Aggregate Supply

The supply of output depends on the behavior of producers. Producers choose the quantity of inputs to employ. These inputs produce output and we assume that producers choose their inputs to maximize their profits. To study this decision, we focus on a single input, work effort. Our conclusions would not change if we increased the number of inputs. We compare the benefit of hiring an additional unit of work effort with the cost of hiring an additional unit of work effort. We begin with the benefit side.

*the marginal product of labor*

The firm hires additional work effort in order to produce output. The firm sells the output to garner additional revenue. The change in total output brought about by a unit change in work effort is called the marginal product of labor (MPL). We write the marginal product as

$$MPL^i = \frac{\Delta Y^i}{\Delta L^i}$$

We have placed a superscript over MPL to indicate that we are examining the behavior of an individual producer.

The marginal product of labor has several important properties. First, given the levels of other inputs, the MPL diminishes as the quantity of work effort increases. The diminishing marginal product occurs because each additional unit of work effort has less of the given inputs with which to work. For example, suppose you have 10 workers and 80 hours of computer time so that the average worker gets 8 hours of computer time. Now if you add an additional worker, the new worker (and the average worker) only have $80/11 = 7.27$ hours of computer time. Since the new worker has less computer time, the new worker will add less to output than her predecessors.

Several factors can change the marginal product of labor. For example, if better software is placed on the computers, new workers will be more productive. If new computers are added, this will raise the marginal product. For example, if the firm purchases another 20 hours of
computer time, the new worker will have $100/11 = 9.09$ hours of time, instead of $7.27$ hours, and this increase can be expected to raise her productivity. In general, an improvement in technology or increase in the capital stock will permanently increase labor’s marginal product.

There are some factors that will temporarily change the MPL. Bottlenecks, dislocations, and labor strikes can temporarily interrupt production and reduce labor's productivity. A temporary increase in the price of an important input, such as energy, can also impair labor's productivity. Other factors, such as weather, may also affect the MPL. We can summarize our discussion of the determinants of the MPL with the table

<table>
<thead>
<tr>
<th>Permanent</th>
<th>Temporary</th>
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<tbody>
<tr>
<td>technology</td>
<td>+ bottlenecks, dislocations, strikes</td>
</tr>
<tr>
<td>capital stock</td>
<td>+ temporary increases in the price of energy (or other important natural resources)</td>
</tr>
<tr>
<td>natural resources</td>
<td>+ good production weather</td>
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</tbody>
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This list is not exhaustive. Other shocks, such as changes in laws or culture, may permanently alter productivity and others yet, such as natural catastrophes, may temporarily affect the MPL.

**the hiring decision**

A producer who hires an additional unit of work effort receives an additional $\text{MPL}^i$ units of output. Each unit of output sells for the price $P^i$ and so the firm receives the additional revenue $P^i \cdot \text{MPL}^i$ from an additional unit of work effort. This additional revenue is called the marginal revenue product of labor. The additional cost of hiring another unit of labor is the wage, $W$. In principle, the wage is not just the wage or salary paid to the worker, but also includes other costs such as the employers contribution to social security, unemployment compensation, and the value of fringe benefits.

Consider the case where

$$P^i \cdot \text{MPL}^i > W$$
In this case, the benefit of adding an additional unit of work effort exceeds the cost, so the firm should continue hiring. On the other hand, if

\[ P^i \cdot MPL^i < W \]

then the benefit of hiring an additional unit of work effort falls short of the additional cost, and the firm should reduce (or not hire in the first place) its work effort. The producer will be happy with their level of work effort when

\[ P^i \cdot MPL^i = W. \]

In short, profit maximizing producers will hire an amount of work effort that makes the marginal revenue product equal the wage.

It turns out to be convenient to put this relationship in terms of the relative price and real wage, so we divide both sides of this equation by the price level, \( P \). This gives us

\[ \left( \frac{P^i}{P} \right) \cdot MPL^i = \frac{W}{P} \]

and reveals that the producer's decision depends on her relative price, \( P^i/P \), the real wage, \( W/P \), and the marginal product of labor.

**shocks to the hiring decision**

Changes in any of these factors will change the hiring and production decision. For example, suppose the relative price of this producer's output increases. Initially, this makes \( (P^i/P) \cdot MPL^i > W/P \) and the firm will increase its hiring and so also the output it produces. We conclude that an increase in the relative price that a firm charges leads to an increase in the output of that producer.

Now suppose there is a temporary increase in the price of energy. Since workers have less of this natural resource with which to work (and probably less capital as well since it is more costly to power machines), the marginal product of labor will fall. Initially this makes \( (P^i/P) \cdot MPL^i < W/P \) and firms will fire or layoff work effort. This adjustment implies that
output will fall in the face of a temporary change in the price of energy. In general, shocks that reduce the marginal product of labor will cause output to decline, while shocks that improve labor's marginal product will cause output to increase.

Suppose workers experience a shift in preferences toward leisure. Workers will begin to exit the work force and this reduction in labor supply will drive the real wage up. This increase in the real wage will initially cause \((P_i/P) \cdot MPL_i < W/P\) and firms will hire fewer workers and output will decline until the equality is restored. Alternatively, suppose an economy experiences a large wave of immigration. The additional workers will increase the supply of work effort and drive real wages down. This reduction in the real wage will encourage firms to hire workers and raise real output. Finally, suppose unions are successful in raising the real wage in important sectors of the economy. This raise will lead firms to hire fewer workers and output will fall.

*the long run aggregate supply curve*

In the long run all prices are flexible and all price information is known. That is to say, all decisions are based on correct information in the long run. Now suppose in the long run all prices, wages, and nominal variables double. What is the effect of this price change on output? If all prices and wages double, then there will be no change in the relative price of any firm or in the real wage. Since marginal products do not depend on prices, so there will be no change in any MPL. In this case, no one's hiring decision will be disturbed and no firm will change its work effort or output decision.

![Figure 1: The Long Run Aggregate Supply Curve](image)
A picture of this result is shown in Figure 1. At the initial price level $P_1$, output of all producers is $Y^*$. When all prices double to $2P_1$, output stays at $Y^*$. This result implies that in the long run output does not depend on the price level. The vertical LAS curve in Figure 1 represents this independence. The vertical LAS doesn't mean that the LAS can never move. For example, an improvement in technology or the accumulation of capital will cause the LAS curve to shift out and to the right.

**the short run aggregate supply curve**

In the short run, decisions are not based on complete information. In particular, we take the short run to be a period short enough that producers do not know the overall price level, $P$. Instead they form some expectation or perception, $P^e$, about the price level. We want to know what happens to output when the price level unexpected increases, say from $P_1$ to $P_2$. Since the price level has increased, the typical producer sees their price $P^i$ increase, but since this increase is unexpected, they believe the price level has not changed, or not changed by much, and so believe their relative price, $P^i/P$, has risen. We know that when producers believe their relative price has increased, they respond by increasing their output. This misperception occurs across the board so the typical or average firm increases their output and so aggregate output increases as well, from $Y^*$ to $Y^*_2$ in Figure 2.

![Figure 2: The Short Run Aggregate Supply Curve](image-url)
Of course, output will not stay at $Y_2$ permanently. Sooner or later, producers will learn that all prices have risen so that the increase in their relative price was but an illusion, and output will return to its long run level, $Y^*$. 

We consider the relationship between the long run and short run aggregate supply curves in Figure 3. Suppose we begin in a long run situation. In the long run, peoples expectations are correct, so currently people expect the price level to be $P_1$. This means the short curve, $AS_1$, is drawn on the assumption that $P^e = P_1$. Now suppose that the price level unexpectedly rises to $P_2$. In the short run, this causes an increase in output to $Y_2$. This increase in price is interpreted by firms as an increase in their relative price, hiring increases, and total output increases to $Y_2$. Firms eventually learn that they were mistaken. Once they realize their relative price has not increased, they cut back on work effort and output returns to $Y^*$. In Figure 3 the realization of the firm that all prices are higher causes a shift in the short run aggregate supply curve back and to the left. When expectations have fully adjusted to the price level $P_2$, so that $P^e = P_2$, output returns to $Y^*$, and the short run aggregate supply curve becomes $AS_2$.

**shocks to short run aggregate supply**

James Hamilton, an economist at the University of California at San Diego, has shown that all but one of the post World War II recessions was immediately preceded by or concurrent
with a sharp increase in the price of oil. Ever since the OPEC oil price shocks of the 1970s economists in general have acknowledged the role of supply shocks in the economy.

In our model a temporary increase in the price of oil lowers the marginal product of labor. As we noted earlier, at any given price level this decrease causes firms to reduce their work effort and output declines. This change implies that the AS curve shifts back and to the left. This shift is depicted in Figure 4.

Not all supply shocks, even temporary ones, are bad. Suppose, for example, the weather takes a turn for the better. Temperatures and rain are just perfect for agriculture and construction. In this case, the marginal products of labor will increase, hiring will expand, and output will increase. This will cause the AS curve to shift out and to the right.

**summary**

Work effort and output are determined by the profit maximizing decision of firms and the willingness of households to supply work effort. If firms perceive an increase in their relative price, it becomes profitable to hire additional workers, and work effort and output will increase. An increase in the marginal product of labor will also make it profitable to increase work effort and output. Changes in labor supply that drive up real wages will make it unprofitable to maintain the same work effort, so firms will reduce work effort and output will fall.