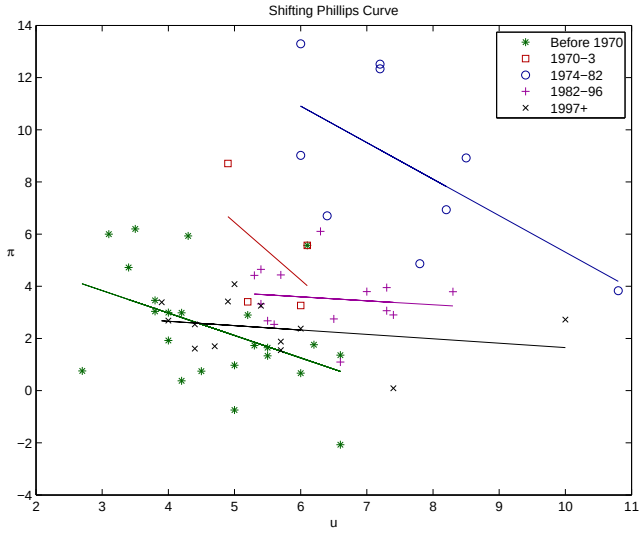


Inflation and output are essentially unrelated for low (less than 20%) inflation countries in the long run. For high inflation countries, inflation and output are *negatively* related (notice that the axes are reversed in the above graph). Most likely, this results from the causality working the other way: countries with low growth have low tax receipts and are

therefore tempted to print money as a revenue source, causing inflation. Nonetheless, for low inflation countries, there is little evidence of a long term relationship between output or unemployment and inflation.

The original Phillips curve used a very small data set: just a decade. When we increase the number of observations:





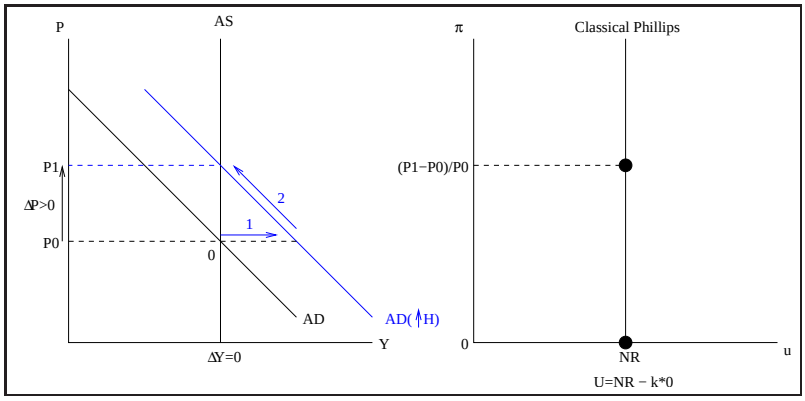
The Phillips curve seems to "shift up," especially in times of high inflation. In addition, during the long period of low inflation from the 1980s to present, the Phillips curve flattened

(the slope moved closer to zero). Note also that I chose these years very carefully. For many other sets of years, the Phillips curve is not even downward sloping. In spite of the mixed data on the Phillips curve, many policy makers and media types believe the Phillips curve is always downward sloping. Nonetheless, it is reasonably consistent with the data to say that, for low to moderate inflation countries, the Phillips curve is:

- Downward sloping in the short run.
- Vertical in the long run.
- Shifts up after a period of high inflation.
- Becomes flatter after a long period of low inflation.

II Classical Phillips Curve

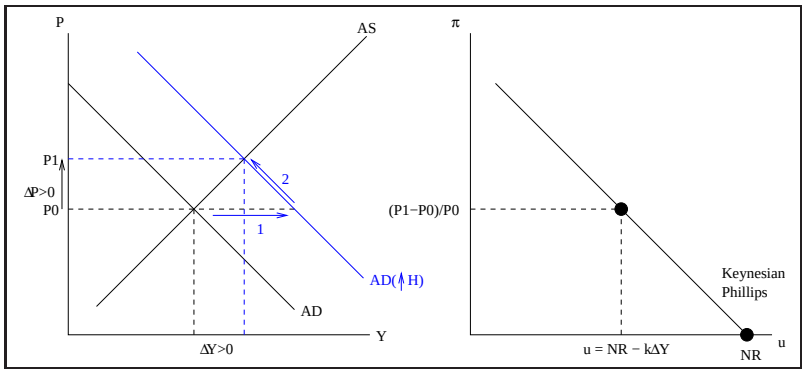
Suppose an increase in high powered money. Then we see that inflation rises while there is no change in output.



The Phillips curve in the Classical model is vertical. An increase in high powered money results in lower interest rates, which increases investment demand. However, supply is unchanged since wages are unchanged. Prices therefore rise and we have higher inflation with no change in output or unemployment.

III Keynesian Phillips Curve

Suppose an increase in high powered money. Then we see that inflation rises while there is an increase in output.



The Keynesian Phillips curve is in fact downward sloping. An increase in high powered money causes interest rates to fall and investment demand to rise. Since $AD > AS$ prices rise, but as prices rise real wages fall. As real wages fall, firms demand more labor, increasing production and reducing unemployment.

In summary, the Keynes does a good job replicating the short run Phillips curve. This makes sense: the primary assumption of the Keynes model is that wages are fixed, which is true in the short run. Similarly, the classical model does a good job replicating the long run Phillips curve. This makes sense as the primary assumption of the classical model is that wages are flexible. But neither does a good job explaining changes in slope or shifts of the Phillips curve.

IV Lucas Monetary Misperceptions

Here we modify the classical model to include monetary misperceptions. Introducing monetary misperceptions will allow the model to better represent shifts and changes in slope in the observed Phillips curve. Further, the classical model will be more realistic because the model will have a major cost of inflation: price confusion leads to a misallocation of resources.

A Monetary Misperceptions

First we review the idea of monetary misperceptions. Consider a seller faced with an increase in demand from consumers. One possibility: the product is better/cooler than others.

Definition 38 *RELATIVE CHANGE IN DEMAND. Change in demand for one product relative to others.*

In response to to a relative change in demand, producers reduce production of low demand goods in favor of high demand goods. In a sense, this is why free markets work: resources naturally gravitate towards things that consumers most want, leading to high satisfaction among consumers. In response to a relative increase in demand, producers increase output and also raise prices somewhat.

Definition 39 *NOMINAL CHANGE IN DEMAND. Change in demand due simply to an increase in cash in hands of consumers, from an increase in the money supply.*

Dollars are in fact worth less, so in response to a nominal change in demand producers should increase prices. No resources need shifting: all goods increase in demand so all producers raise prices. So in response to a nominal change in demand producers should not increase output.

Misperceptions occur when some sellers mistake a nominal change in demand for a relative change in demand. It is very easy for sellers to see an increase in demand, and not having checked CNBC for any FED money supply action that day, and just assume it is a relative change in demand. Thus some producers mistakenly increase output in response to a nominal change in demand. This illustrates a major cost of inflation: price confusion leads to a mis-allocation of resources.

We will model the firms misperceptions as follows. Suppose first a fraction of firms a misperceive (we can also think of a as the number of firms that misperceive). In response to an increase in H, firms that do not misperceive will increase prices to P. Firms that misperceive increase prices by less. They set a price equal to their expectations, $P^e < P$. Since misperceiving firms have lower prices, they will see an increase in demand that is proportional to to the difference in prices. So the aggregate supply curve is:

$$Y = Y^* + a\left(P - P^e\right) \tag{71}$$

If misperceptions are zero ($P^e = P$), then AS (Y) is equal to $Y^* = F\left(n^*, k, z\right)$ as in the classical model. AS increases when prices are higher than misperceiving firms anticipate. Because misperceiving firms raise prices by less, they see an increase in demand and produce more. Similarly, if $P < P^e$, then misperceiving firms set their prices too high, and see a decrease in demand. This they interpret as relative rather than nominal, and reduce output and employment rather than reduce prices.

Using Okun's law:

$$u = NR - k\Delta Y = NR - k\left(Y - Y^*\right). \tag{72}$$

So using the AS curve:

$$u = NR - k \cdot a\left(P - P^e\right). \tag{73}$$

$$u = NR + k \cdot a\left(P^e - P\right). \tag{74}$$

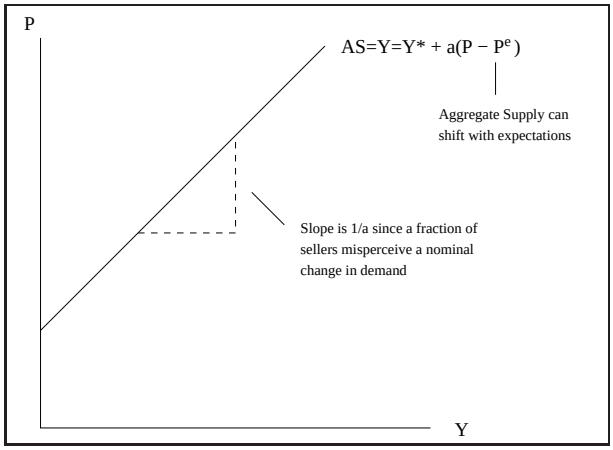
So if expected prices are greater than the actual price increase, misperceiving firms raise their prices too much and see a decrease in demand. Misperceiving firms then think the decrease in demand is relative, and reduce output by firing workers. This creates unemployment above the natural rate.

In general, the FED increases H by a percentage each year. In this case, sellers should raise prices by a percentage π each year. If inflation is unexpectedly high, misperceiving firms raise their prices too little ($\pi^e < \pi$) and see an increase in demand which they interpret as relative. So if we are thinking of the FED as continually increasing H but where firms are uncertain as to how much, we write:

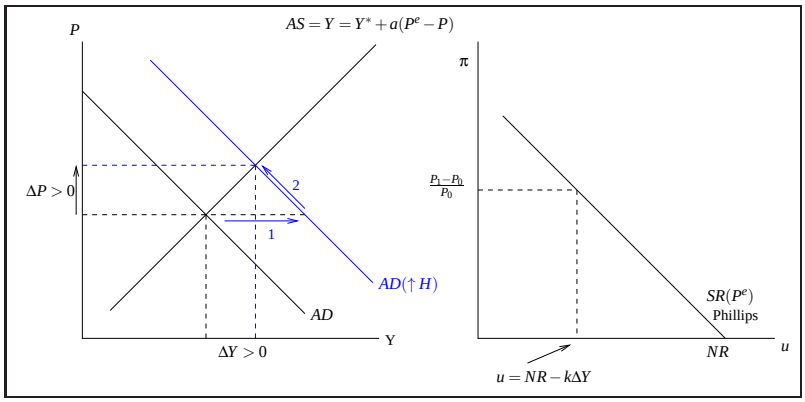
$$u = NR + k \cdot a\left(\pi^e - \pi\right). \tag{75}$$

B Phillips Curve

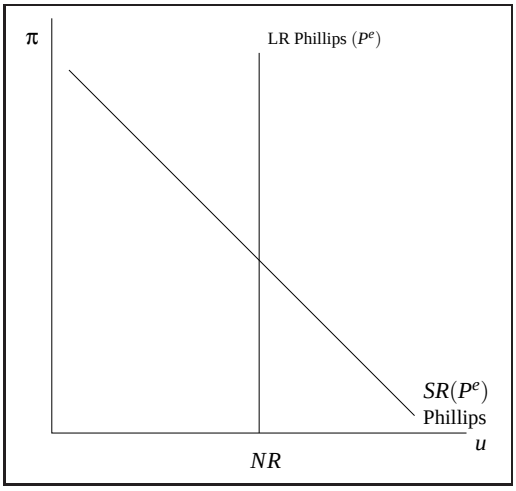
Here is the Aggregate Supply curve for the classical model with monetary misperceptions:



Aggregate supply increases with prices because a fraction of sellers confuse a nominal increase in demand with a relative increase in demand and increase output. So the Phillips curve of the classical model with misperceptions has a downward slope:



In the long run, the Phillips curve is again vertical as there are no misperceptions ($P^e = P$) and thus $Y = Y^*$ and $u = NR$.



Note that we shift the curve when we change P^e.

C Shifting Phillips Curve

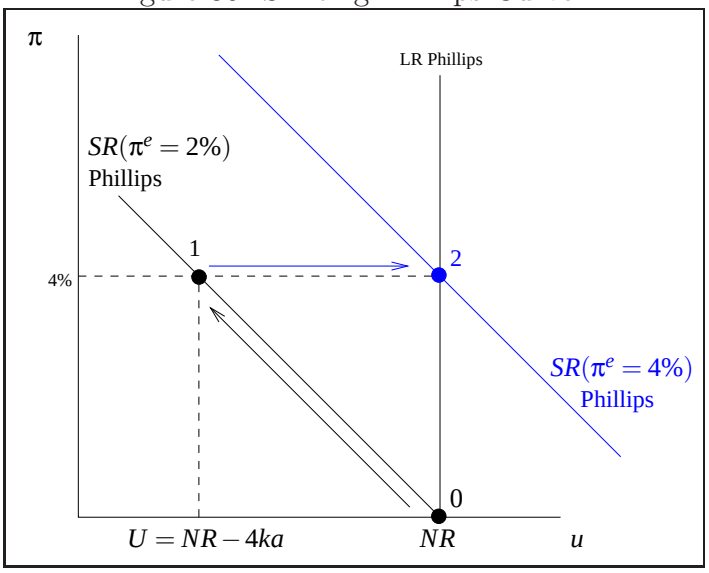
Suppose prices are initially constant ($\pi_0 = 0$) and expectations equal actual inflation ($\pi_0^e = 0$). Expectations are $\pi_{t+1}^e = \pi_t$. Expectations are initially equal to actual inflation so we are at point 0 on figure 30. Now suppose in period one the FED increases H so that $\pi_1 = 4$ percent inflation. Expectations remain at zero: $\pi_1^e = \pi_0 = 0$. Some firms do not raise prices. But then these firms see an increase in demand as other firms raised prices by 4%. They misinterpret the increase in demand as relative and incrase output by hiring more workers,

which decreases unemployment to:

$$u = NR + k \cdot a\,(0 - 4) = NR - 4k \cdot a. \tag{76}$$

We are therefore at point 1 on Figure 30. Suppose the FED continues with the same policy in periods 2 onward as in period 1. Then $\pi_2 = 4$ and $\pi_2^e = \pi_1 = 4$. So $u = NR$ and we are at point 2 on the graph. The Phillips curve has shifted to the right (point 2 cannot be on the old Phillips curve).

Figure 30: Shifting Phillips Curve.



So we can see that we move along the short run curve for a change in π that is unexpected, and shift the short run curve when we have a change in expectations. An important result is that for the FED to reduce unemployment, the increase in H and π must be unexpected to some degree.

D More Examples

1 Example 1: Decrease in inflation

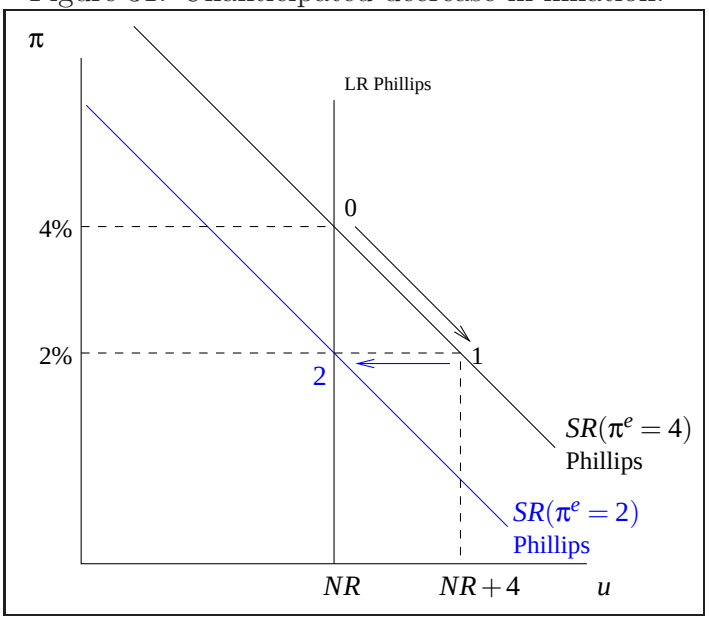
Suppose initial inflation is 4%, initial expectations equal actual inflation, so $\pi_0^e = \pi_0 = 4$. Let $k = 1$ and $a = 2$ sellers misperceive. Assume again that $\pi_{t+1}^e = \pi_t$. We are at point 0 on Figure 31 below.

Now suppose the FED introduces an inflation target of 2%. We have $a = 2$ sellers do not observe the change in policy and continue to raise prices by 4%. Since these sellers raised

prices by more than other sellers, they face a reduction in demand, which they mistakenly believe is a relative change in demand. They therefore reduce output and employment, causing more unemployment. Unemployment is $u = NR + 1 \cdot 2\,(4-2) = NR + 4$. A rececession results, which is point 1 on Figure 31.

Starting in the second period, expectations equal actual inflation of 2%, causing the Phillips curve to shift to the left, which is point 2 on Figure 31.

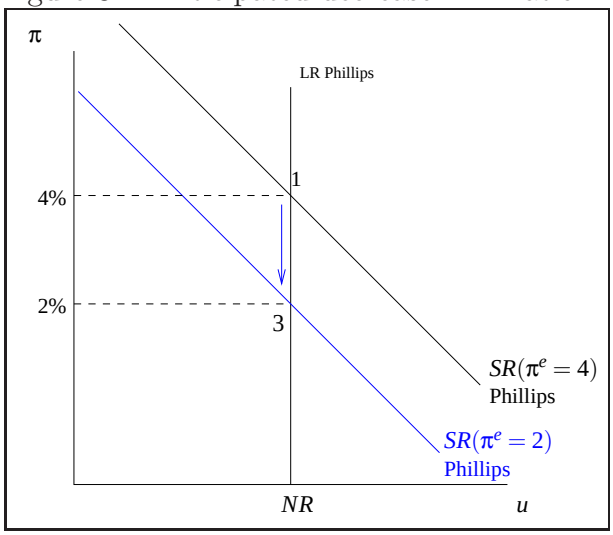
Figure 31: Unanticipated decrease in inflation.



2 Example 2: Anticipated Decrease in Inflation

Suppose as in example 1, but the decrease in inflation is anticipated. The FED loudly announces to all that they will decrease π to 2% and this is believed by all. Then $\pi_1^e = 2$ and we move directly from point 1 to point 3.

Figure 32: Anticipated decrease in inflation.



The decrease in inflation is acheived without costly unemployment. This is very desirable for the FED and the economy in general. Therefore, the FED will always loudly proclaim it desires to reduce inflation. Indeed, this was part of the strategy of reducing inflation in the early 1980s in Britain and the US.

The hard part is getting the population to believe the FED. Credibility has to be earned, and central banks that promise low inflation but don't deliver are eventually ignored. This raises the cost of decreasing inflation.

One good example is the hyperinflations following WWI. The promised lowering of inflation was backed by allied tanks and was therefore very credible. Inflation declined from thousands of percent per year to zero without any unemployment, as predicted by Figure 32.

E Slope of the Phillips Curve

Monetary misperceptions also has implications for the slope of the Phillips curve. After a period during which inflation has been historically low, few sellers will pay much attention to changes in the money supply. The parameter a thus increases, which in turn means that $-1/a$, which is the slope of the Phillips curve, moves closer to zero. So the Phillips curve becomes flat.

$$u = NR + k \cdot a \left(\pi^e - \pi\right), \tag{77}$$

$$\frac{u}{ka} - \frac{NR}{ka} = \pi^e - \pi, \tag{78}$$

$$\pi = \pi^e + \frac{NR}{ka} - \frac{1}{ka}u. \tag{79}$$

The first two terms are the constants and $-1/ka$ is the slope.

A flat Phillips curve offers several advantages to the FED. First, the FED can increase the money supply resulting in misperceptions and an increase in output with little resulting inflation. Few firms will raise prices. Thus the FED can respond aggresively to recessions without much fear of inflation. Further, inflationary expectations are unlikely to shift, because inflation is low and few firms pay much of a penalty for misperceptions. This seems to fit the facts of the mid 1980s to present, a time period of low inflation.

One disadvantage of a flat Phillips curve is that a long recession will occur if the FED seeks to lower inflation. It will take years of misperceptions and high unemployment before firms begin to lower their price increases.