

Chapter 5: Aggregate Supply

5.1. Introduction

We have developed a framework for understanding the demand for goods and services as a function of the aggregate price level (among other things). We now need the other part, that is aggregate supply, and how it depends on the aggregate price level.

Aggregate supply (AS) is the relationship between the quantity of goods and services supplied and the price level. Because the firms that supply goods and services have flexible prices in the long run but sticky prices in the short run, the aggregate supply relationship depends on the time horizon. We need to discuss two different aggregate supply curves: the long-run aggregate supply curve LRAS and the short-run aggregate supply curve SRAS.

5.2. Long-run aggregate supply (LAS): the classical approach

Because the classical model describes how the economy behaves in the long run, we derive the long-run aggregate supply curve from the classical model. The amount of output produced depends on the fixed amounts of capital and labor and on the available technology. To show this, we write

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$$Y = F(K, L)$$

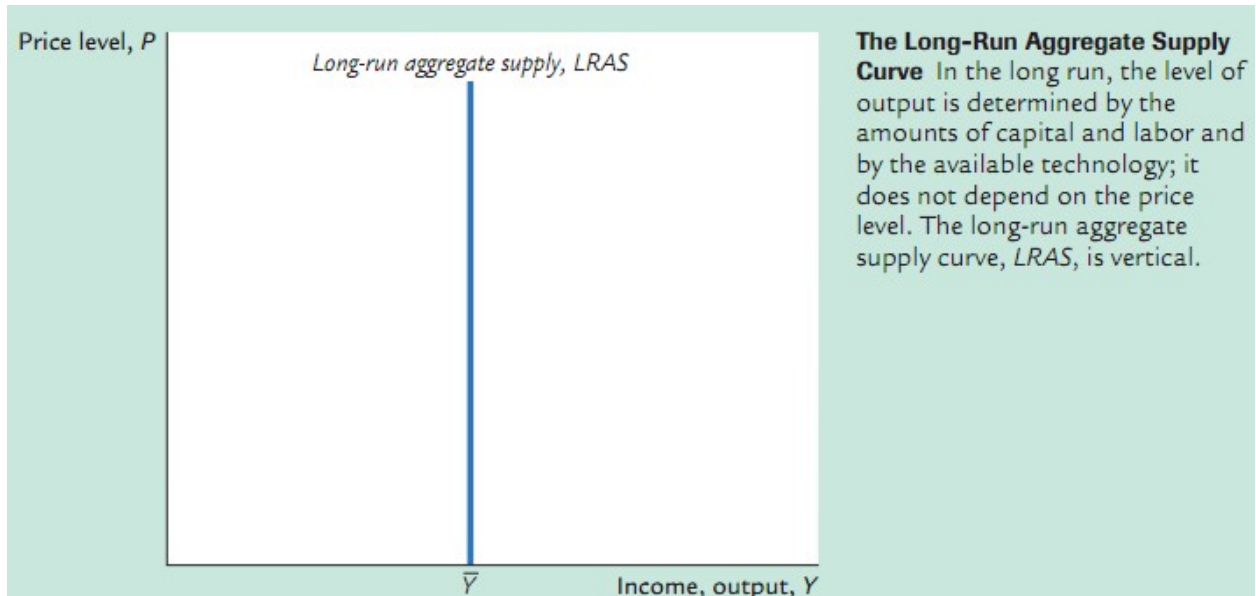
According to the classical model, output does not depend on the price level. To show that output is the same for all price levels, we draw a vertical aggregate supply curve. The intersection of the aggregate demand curve with this vertical aggregate supply curve determines the price level.

If the aggregate supply curve is vertical, then changes in aggregate demand affect prices but not output. For example, if the money supply falls, the aggregate demand curve shifts downward. The economy moves from the old intersection of aggregate supply and aggregate demand, point to the new intersection, where price is lower. The shift in aggregate demand affects only prices. The vertical aggregate supply curves satisfy the **classical dichotomy**, because it implies that the level of output is independent of the

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money supply. This long run level of output, $\bar{Y}$, is called the full-employment or natural level of output. It is the level of output at which the economy's resources are fully employed or, more realistically, at which unemployment is at its natural rate.



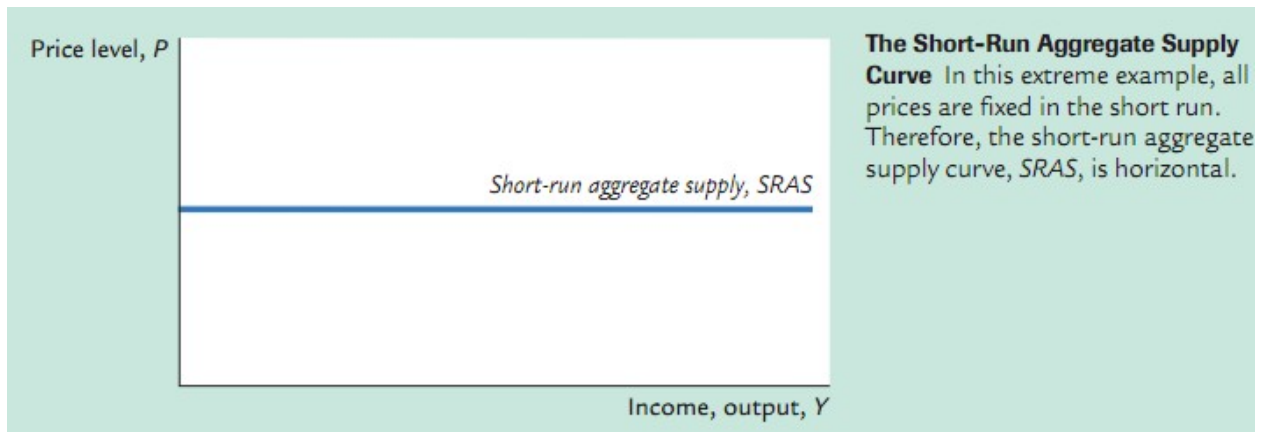
Short-run aggregate supply (SAS): the Keynesian approach

It is the SAS that we will be concerned with, since almost all macroeconomists agree that the Long-run aggregate supply curve is vertical and that business cycles are a short-run phenomenon

The classical model and the vertical aggregate supply curve apply only in the long run. In the short run, some prices are sticky and, therefore, do not adjust to changes in demand. Because of this price stickiness, the short-run aggregate supply curve is not vertical. As an extreme example, suppose that all firms have issued price catalogs and that it is costly for them to issue new ones. Thus, all prices are stuck at predetermined levels. At these prices, firms are willing to sell as much as their customers are willing to buy, and they hire just enough labor to produce the amount demanded. Because the price level is fixed, we represent this situation with a horizontal aggregate supply curve.

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The short-run equilibrium of the economy is the intersection of the aggregate demand curve and this horizontal short-run aggregate supply curve. In this case, changes in aggregate demand do affect the level of output. For example, if the central bank reduces the money supply, the aggregate demand curve shifts inward. The economy moves from the old intersection of aggregate demand and aggregate supply to the new intersection which represents a decline in output at a fixed price level.

Thus, a fall in aggregate demand reduces output in the short run because prices do not adjust instantly. After the sudden fall in aggregate demand, firms are stuck with prices that are too high. With demand low and prices high, firms sell less of their product, so they reduce production and lay off workers. The economy experiences a recession.

Generally, over long periods of time, prices are flexible, the aggregate supply curve is vertical, and changes in aggregate demand affect the price level but not output. Over short periods of time, prices are sticky, the aggregate supply curve is flat, and changes in aggregate demand do affect the economy's output of goods and services.

Models of aggregate supply

There are four basic models of aggregate supply: the sticky price model, the sticky wage model, the imperfect information model and workers misperception model. In all the models, some market imperfection (that is, some type of friction) causes the output of the economy to deviate from the classical benchmark. As a result, the short-run aggregate supply curve is

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upward sloping. Although each of the models takes us down a different theoretical route, each route ends up in the same place. That final destination is a short-run aggregate supply equation of the form

$$Y = Y_1 + a (P - P_e), a > 0$$

Where Y is output, Y_1 is the natural rate of output, P is the price level, and P_e is the expected price level. This equation states that output deviates from its natural rate when the price level deviates from the expected price level. The parameter a indicates how much output responds to unexpected changes in the price level; $1/a$ is the slope of the aggregate supply curve.

5.3.1. The Sticky Price model

The sticky price model emphasizes that firms do not instantly adjust the prices they charge in response to changes in demand. Sometimes prices are set by long-term contracts between firms and customers. Even without formal agreements, firms may hold prices steady in order not to annoy their regular customers with frequent price changes. Some prices are sticky because of the way markets are structured: once a firm has printed and distributed its catalogue or price list, it is costly to alter prices

If we really want to explain why prices may be sticky, we have to think about who actually sets prices and on what basis. In reality, firms generally set the prices at which they want to sell their output. To analyze this situation properly, we need models of *imperfect competition* in which firms have some monopoly power.

Consider the pricing decision facing a typical firm. The firm's desired price p depends on two macroeconomic variables: The overall price P and aggregate demand. A higher price level implies that the firm's costs are higher. Hence, the higher the overall price level, the more the firm would like to charge for its product. In the same way, a higher level of income raises the demand for the firm's product. Because marginal cost increases at higher levels of production, the greater the demand, the higher the firm's desired price.

We write the firm's desired price as

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$$p = P + a(Y - \bar{Y})$$

This equation says that the desired price p depends on the overall level of prices P and on the level of aggregate output relative to the natural rate ($Y - \bar{Y}$). The parameter a ($a > 0$) measures how much the firm's desired price responds to the level of aggregate output.

Now assume that there are two types of firms. Some have flexible prices: they always set their prices according to this equation. Others have sticky prices: they announce their prices in advance based on what they expect economic conditions to be. Firms with sticky prices set prices according to

$$p = P^e + a(Y^e - \bar{Y}^e)$$

For simplicity assume that these firms expect output to be at its natural rate, so the last term, $a(Y^e - \bar{Y}^e)$, is zero. Then these firms set price as

$$p = P^e.$$

That is, firms with sticky prices set their prices based on what they expect others firms to charge.

If s is the fraction of firms with sticky prices and $1 - s$ the fraction with flexible prices, then the overall price level is

$$P = sP^e + (1 - s)[P + a(Y - \bar{Y})]$$

The first term is the price of the sticky-price firms weighted by their fraction in the economy, and the second term is the price of the flexible-price firms weighted by their fraction. Now subtract $(1 - s)P$ from both sides of this equation to obtain

$$P - P + sP = sP^e + P + a(Y - \bar{Y}) - sP - sa(Y - \bar{Y}) - P + sP$$

$$sP = sP^e + a(Y - \bar{Y}) - sa(Y - \bar{Y})$$

$$sP = sP^e + a(1 - s)[Y - \bar{Y}]$$

Dividing both sides by s to solve for the overall price level:

$$P = P^e + \frac{a(1 - s)}{s}[Y - \bar{Y}]$$

The two terms in this equation are explained as follows:

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When the firms expect a high price level, they expect high costs. Those firms that fix prices in advance set their prices high. These high prices cause the other firms to set high prices also. Hence, a high expected price level leads to a high actual price level P .

When output is high, the demand for goods is high. Those firms with flexible prices set their prices high, which leads to a high price level. The effect of output on the price level depends on the proportion of firms with flexible prices.

Hence, the overall price level depends on the expected price level and on the level of output.

From the price equation above we can derive the aggregate supply equation using some algebraic manipulation.

Letting $\frac{a(1-s)}{s}$ to be n , the price equation above can be written as

$$P = P^e + n[Y - \bar{Y}], \text{ and we can solve for } Y - \text{i.e.}$$

$$nY = n\bar{Y} + P - P^e$$

$$Y = \bar{Y} + \frac{1}{n}(P - P^e)$$

$$\text{Letting } \frac{1}{n} \text{ to be equal to } \alpha$$

$$Y = \bar{Y} + \alpha(P - P^e)$$

Like the other models, the sticky-price model says that the deviation of output from the natural rate is positively associated with the deviation of the price level from the expected price level.

5.3.2. The Sticky Wage Model

The first argument we will look at has to do with the operation of the labor market. In particular, some economists have argued that there are factors that make the nominal wage inflexible in the short-run. We will see what these factors are and the implications this would have for the whole economy.

Contract versus Auction Markets

Labour market is not an auction market, instead is a contract market. That is, suppliers of labour services and buyers of labour services entered into contracts which set the values of various employment related parameters. One important such parameter is the value of the nominal wage. Typically the contract will also cover working conditions concerning hours of work, redundancy, grievance procedures, etc.

Such contracts are not typically renegotiated instantaneously if the economy experiences a “shock” (although in principle renegotiation clauses could be included in a contract) because it would be terribly expensive to do so. Thus contracts are only *renegotiated infrequently*.

When the contract is negotiated firms and suppliers have to guess what will happen to the price level for the period of the contract. Both groups will have some expectation about:

1. The future price level
2. Some target level of the real wage

The contract is successfully negotiated when the two groups have *common expectations* about the price level and a common target real wage rate. The common target real wage will be the one that clears the labour market if the actual price level equals the forecast price level.

Furthermore, many contracts are claimed to have the feature that workers agree to supply the quantity of labour demanded by firms, either through things like overtime or working fewer hours a week or being made redundant if necessary. This would imply that given a contracted nominal wage, that the demand for labour determines the actual quantity of labour traded over the lifetime of the contract, which changes as the state of the economy changes.

Note: there is also some evidence that the nominal wage is particularly inflexible downwards (found by an economist called Bewley). That is, firms do not like to reduce nominal wages of workers. This is claimed to occur

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because of workers feeling that these cuts reduce their status and are an insult to them, which lowers their morale, and their productivity.

The sticky-wage model shows what a sticky nominal wage implies for aggregate supply. To preview the model, consider what happens to the amount of output produced when the price level rises. When the nominal wage is stuck, a rise in the price level lowers the real wage, making labor cheaper. The lower real wage induces firms to hire more labor. The additional labor hired produces more output. This positive relationship between the price level and the amount of output means that the aggregate supply curve slopes upward during the time when the nominal wage cannot adjust.

The model

It is assumed that firms and workers negotiate contracts and fix the nominal wage before they know what the price level will turn out to be. The workers and firms set the nominal wage W based on the target real wage q and on their expectation of the price level P^e . The nominal wage they set is

$W = w \times P^e$ i.e. Nominal wage = Target Real Wage X Expected Price Level.

After the nominal wage has been set and before labor has been hired, firms learn the actual price level P . The real wage turns out to be

$$\frac{W}{P} = w \times \frac{P^e}{P}$$

$$\text{I.e. Real wage} = \text{target real wage} \times \frac{\text{expected price level}}{\text{actual price level}}$$

It turns out that:

If $P = P^e$ then unemployment and output are at their natural rates

If $P > P^e$ then Real wage is less than its target, so firms hire more workers and output rises above its natural rate.

If $P < P^e$ then Real wage exceeds its target, so firms hire fewer workers and output falls below its natural rate.

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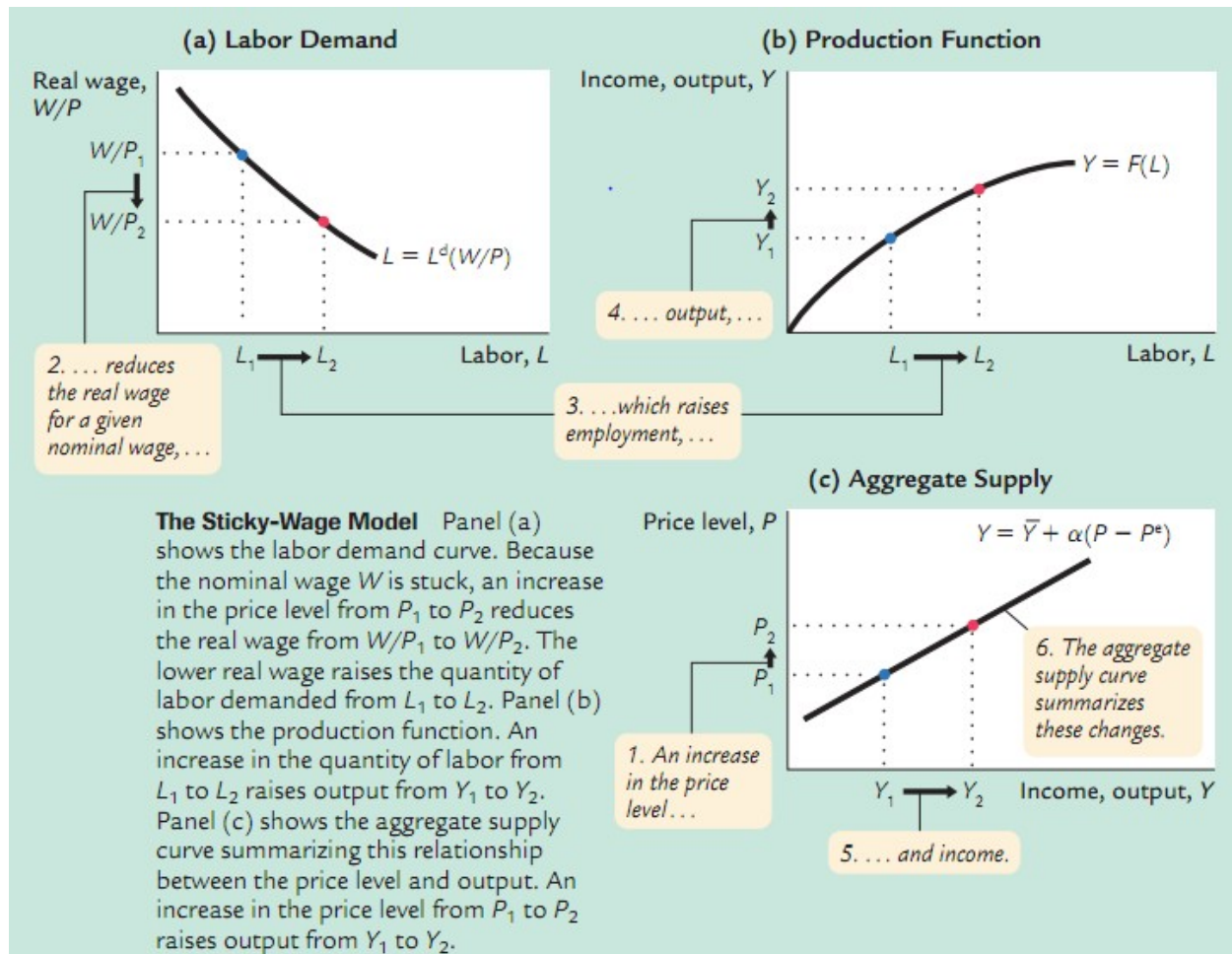
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The other assumption of the model is that the quantity of labour traded at a point in time once the contract is agreed is given by the labour demand function that is:

$$L = L^d(M/P)$$

Output is determined by the production function:

$$Y = f(L)$$



Because the nominal wage is sticky, an unexpected change in the price level moves the real wage away from the target real wage, and this change in the real wage influences the amounts of labor hired and output produced. The aggregate supply curve can be written as:

$$Y = \bar{Y} + \alpha(P - P^e).$$

Implies that the real wage should be counter-cyclical, should move in the opposite direction as output during business cycles:

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In booms, when P typically rises, real wage should fall. In recessions, when P typically falls, real wage should rise. This prediction does not come true in the real world.

5.3.3. Imperfect information Analysis

The other explanation for the upward slope of the short-run aggregate supply curve is called the imperfect-information model. Unlike the sticky-wage model, this model assumes that markets clear that is, all wages and prices are free to adjust to balance supply and demand. In this model, the short-run and long-run aggregate supply curves differ because of temporary misperceptions about prices.

The imperfect-information model assumes that each supplier in the economy produces a single good and consumes many goods. Because the number of goods is so large, suppliers cannot observe all prices at all times. They monitor closely the prices of what they produce but less closely the prices of all the goods they consume. Because of imperfect information, they sometimes confuse changes in the overall level of prices with changes in relative prices. This confusion influences decisions about how much to supply, and it leads to a positive relationship between the price level and output in the short run.

Consider the decision facing a single supplier wheat farmer, for instance. Because the farmer earns income from selling wheat and uses this income to buy goods and services, the amount of wheat she chooses to produce depends on the price of wheat relative to the prices of other goods and services in the economy.

If the relative price of wheat is high, the farmer is motivated to work hard and produce more wheat, because the reward is great. If the relative price

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of wheat is low, she prefers to enjoy more leisure and produce less wheat. Unfortunately, when the farmer makes her production decision, market closely and always knows the nominal price of wheat. But she does not know the prices of all the other goods in the economy. She must, therefore, estimate the relative price of wheat using the nominal price of wheat and her expectation of the overall price level.

Consider how the farmer responds if all prices in the economy, including the price of wheat, increase. One possibility is that she expected this change in prices. When she observes an increase in the price of wheat, her estimate of its relative price is unchanged. She does not work any harder. The other possibility is that the farmer did not expect the price level to increase (or to increase by this much). When she observes the increase in the price of wheat, she is not sure whether other prices have risen (in which case wheat's relative price is unchanged) or whether only the price of wheat has risen (in which case its relative price is higher). The rational inference is that some of each has happened. In other words, the farmer infers from the increase in the nominal price of wheat that its relative price has risen somewhat. She works harder and produces more.

Our wheat farmer is not unique. When the price level rises unexpectedly, all suppliers in the economy observe increases in the prices of the goods they produce. They all infer, rationally but mistakenly, that the relative prices of the goods they produce have risen. They work harder and produce more. To sum up, the imperfect-information model says that when actual prices exceed expected prices, suppliers raise their output.

The model implies an aggregate supply curve that is now familiar: $Y = Y_1 + a(P - P_e)$.

Output deviates from the natural rate when the price level deviates from the expected price.