Chapter 14

Competitive Market Equilibrium

We have spent the bulk of our time up to now developing relationships between economic variables and the behavior of agents such as consumers, workers and producers.\footnote{This chapter requires a good understanding of consumer theory as exposited in Chapters 2, 4 through 6 and Sections 9A.1 and 9B.1 of Chapter 9 while making only a brief reference to consumer theory as it pertains to labor and capital markets. It also relies on a good understanding of cost curves as covered in Sections 13A.1 and 13B.1 of Chapter 13.} To be more precise, we began by developing “models” — simplified versions of reality — in which we then assumed that economic agents “do the best they can given their economic circumstances.” This process of “optimizing” results in the relationships between prices and behavior — such as demand curves, supply curves, and cross-price demand and supply curves. And it is these relationships we can now use to take the economic analysis to its final step: describing how the economic environment (that agents take as given) arises within the model as many individuals optimize. This economic environment is called a competitive equilibrium.

In this and the next chapter, we will focus on a “market” or an “industry” — terms we will use interchangeably. Firms are considered to operate in the same market (or industry) if they produce the same goods — and the market (or industry) is considered “competitive” if all firms are sufficiently small such that they cannot individually manipulate the economic environment. We will discover the important role played by equilibrium market prices in such competitive industries. Perhaps the most fascinating aspect of such prices is that they emerge “spontaneously” without anyone planning the process. Thus, the equilibrium we are about to analyze is a “decentralized market equilibrium” in the sense that it comes into being without central planning and only from the decentralized decisions of individuals who have no control over — or even awareness of — the process. In fact, production, \textit{guided by self-interest and the emergence of market prices}, occurs in many cases without most of the participants in the process even knowing the nature of the final product they are producing. And we will see in Chapter 15 that the “spontaneous order” that is generated by this combination of self-interest and prices can create enormous benefits for society.

The insights emerging from the analysis in chapters 14 and 15 are perhaps the most significant to come out of the discipline of economics. They derive from an internally consistent model in which the counterintuitive happens: \textit{order emerges without planning, and self-interest does not (necessarily) conflict with the “social good”}. The same model, as we will see in upcoming chapters, also illustrates that real-world frictions may create circumstances in which the order that emerges entails conflict between private self interest and the social good. We will thus \textit{begin the process}...
of defining a role for non-market institutions in society. Put differently, the insights that we will discuss in this and the next chapter have come to define most aspects of the discipline of economics as it searches for non-market institutions that harness self-interest for the social good when market forces by themselves do not adequately do so.

14A Equilibrium: Combining Demand and Supply Curves

We will begin by illustrating the concept of a competitive equilibrium in the context of one industry that is composed of many small producers who compete with one another for the business of many consumers. We therefore continue to assume that each economic agent is “small” relative to the industry and the economy and that, as a result, no economic agent has sufficient power to, by herself, alter the equilibrium. Rather, it is rational for each economic agent to simply take the world as given and do the best she can within that world — even though it is from the combination of all the individual optimizing decisions that the equilibrium and thus the economic environment springs. In later chapters we will investigate how our understanding of an equilibrium changes when some economic agents are “large” in the sense that their behavior influences the economic environment in a significant way. While there is no need for “small” economic agents to think strategically about the impact of their behavior on the economic environment, such strategic thinking will become central to understanding the behavior of “large” agents.

14A.1 Equilibrium in the Short Run

As we will see shortly, an equilibrium in an industry will be defined by the intersection of market (or industry) demand and supply curves. Deriving these curves for a particular industry in the short run is easy in that it simply involves adding up the individual demand and supply curves that are generated from individual optimization problems. For instance, in panel (a) of Graph 14.1, we plot two individual demand curves $D_1$ and $D_2$ and a third market demand curve $D_M$ that would result if these were the only two consumers in the market. At a price above $90$, individual 2 demands none of the output $x_1$ — which implies that individual 1 is the only consumer in the market, and her demand curve therefore represents the market demand curve (for $p > 90$). For prices below $90$, however, both consumers demand some of the output. For instance, at a price of $80$, consumer 1 demands 20 units of $x_1$ while consumer 2 demands 10 units — for an overall market demand of 30 units. A similar process for adding up individual supply curves to get a short run market supply curve $S_M$ is illustrated in Graph 14.1b, with only firm 2 supplying output for prices below $40$ and both firms supplying output for prices above $40$. The process of adding up more than two demand or supply curves is a straightforward extension of this.

We will see a little later in this chapter that market supply is derived somewhat differently in the long run, and that “adding up supply curves” is the correct way of finding market supply curves only in the short run. For now, however, we will stick with the short run curves and investigate the resulting short run equilibrium. We will also see in Chapter 15 that we have to be careful about what precise interpretations we give to market demand curves.

14A.1.1 Short-Run Equilibrium in the Goods Market

Market (or industry) demand and supply curves are powerful tools that help us predict the terms under which consumers and producers will interact in a competitive world — and how these terms
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Graph 14.1: Adding up Demand and Supply Curves

will change as underlying institutional and technological constraints change. Put differently, these curves help us predict the economic environment that governs individual behavior. If you have ever taken an economics course before, you have almost certainly been exposed to this as demand and supply curves were used in your course to describe equilibrium price and quantity in a market. Our work leading up to this chapter has informed us about what is behind this type of analysis – and this work will help us determine what we can and cannot say from economic analysis that relies on market demand and supply curves.

Consider, for instance, the sequence of graphs in Graph 14.2. In panel (a) we begin with the basic building blocks of the consumer model — indifference curves (representing tastes) and budgets (representing different economic environments as the price for good $x_1$ changes). From the budgets in (a), we can then derive the consumer’s demand curve $D_i$ for $x_1$ in panel (d) as directly arising from many different optimal points at different prices in panel (a). If we were to conduct the same analysis for all consumers in the market, we would then be deriving many different demand curves which we could add up to arrive at the market demand curve $D^M$ in panel (e) (with $\sum D_i$ in the graph simple read as “the sum of all individual $D_i$ demand curves”).

On the producer side, we are similarly starting with the fundamentals of the producer model in panel (b) — the technological constraint represented by the producer choice set (which is modeled here using a single-input model). Panel (c) then derives the total cost curve (assuming a particular input price) from the production frontier, allowing us to derive the average and marginal cost curves for a single firm in panel (f). The portion of the marginal cost curve above $AC$ is then a profit maximizing firm’s supply curve $S^J$. We could then repeat this analysis for each of the firms in the industry that produces output $x_1$ — thus arriving at many individual supply curves that we can simply add up to derive the market supply curve $S^M$ in panel (e).

Focusing then on panel (e), we have a simple demand and supply picture of the market for good $x_1$ — with the intersection of the two curves representing the market equilibrium that results in equilibrium price $p^*$ and equilibrium output quantity $X_1^*$. If price were to rise above this equilibrium, more of $x_1$ would be supplied than demanded, which would cause producers who are seeing their
inventories build up to individually lower prices in order to sell their goods and make themselves better off. Thus, price would drop. Similarly, if price were ever below $p^\ast$, consumers would demand more than producers are willing to supply — giving an incentive to each producer to raise price and have fewer people lining up in front of the stores to buy goods the producers don’t have. Thus price would rise. What makes $p^\ast$ an equilibrium price is the fact that, if price is anything other than $p^\ast$, there is a natural tendency of individual producers to adjust price toward $p^\ast$. Put differently, only when all firms charge $p^\ast$ does no producer have an incentive to change her price.

Without any particular individual intentionally directing the formation of $p^\ast$, the natural tendency is in place for $p^\ast$ to emerge as individual consumers and producers simply try to do the best for themselves. Once $p^\ast$ is formed, it then directs individual actions — telling each consumer how much she will consume and each producer how much she will produce. Thus the market signals consumers and producers through the equilibrium price — coordinating their actions in a decentralized way that, as we will see in Chapter 15, is “efficient” under some circumstances. In the case graphed here, the signal $p^\ast$ tells the consumer we modeled to consume $x_1^1$ and the producer...
we modeled to produce $x^*_1$, with the market as a whole producing $X^*_1$.

14A.1.2 Short-Run Equilibrium in Input Markets

In an analogous way, a decentralized market equilibrium also emerges in the labor market when different producers in many different industries compete for workers. Graph 14.3 illustrates this, with producers facing production choice sets in panel (a) that result in marginal revenue product curves in panel (d), and with a portion of this marginal revenue product curve composing the short run labor demand curve for each producer. Workers, on the other hand, begin with preferences over leisure and consumption in panel (b), with different wages resulting in different optimal leisure choices. Panel (c) then illustrates a typical “leisure demand” curve, with panel (f) representing the implied labor supply curve for this consumer. Adding up the individual labor demand curves of firms and labor supply curves of workers, we arrive at a market demand and supply curve for the particular type of labor modeled here, with the intersection of the two resulting in an equilibrium wage rate $w^*$ that sends a signal back to workers and producers. This signal causes the producer we modeled to hire $\ell^*_j$ worker hours and the worker we modeled to sell $\ell^*_i$ labor hours, with the market as a whole trading $L^*$ labor hours across the many industries that hire the types of workers modeled in the series of graphs.

Note that, while the demand curve in output markets comes from all those consumers who consume the output we are modeling, the demand curve in labor markets comes from all those producers who hire the kind of labor we are modeling. Thus, in our labor market graph, we are adding up labor demand curves from firms that could potentially be producing very different outputs but are all demanding the same kind of labor input. On the supply side, we considered in our output market only those firms that produce the particular output we are modeling, just as in the labor market we only consider those workers who supply the type of labor we are modeling.

Exercise 14A.1 Can you explain why there is always a natural tendency for wage to move toward the equilibrium wage if all individuals try to do the best they can?

In the capital market, we could similarly derive a demand curve for capital by producers except that it would be a more long run demand curve if capital for firms is fixed in the short run. The supply curve would emerge from consumers making tradeoffs between consuming now or consuming in the future – and thus saving for future consumption – and the equilibrium price that emerges in the market is the equilibrium interest rate.

14A.2 A Market (or Industry) in Long Run Equilibrium

As we glance at Graphs 14.2 and 14.3, we might at first think that not all that much changes in the graphs when we think of the long run rather than the short run. After all, in our exploration of the difference between short and long run producer behavior in Chapter 13 we simply concluded that output supply and input demand curves will tend to be shallower in the long run than in the short run (with higher “exit” prices than short run “shut down” prices) — and it might therefore seem that we just have to draw our producer pictures a little bit differently to turn our previous two graphs into long run equilibrium pictures. This is, however, not the case — because, in addition to changing their input mix more in the long run than in the short run, firms have the opportunity to enter or exit industries in the long run. This implies that, while the number of firms in an industry is fixed in the short run (even if some of them perhaps shut down), that number is variable in the long run as more or fewer firms might exist in response to changing market conditions.
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Formally, we thus define the “long run” for a firm as the time it takes for a firm to adjust the input levels that are fixed in the short run, and we define the “long run” for an industry as the time it takes for firms to be able to enter or exit the industry. Notice, however, that the fundamentals that underlie these two definitions of “long run” derive from a similar source. A firm may have a fixed level of capital (such as a fixed factory size) in the short run, and this keeps it from adjusting its capital as conditions change until the long run. That same firm also cannot exit an industry – or enter a new industry – in the short run for exactly the same reason: It is currently locked into a fixed level of capital that can only be changed in the long run. Thus, when we think of the “long run” for an industry as the time it takes for firms to enter or exit, we are usually thinking of the time it takes to adjust capital – to dispose of the factory if a firm exits or acquire one if a firm enters. In this sense, there is usually a nice symmetry between what we think of as the “long run” for a firm and for an industry. The only difference is that some firms might be locked into their current capital for shorter periods than others – and the “long run” for an industry does not truly emerge until sufficient numbers of firms have had the opportunity to enter or exit.
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14A.2.1 Revisiting the Entry/Exit Decision

In Chapter 13, we drew the distinction between a firm “shutting down” in the short run and “exiting an industry” in the long run. The short run was defined as the time during which one of the firm’s inputs (capital, in particular) is fixed — and during which the cost associated with the fixed input is a fixed expenditure and a sunk cost. The firm’s decision whether to produce in the short run depended on the firm’s ability to cover its short-run economic costs — which don’t include the expense on fixed inputs or other types of fixed expenditures (like license fees). The firm’s short run supply curve then arises from the (short run) $MC$ curve above the short run $AC^{SR}$ curve. In the long run, however, the firm needs to cover all its economic costs – which will now include the costs of inputs that are fixed in the short run as well as other fixed costs (like license fees) – and thus will enter an industry if it can do so and make some profit and will exit an industry if it cannot cover these costs. Thus, in the long run, a firm will exit the industry if price falls below the long run $AC$ curve.

Suppose, for instance, that we consider the case in which one of the inputs is fixed in the short run or, alternatively, there is a fixed cost associated with an annual license to operate my business. Graph 14.4 then illustrates the resulting $AC^{SR}$ curve representing all my economic costs in the short run when the fixed input or license expense is sunk, and the $AC$ curve that represents my long run economic costs that take into account the cost of fixed inputs or of renewing my annual license. In the short run, I will operate my business so long as price is not below $p'$, the lowest point of the short run $AC^{SR}$ curve, while in the long run I will exit if price falls below $p$, the lowest point of my long run $AC$ curve. In between these prices, there exists a range of prices that allow me to cover my short run costs but not my fixed expenses — sufficient to keep me open in the short run but not sufficient to keep me from exiting in the long run. If price is above $p$, on the other hand, I can make (long run) positive profits, which implies that I will produce and will enter the industry if I am not already in it.

Graph 14.4: Shutting Down versus Exiting and Industry

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Exercise 14A.2 Suppose your firm only used labor inputs (and not capital) and that labor is always a variable input. If your firm had to renew an annual license fee, would the AC<sub>SR</sub> and the long-run AC curves ever cross in this case?

Exercise 14A.3 Why might the AC<sub>SR</sub> and the long-run AC curves cross when the difference emerges because of an input (like capital) that is fixed in the short run? (Hint: Review Graphs 13.2 and 13.3.)

Exercise 14A.4 Explain why the MC curve in Graph 14.4 would be the same in the long and short run in the scenario of exercise 14A.2 but not in the scenario of exercise 14A.3.

14A.2.2 Long Run Equilibrium Price when All Producers Are Identical

Now suppose there are many producers of “hero cards” like me. Each one of us wants to make as much profit as possible, and so we constantly look around for the best opportunities. In the short run, we are stuck in the particular industries in which we are currently producing, but in the long run we can switch if new opportunities open up. Put differently, we can keep track of the AC curves in many different industries, and when we notice that AC is below output price in some industry, we know there is profit to be made — and we enter. Some of us might be a little faster at doing this than others, or some of us might notice opportunities a bit sooner than others. But whatever determines the sequence of which one of us pounces on new opportunities first, the fact that we all eventually will pounce on these opportunities means that together we will shift the market supply curve as we enter — and we will keep shifting it as long as there are profits to be made.

Consider, for instance, Graph 14.5. Suppose that the market for good x finds itself in the short run equilibrium represented by the intersection of the blue market demand and supply curves with equilibrium price <i>p</i>′ in panel (a). This price signal tells each producer to produce <i>x</i>′ of output along her (green) supply curve as illustrated in panel (b) — which generates a long run profit equal to the shaded blue area in panel (b) for each firm (assuming we have included all the costs relevant for the long run in the AC curve). Remember from our discussion of economic profit in Chapter 11 that positive profit — no matter how small — means that a producer is doing better here than she could do anywhere else. Thus, since we are assuming for now that all producers are identical, there are producers who currently operate in a different industry and see that they could make positive profits in the industry that produces x — which logically implies that they are making negative profit in their current industry.

Given the current price <i>p</i>′, there is thus an incentive in place for additional firms to enter the industry — with each entry shifting the short run market supply curve just a little bit in panel (a). The incentive for firms to enter remains as long as (long run) profits in the industry are positive and thus as long as price remains above <i>p</i>∗. Thus, the shift in short run supply curves in panel (a) of the graph will not stop until we arrive at the green short run supply curve when the price has reached the lowest point of each individual producer’s long run AC curve. Once we have reached this new short run equilibrium, each producer in the industry makes zero (long-run) profit, eliminating any incentive for any new producers to enter and stopping short of giving an incentive to current producers to exit.

We could have drawn a similar sequence of shifts in short run supply curves but in the opposite direction if we had drawn the original intersection of the blue supply and demand curves in panel (a) at an equilibrium price below <i>p</i>′. In that case, the shift in short run supply curves would have resulted from the exiting of firms from the industry in which firms were experiencing negative profits — i.e. where firms could be doing better elsewhere. Thus, whenever producers face identical
costs and the short run equilibrium output price lies anywhere other than at the lowest point of (long-run) AC, entry and exit of firms will drive the long run price of output to that lowest point. In panel (c) of the graph, the long run market supply curve is then horizontal and lies at the lowest point of AC. Put differently, the market will, in the long run when firms can enter and exit, supply any quantity that is demanded at the price $p^*$ that falls at the lowest point for AC. This implies that the long run market (or industry) supply curve arises not from adding up individual supply curves but rather from the entry and exit decision of firms that will drive price to the point where long run profit is equal to zero – i.e. where price settles at the lowest point of the long run AC curve for individual firms.

Exercise 14A.5 Can you draw the analogous sequence of graphs for the case when the short run equilibrium price falls below $p^*$?

Exercise 14A.6 How does the full picture of equilibrium in Graph 14.2 look different in the long run?

14A.2.3 Long Run Equilibrium in Labor Markets

While entry and exit of firms shape the difference between long and short run equilibrium in the output market for a particular industry’s good, the same is generally not true of labor market equilibria, at least not when a particular industry is small relative to the whole economy. This is because the “labor market” in Graph 14.3 is composed of firms from many different industries, and conditions that affect one particular industry will tend not to have an impact on the economy-wide labor market when an industry is small relative to the economy as a whole. Thus, whether some firms are entering or exiting a particular industry will not be perceptible as causing a shift in labor demand.

Entry and exit may play a role on the labor supply curve if an increase or decrease of wages for a particular type of labor alters perceptions sufficiently to cause workers to retrain or new workers to choose training differently than in the past. For instance, over the past 10 years, there has been a substantial increase in salaries paid to young PhD economists. While it is not easy to simply
“retrain” from being a non-economist to being an economist, one would expect that, in the long run, more college seniors might choose to get a PhD in economics when salaries for young economists have risen — thus increasing the supply of economists and driving down wages in the long run. Long run wages in each labor market thus have to have a relationship with the relevant opportunity costs of workers, a topic you can (if it interests you) study in much more detail in a labor economics course.

Exercise 14A.7 How would you think the time-lag between short and long run changes in labor markets is related to the “barriers to entry” that workers face, where the barrier to entry into the PhD economist market, for instance, lies in the cost of obtaining a PhD.

14A.2.4 Long Run Market Supply when Producers Differ

In deriving the flat long run industry supply curve in Graph 14.5c, we explicitly assumed that all producers had access to the same technology — and thus faced the same AC and MC curves. For the argument (that the long run market supply curve is horizontal) to hold, it is actually only necessary to assume that all firms have technologies that give rise to long run AC curves that reach their minimum at the same dollar value — regardless of what the remainder of the curves look like.

Exercise 14A.8 Can you explain why the previous sentence is true?

Now suppose that different producers have access to very different technologies. It might then be true that, at a given output price, some producers are able to make a profit while others are not. This in turn has implications for who will enter and who will exit an industry as market conditions change, and it has implications for the shape of the long run market supply curve.

Consider, for instance, the short run market equilibrium pictured in panel (a) of Graph 14.6 as the intersection of the blue demand and supply curves at point A (with \( p^* \) as the equilibrium price). Suppose further that there are many potential firms for this industry, and to keep the graph manageable, suppose that each of these firms has a (long run) AC curve that reaches its minimum at output level \( x^* \), but some AC curves are lower everywhere than others. Six such AC curves are pictured in panel (b) of the graph, and we can imagine that there are many firms whose similarly shaped AC curves fall in between these. At the price \( p^* \), firms 1, 2 and 3 all make at least zero profit, while firms 4, 5 and 6 would make negative long run profit if they produced. Thus, those firms with lower average cost curves — those that are “better” at producing \( x \) — will chose to be in the industry while those with higher cost curves will not.

Next, suppose that there is a shift in market demand (from \( D^M \) to \( D^M' \)) that causes the (short-run) equilibrium price in panel (a) to rise above \( p^* \) to \( p' \). Producer 4 would then notice that she is now able to make a positive profit in this industry, and she would therefore have an incentive to enter the industry — as would other firms that previously would have made negative profit. This entry of new firms then shifts the short run supply curve in panel (a) as new firms enter the market, but the process will stop before the price falls back to the original \( p^* \) because the firms that are entering have higher costs than the firms that originally composed the industry. In our graph, producer 5 is the last one to enter, with all producers whose costs fall below \( p'' \) also entering but no producer whose costs are higher than those of producer 5 entering. The shift in market demand from \( D^M \) to \( D^M' \) thus causes a short run shift in the equilibrium from A to B and a long run shift to C in panel (a) of the graph, with a short run increase in the price from \( p^* \) to \( p' \) and a long run change to \( p'' \). Panel (c) then simply graphs the long run market supply relationship.
Graph 14.6: Long Run Market Supply when Firms Differ

from A to C, indicating an upward sloping long run market supply curve when producers have different cost curves. Once again, the long run market supply curve is not determined by the shape of individual firm supply curves – only by the distribution of the lowest point of the AC curves for firms. Industries like this – with upward sloping (long run) industry supply curves, are called increasing cost industries.

Exercise 14A.9 Suppose market demand shifts inward instead of outward. Can you illustrate what would happen in graphs similar to those of Graph 14.6?

Exercise 14A.10 True or False: The entry and exit of firms in the long run insures that the long run market supply curve is always shallower than the short run market supply curve.

It is in principle also possible for long run market supply curves to slope down in industries where firm costs fall as the industry expands. This may occur if, for instance, the expansion of an industry leads to greater competition in one of the input markets unique to that industry – and thus to a decline in costs for all firms. Such industries are called decreasing cost industries. Since this is relatively rare for industries that are appropriately modeled as perfectly competitive, we will not focus on this case here and only mention it for the sake of completeness.²

Exercise 14A.11 True or False: While long run industry supply curves slope up (in increasing cost industries) because firms have different cost curves, long run industry supply curves in decreasing cost industries slope down even if firms have identical cost curves.

14A.2.5 Zero Profit for Marginal Firms in the Long Run

Finally, notice that entry and exit of firms into markets always continues until the marginal producer makes zero (long-run) profit. By “marginal producer” I mean the producer who has the highest

²In Chapter 21 where we develop the concept of externalities, we provide in end-of-chapter exercise 21.9 another example of a decreasing cost industry that arises from positive production externalities. We similarly illustrate in this example that we can get upward sloping industry supply curves from negative production externalities even when all firms have identical production technologies.
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costs within an industry. In the case where all producers have the same costs (as in Graph 14.5), all producers are marginal — and thus all producers make zero (long-run) profit. In the case where producers have access to different technologies and thus face different cost curves (as in Graph 14.6), on the other hand, all producers other than the marginal producer make positive (long-run) profit. Similarly, if all potential producers have the same costs as all those within the industry, then all producers who are not in the industry are also marginal — and would make zero (long-run) profit if they entered. When producers face different costs, however, those who are outside the industry in long-run equilibrium would make negative profits if they entered — because their costs are greater than the costs of the marginal producer in the industry (who is making zero profit).

Exercise 14A.12 True or False: In the presence of fixed costs (or fixed expenditures), short-run profit is always greater than zero in long run equilibrium.

14A.3 Changing Conditions and Changing Equilibria

In the real world, conditions facing particular industries change constantly as new competing products enter the larger market, labor and capital input prices change and government tax and regulatory policies are altered. The concepts of short and long run equilibria are useful, however, not only for those industries that find themselves in relatively stable economic environments for long periods but also for those industries that experience constantly changing conditions. Whether we remain in any particular equilibrium for very long or whether we even reach a static equilibrium before conditions change once again, knowing what the ultimate equilibrium in an economy is lets us know which way an economy is headed — and that is useful even if conditions change once again before the economy reaches the new equilibrium. It is a bit like predicting the weather: it is never quite in equilibrium, but the forces of nature are constantly aiming to get toward an equilibrium. Thus, if we know that a new high pressure system is moving into our area, we can predict what will happen to the weather because we understand how the weather will adjust in an “attempt” to head toward a new equilibrium. So it is with an economy: when a new force is introduced, we can predict which way things are headed by knowing the equilibrium the economy is aiming for.

In our model of a competitive industry, a “change in conditions” translates in some way into a change in demand or supply curves — and thus a change in short-run and/or long-run equilibrium. In the remainder of this chapter, we will run through some of the types of changes that might have short and long run impacts on a particular industry. On the producer side, changing conditions might result from (1) a change in variable costs (like those associated with labor), (2) a change in fixed expenditures associated with an input that is fixed in the short run, or (3) a change in a fixed cost that is avoidable only by exiting the industry. On the consumer side, changes in consumer tastes or the appearance of new products on the market may cause shifts in market demand. For each of these cases, we will begin our analysis with the assumption that the market was in long run equilibrium prior to the change in underlying conditions faced by the industry.

14A.3.1 Short-Run Equilibrium within a Long-Run Equilibrium

Suppose that our industry is currently in long-run equilibrium, which implies that the marginal producer is making zero (long-run) profits and thus producing at a price that falls at the lowest point of her (long run) \( AC \) curve. This is illustrated in Graph 14.7 where the market demand and market supply curves — both consisting simply of individual demand and supply curves added up — cross in panel (a) at price \( p^* \) which falls at the lowest point of the (long run) \( AC \) curve of
the marginal firm in the industry in panel (b). Since panel (b) illustrates the “marginal firm” in the industry, we know that all firms outside the industry have costs that are at least as high as this firm’s. Thus all firms outside the industry would make zero (long-run) profit or less if they entered the industry. Similarly, we know that the firms inside the industry have costs that are no higher than the marginal firm’s. Thus, all the firms inside the industry make at least zero (long-run) profit. The industry finds itself in long run equilibrium because no firm has an incentive to enter or exit this industry unless conditions change.

At the same time, note that each firm in the industry makes positive short run profits. This is because short run economic costs are fully contained in the short run average cost curve whose lowest point lies below the lowest point of the long run AC curve because certain expenses (associated with fixed inputs or recurring long run fixed costs) are not economic costs in the short run. It is for this reason that the green (short run) supply curve in panel (b) of the graph extends below the lowest point of the (long run) AC curve as we illustrated before in Graph 14.4.

Graph 14.7: An Industry in both Short- and Long-Run Equilibrium

**Exercise 14A.13** Can you illustrate graphically the short and long run profits of the marginal firm in long run equilibrium? (Hint: You can do this by inserting into the graph the AC^{SR} curve as previously pictured in Graph 14.4.)

This will then be the starting point for our analysis of the impact of changing conditions on short and long run equilibrium. In each case, we will need to ask ourselves which curves in our graph are affected by the change — and this will permit us to come to a conclusion about how changing firm behavior results in changes in the equilibrium. For purposes of illustration, we will also assume for the remainder of this chapter that all firms face the same cost curves — and all firms are therefore marginal firms. I will leave it to you as an end-of-chapter exercise to think about how the graphs would differ if firms had different cost curves. Before proceeding, notice that we have stripped the firm side of our pictures to only those curves that actually matter for our analysis — the short run supply curve and the long run AC curve, with the short run supply curve extending below AC. We should keep in mind throughout, however, that the short run supply curve is really a portion of the MC curve and is thus moved by changes in (short run) marginal costs.
14A.3.2 A Change in a Long Run Fixed Cost

Suppose first that producers in an industry incur some annual fixed cost that is not associated with an input. An annual license fee charged by the government is one example of this type of cost — each year, in order to continue producing, a firm has to pay a fee to the government. Another example might involve annual insurance premiums, premiums that might insure the firm against damage to its property or liability suits from its consumers or workers. Once paid, such fees are sunk costs in the short run and thus do not enter the short run cost curves. In the long run, however, such fees are a real economic cost of staying in the industry and thus become part of the long run cost curve $AC$.

Now suppose that this fee goes up, a scenario considered in Graph 14.8. Since it is not a part of the short run average or marginal curves, it is not part of any of the cost curves that are relevant for the firm’s short run decisions. Thus the firm’s short run supply curve (which is not pictured in panel (b)) remains unchanged. Since the (blue) short run market supply curve $S_M$ is simply composed of the sum of all firm supply curves, this also implies that the market supply curve does not change in the short run. This further implies that the equilibrium price in the market remains at $p^*$ in the short run. As a result, the increase in the fee causes no changes in the industry in the short run.

Graph 14.8: An Increase in a Long Run Fixed Cost

The increased fee does, however, cause the (long run) $AC$ curve to move up as depicted in the green curve in Graph 14.8b. While short run profit for the firms is unchanged, long run profit therefore falls and, since it was zero in the initial equilibrium, it now becomes negative. This causes
some firms to exit the market in the long run, which in turn causes the (short-run) market supply curve \( S^M \) to shift inward. More specifically, as individual firms exit, the magenta market supply curves in panel (a) drive up the market price, and firms will continue to exit so long as the market price remains below the new lowest point of the green \( AC' \) curve in panel (b). Only when the market price has increased all the way to \( p' \) will the firms that remain in the industry make zero profits again — eliminating any further incentive for firms to exit (or enter). The short run market supply curve then stops shifting when it has reached the green \( S^{M'} \) curve in panel (a). The firms that remain in the industry then produce \( x' \) — which is more than they produced initially \( (x^*) \), but the industry as a whole produces less \( (X' \) rather than \( X^* \) in panel (a)).

**Exercise 14A.14** Why does the increase in the fee result in a new (green) \( AC' \) curve that converges to the original (blue) \( AC \) curve?

**Exercise 14A.15** If you add the firm’s long run supply curve into panel (b) of the graph, where would it intersect the two average cost curves? Would the same be true for the firm’s initial short run supply curve? (Hint: For the second question, keep in mind that the firm will change its level of capital as its output increases.)

We could similarly illustrate the long run change in the equilibrium by simply focusing on what happens in graphs using only curves relevant in the long run. This is done in panels (c) and (d), where the long run market supply curve in (c) is drawn flat because we are assuming that all firms in the industry are identical. As the lowest point of the individual firms’ \( AC \) curves shifts up, we know that the price in the long run has to shift up by the same amount in order for the industry to reach a new long run equilibrium in which all firms in the industry make zero profits as they produce at the lowest points on their \( AC \) curves. Thus, the horizontal long run supply curve (which is always located at the price corresponding to the lowest point on individual \( AC \) curves) shifts up, causing an increase in price to \( p' \), a reduction in industry output to \( X' \) (in panel (c)) and an increase in output by those firms that stay in the industry to \( x' \) (in panel (d)). This is of course the same result we got in panels (a) and (b), but in panel (a) we are illustrating how the industry transitions from the initial long run equilibrium to the new one, while in panel (c) we simply illustrate the starting and end points.

### 14A.3.3 A Change in the Price of an Input that is Fixed in the Short Run

Next, consider an increase in the price of capital, the input we have assumed fixed in the short run and variable in the long run. This increase might happen, for instance, if conditions in the capital market have changed, thus increasing the equilibrium price of capital. Or it might happen if the government imposes a tax on capital, thus raising the rental rate demanded in the capital market.

Since we are assuming that capital is fixed in the short run, this is again a change in a long run cost and thus does not affect any of the cost curves relevant for short run decision making. Unlike the increase in a fixed fee, a long run (recurring) fixed cost, this is an increase in a long run variable cost, not a long run fixed cost. As a result, the shift in the (long run) \( AC \) curve for each firm will look a little different than it did in the previous section where the new (green) \( AC' \) curve converges to the original (blue) \( AC \) curve. More specifically, while the average cost curve will definitely shift up, its lowest point might lie either to the right or left of where it was previously depending on the underlying technology. As we did in Chapter 13, we will graph the shift here (in Graph 14.9) as one that keeps the lowest point of the \( AC' \) curve at the same output level, but this is simply a special case of what might happen more generally.
Exercise 14A.16 Could the AC curve shift similarly in the case where the increase in cost was that of a long run fixed cost?

This can get a little confusing at first because it seems to involve a logical contradiction: How can it be that the lowest point of the AC curve can remain at the same output quantity when we know that the short run MC curve has to cross the (long run) AC curve at its lowest point in the new long run equilibrium? After all, doesn’t the short run MC curve include only the cost of labor—and not the cost of capital that has just increased? The apparent contradiction is resolved, however, if we recognize that the firm will shift away from capital and toward labor when \( r \) increases. This implies that, from a short run perspective (in the new long run equilibrium), costs will be higher since more labor will be involved in producing each unit of output. It is for this reason that the short run MC curve shifts as a result of moving to the new long run equilibrium—but that shift only happens in the long run when firms substitute away from capital and toward labor.

This is illustrated in panel (b) of Graph 14.9 where the blue curves represent the original cost curves and the green curves represent the new cost curves. The (long run) AC is drawn as shifting up with its lowest point remaining at the same output level \( x^* \). Once the firm has been able to adjust its level of capital in the long run, it will now face a new (green) short run MC curve that is higher than the original MC because the firm has substituted away from capital and toward labor—and the short run MC curve considers only the cost of labor since capital is now once again fixed in the short run. Thus, even though the cost of labor has not increased and the short run MC curve only includes the cost of labor, the short run MC curve in the new long run equilibrium has shifted up because each producer is now using more labor and less capital for each input she produces.

The rest of the story of how the equilibrium changes is then similar to what we discussed in the previous section for an increase in a fixed fee. Nothing changes in the short run (since none of the short run curves are affected in the short run by an increase in the cost of an input that is fixed in the short run). However, each firm in the industry now makes negative profits, which means that some firms will exit. As firms exit, the equilibrium price rises, and this continues until all firms in the industry once again make zero profits. Thus, the long run supply curve in the industry shifts up, with industry output falling to \( X' \) in panel (a) of Graph 14.9 and price settling at the new lowest point of the AC' curve \( p' \). The only difference between the increased fee and the increased
cost of capital is that, because of the different shifts in the AC curve, we can no longer be sure whether each firm will produce more or less in the new equilibrium than it did originally. When the shift in the AC curve is drawn as in Graph 14.9, each firm in the industry will now produce the same as it did before.

**Exercise 14A.17** How would you illustrate the transition from the short run to the long run using graphs similar to those in panels (a) and (b) in Graph 14.8?

**Exercise 14A.18** Consider two scenarios: In both scenarios, the cost of capital increases, causing the long run AC curve to shift up, with the lowest point of the AC curve shifting up by the same amount in each scenario. But in Scenario 1, the lowest point of the AC curve shifts to the right while in Scenario 2 it shifts to the left. Will the long run equilibrium price be different in the two scenarios? What about the long run equilibrium number of firms in the industry?

### 14A.3.4 A Change in Variable Costs

Now suppose that something causes variable costs for producers in an industry to rise immediately. Perhaps labor costs went up because of changes in the national labor market, or industry-specific taxes or regulation are imposed by the government. Any of these scenarios will change all three of the curves pictured in Graph 14.10b — and with it the supply curve from the initial blue to the new magenta curve. If this happens for all firms in an industry, then this will of course also cause a shift in the short run industry supply curve in panel (a) (from the blue to the magenta), which in turn will result in an increase in output price in the short run.

In the short run, the industry as a whole will therefore produce less, \( X_{SR}^{'} \) instead of \( X^* \). Since all firms are assumed to be identical, each firm will continue to produce in the short run — with each firm producing less (\( x^' \) rather than \( x^* \) in panel (b)). Thus, price in the short run rises sufficiently (to \( p^' \)) to insure that short run profit remains above zero. (If we assumed instead that some firms had lower cost curves than others, some higher cost firms might shut down in the short run if they can no longer make non-negative short run profits.)

In the long run, price has to adjust to the new lowest point of \( AC' \) — which implies that the long run market supply curve in panel (c) rises from the initial blue horizontal line to the new green line at price \( p'' \). If we stick with our assumption that the lowest point on the long run average cost curve remains at the same output level, each firm that remains in the industry will therefore again produce as much as it did before wages increased (panel (d)), but since the overall market output falls at higher prices, some firms must have exited as we transition from the short run to the long run. It is for this reason that we can place the magenta short run shift in the market supply curve (that resulted from an increase in short run \( MC \) for all firms) into panel (c) intersecting the demand curve at a price below the long run price \( p'' \), with the shift from this magenta curve to the new (green) final short run supply curve resulting from the exit of firms that experienced negative long run profits at the price \( p' \). Thus, even though each firm that remains in the industry will end up producing as much as it did before the wage increased, the market produces less \( (X_{LR}^{'}) \) as the industry has shrunk. The long run effect of an increase in labor costs is in fact similar to the long run increase in the price of capital — with the difference between the two cases emerging in the short run because labor is assumed to be variable in the short run while capital is not.

\[ 3 \] In fact, there are some additional subtle changes that we are not picturing — because the short run \( MC \) itself will shift again in the long run as firms substitute away from labor and into capital.
Exercise 14A.19 How can it be that firms are making short run profit (and thus remain open in the short run) while simultaneously making negative long run profit (causing some of them to exit and thus price to rise further)?

Note again, however, that the upward shift in the AC curve in Graph 14.10 would not typically involve neither a rightward nor a leftward shift in the lowest point of the curve. If it shifted to the right, we would also know that the number of firms in the industry has fallen as a result of the increase in the wage. This is because we know the industry produces less (at the higher price) and each firm produces more when the lowest point of the AC curve shifts to the right. But if that lowest point shifts to the left instead, then it is no longer as clear whether the number of firms in the industry will increase or decrease. While the total industry output would fall just as before (because consumers demand less when prices are higher), it may still take more firms to produce that lower industry output if each firm produces sufficiently less than before. In this case, $p''$ and $p'$ in panel (c) of Graph 14.10 would be reversed, with the short run increase in price being sufficiently high to attract new firms into the industry.

Exercise 14A.20 What would happen if instead the government imposed a per unit tax for each packet of economist cards?

14A.3.5 A Change in Demand

As we already demonstrated in Graph 14.6 when we considered the shape of long run market supply when firm costs differ, an industry may be impacted not only by changing costs but also by
changing market demand. The market for standard portable music players, for instance, may be affected when the demand curve for such players shifts in as new MP3 players gain in popularity. The market demand for MP3 players, on the other hand, might be affected as it becomes easier to purchase music via the internet by the song rather than in standard tape or CD formats. Such shifts in market demand may result both from changing tastes (that change individual demand curves that compose the market demand curve), from the introduction of new products in a related market, or from new consumers entering a market. Such shifts in demand have no impact on the cost curves of firms – which implies that we will not need to change any of the firm cost curves.

Consider, for instance, the increase in demand for the good \( x \) graphed in panel (a) of Graph 14.11, and let’s stick with the assumption that all firms are identical in terms of their cost structure. We begin at the initial industry equilibrium, with the industry producing \( X^* \) at the equilibrium price \( p^* \). When demand shifts from the blue demand curve to the green, there is an immediate increase in price to \( p' \) as the existing firms in the industry meet the new demand along the existing individual supply curves that sum to the market supply curve. But, since firms were initially making zero long run profits, the increase in price now allows them to earn positive long run profits. This provides new firms an incentive to enter the industry, and the (short run) market supply curve therefore shifts out with each new entrant. This in turn puts downward pressure on price, with that pressure continuing so long as firms in the industry are making positive long run profits. Thus, entry into the industry will stop (assuming all firms have identical costs) only when price falls back to the original \( p^* \) where all firms once again make zero long run profits. The final short run market supply curve therefore settles at the green curve \( S^{M'} \).

Graph 14.11: An Increase in Market Demand
While panel (a) of the graph illustrates the transition from the initial change in the short run equilibrium to the final long run equilibrium by showing the shifting (magenta) supply curves as new firms enter, panel (c) illustrates the change from the initial long-run equilibrium to the final long run equilibrium by focusing on the long run supply curve $S_{LR}^M$ that does not shift (because the lowest point of the $AC$ curve for firms does not shift). In both panels (a) and (c) we see that industry output rises to $X_{SR}'$ in the short run and ultimately settles at the larger industry output $X_{LR}'$. In panel (b) we furthermore see that each firm in the industry initially increases its production, but panel (d) illustrates that each firm will ultimately end up producing the same as it did before the increase in demand. The larger industry output therefore arises solely from the fact that the industry as a whole has expanded through the entry of new firms.

14A.3.6 Changes affecting a Single Firm versus Changes affecting the Industry

In everything we have done thus far in this section, we have assumed that the change we are analyzing affects every firm in the industry. Sometimes, however, only a single firm in the industry might experience a change. The analysis of what happens for such firm-specific changes is then considerably simpler because each firm in a competitive industry is sufficiently small so that any change in behavior by that firm will not affect the short or long run market equilibrium.

Suppose, for instance, that I am one of many producers who produces trading cards with heroes (economists, in my case) pictured on them. I am only one of many producers of “hero cards”, and so what I do has no impact on the market. Now suppose the government gets upset at me because economists are critical of government policy and, in the view of the government, therefore do not represent legitimate heroes for children. As a result, the government raises my annual license fee for operating in the hero card market, but it does not raise the fees for anyone else. In that case, I’ll continue to produce in the short run as if nothing happened until my license fee for next year comes due. Since I (as every other firm in the industry) was initially making zero profits, I would now make negative long run profits if I paid the license fee again and continued to produce. So, I will exit the industry — leaving the market equilibrium unchanged (since I am one of many producers and therefore can’t by myself shift the market supply curve).

Sometimes, the change in costs that affect a single firm are less obvious than the simple example of the government imposing a fee or tax on just me. Suppose, for instance, that I discovered that the economist card factory I owned sits on land that contains substantial oil reserves underneath. This new information would imply that the value of the land under my factory is considerably higher than I initially thought — and thus the opportunity cost of using this land for my factory has gone up. Thus, my $AC$ shifts up, implying that I will now make negative profits if I continue to produce economist cards. I will therefore exit the industry and either go into the oil business or sell the land to an oil company. The increase in my costs has thus driven me out of the hero card business, even though I am better off since I get to make more money in the oil business (or make more money by selling the land). If, on the other hand, I had rented the land rather than owned it, the rent for the land would have increased — thus again raising my $AC$ and driving me out of business, but now the owner of the land would have benefitted rather than me. In either case, though, the increase in opportunity costs for me as a hero card producer increased and drove me out of the industry.

Exercise 14A.21 True or False: Regardless of what cost it is, if it increases for only one firm in a competitive industry, that firm will exit in the long run but it might not shut down in the short run.
14A.4 An Overview of Changes affecting Firms and Industries

In this chapter, we have – for the first time – aggregated both the consumer and producer sides of a competitive market. By understanding what moves the supply side of the goods market, we have then been able to trace the short and long run impacts of changes in several types of market conditions on prices and output levels within affected industries. Table 14.1 summarizes our main conclusions.

<table>
<thead>
<tr>
<th>Example</th>
<th>Affected Costs</th>
<th>Market</th>
<th>Industry</th>
<th>Firm</th>
<th>LR # of Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>License Fee</td>
<td>None</td>
<td>$AC$</td>
<td>$\downarrow SR \uparrow LR$</td>
<td>$\downarrow SR \uparrow LR$</td>
<td>$\downarrow SR \uparrow LR$</td>
</tr>
<tr>
<td>$r$ ↑</td>
<td>None</td>
<td>$AC$, $MC$</td>
<td>$\downarrow SR \uparrow LR$</td>
<td>$\downarrow SR \uparrow LR$</td>
<td>$\downarrow SR \uparrow LR$</td>
</tr>
<tr>
<td>$w$ ↑</td>
<td>$AC$, $MC$</td>
<td>$AC$, $MC$</td>
<td>$\uparrow SR \uparrow LR$</td>
<td>$\uparrow SR \uparrow LR$</td>
<td>$\downarrow SR \uparrow LR$</td>
</tr>
<tr>
<td>Demand ↑</td>
<td>None</td>
<td>None</td>
<td>$\uparrow SR \downarrow LR$</td>
<td>$\uparrow SR \downarrow LR$</td>
<td>$\uparrow SR \downarrow LR$</td>
</tr>
</tbody>
</table>

Table 14.1: The Impact of Changing Conditions of Firms and Industries

The table gives an example for each of the four general market conditions we have covered: (1) changes in (long run) fixed costs (e.g. license fees); (2) changes in costs associated with inputs that are fixed in the short run but variable in the long run (e.g. the price $r$ of capital); (3) changes in costs associated with inputs that are immediately variable (e.g. the price $w$ of labor); and (4) changes in consumer demand for the product produced in the industry. For each of these, the table first indicates which of the key cost curves are affected in firms in both the short and long run. It then indicates short and long run movements in equilibrium prices, industry output levels and individual firm output levels. Single arrows (such as ↑) indicate a smaller change than a double arrow (such as ↑↑) when variables are expected to move in the same direction in both the short and long run; a horizontal line — indicates no change from the initial equilibrium; and a question mark (?) indicates that the theory, absent additional assumptions, allows for changes in either direction. Finally, the last column indicates whether the change causes the overall number of firms in the industry to increase or decrease in the long run — indicating whether firms are expected to enter or exit the industry as a result of the change.

Exercise 14A.22 "Replicate Table 14.1 for the cases where the demand and the various cost examples decrease rather than increase.

14B The Mathematics of Industry (or Market) Equilibrium

Given that we have derived demand and supply for various scenarios quite carefully, there is little in terms of new mathematics that has to be added at this point to further our understanding of the intuitive concepts related to industry or market equilibrium in Section A. I will therefore use Section B in this chapter to simply run through an example illustrating how we use all we have learned to calculate an industry equilibrium from knowing some basics about an economy. This is obviously going to be a stylized example, not one meant in any way to approximate any real world industry. Nevertheless, it is often the case that understanding the full implications of what one

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4See Graphs 14.8, 14.9, 14.10 and 14.11 and surrounding discussion for details on each of the rows in Table 14.1.
Chapter 14. Competitive Market Equilibrium

learns is more than understanding the sum of all the parts. It is for this reason that I think we benefit from fully developing an industry equilibrium from the ground up.

We will begin with consumers who all have tastes over the good $x$ and “all other goods” $y$ that can be represented by the quasilinear utility function

$$u(x, y) = 50x^{1/2} + y.$$  \hfill (14.1)

You can check for yourself that such consumers have the demand function

$$x^d(p) = \left(\frac{25}{p}\right)^2 = \frac{625}{p^2},$$  \hfill (14.2)

where we assume a price of 1 for the composite good $y$ and let $p$ denote the price of good $x$.

**Exercise 14B.1** Why is the demand function not a function of income?

Suppose further that producers operate in competitive input markets in which labor costs $w = 20$ and capital costs $r = 10$, and that all producers (and potential producers) for the good $x$ face the same technology that can be captured by the production function

$$f(\ell, k) = 20\ell^{2/5}k^{2/5}. \hfill (14.3)$$

Note that this is the same decreasing returns to scale technology for which we calculated the various functions in the duality picture in Chapter 12. Suppose that in addition to the inputs $\ell$ and $k$, however, the firm must purchase a recurring operating license that costs $1,280 from the government. As you should have concluded if you did end-of-chapter exercise 12.4, an addition of a fixed cost such as this to a decreasing returns to scale production process results in a U-shaped long run average cost curve for the producer.

We can demonstrate this here by combining results we already derived (for the most) part elsewhere. In Chapter 12 (equation (12.46)), we derived the cost function for the production function (14.3) as $C(w, r, x) = 2(wr)^{1/2} \left(\frac{x}{20}\right)^{5/4}$. With the additional recurring fixed cost of 1,280, this implies a long run cost function for the production process in equation (14.3) of

$$C(w, r, x) = 2(wr)^{1/2} \left(\frac{x}{20}\right)^{5/4} + 1280 \hfill (14.4)$$

or, when $w = 20$ and $r = 10$,

$$C(x) = 0.66874x^{5/4} + 1280. \hfill (14.5)$$

This implies an $AC$ function (when $w = 20$ and $r = 10$) of

$$AC(x) = 0.66874x^{1/4} + \frac{1280}{x} \hfill (14.6)$$

which is U-shaped and attains its minimum at $x = 1280$ at an average cost of $\$5$ per unit.

**Exercise 14B.2** Demonstrate that the average cost of production is U-shaped and reaches its lowest point at $x = 1280$ where $AC = 5$. (Hint: You can illustrate the U-shape by showing that the derivative of $AC$ is zero at 1280, negative for output less than 1280 and positive for output greater than 1280.)
14B. The Mathematics of Industry (or Market) Equilibrium

14B.1 Industry Equilibrium in the Short Run

Short-run industry equilibrium is then determined solely by the intersection of market demand and supply curves, where demand and supply curves are represented by the sum of all individual demand curves from consumers and supply curves from producers who are currently operating in the industry. Adding up demand curves in our example is particularly easy because the demand functions (equation (14.2)) of all consumers are exactly identical (since they share the same quasi-linear tastes and thus their income does not matter for demand). “Adding up” demand curves for all consumers therefore simply means “multiplying” equation (14.2) by the number of consumers in the market for good \( x \). For instance, suppose the total number of consumers in the market is 64,000. Then the market demand function \( D^M(p) \) is

\[
D^M(p) = 64000d(p) = 64000 \left( \frac{625}{p^2} \right) = \frac{40,000,000}{p^2}. \tag{14.7}
\]

14B.1.1 Short Run Industry Supply

To calculate the market supply curve, we need to first know the individual short run supply function for each producer and then similarly “add up” these functions. In equation (11.33) of Chapter 11, we concluded that the supply function for a producer with technology \( f(\ell) = A\ell^\alpha \) is

\[
x(p, w) = A \left( \frac{w}{\alpha p} \right)^{\frac{\alpha}{\alpha-1}}. \tag{14.8}
\]

If capital is fixed at \( k^A \) in the short run, then our production function from equation (14.3) is simply

\[
f(\ell) = A\ell^\alpha \text{ where } A = 20(k^A)^{2/5} \text{ and } \alpha = 2/5. \tag{14.9}
\]

Suppose, for instance, that \( k^A = 256 \), which we will show shortly in Section 14B.2 is the case in long run equilibrium. Then, using the values for \( A \) and \( \alpha \) specified in equation (14.9) and plugging them into equation (14.8), we get a short run supply function

\[
x(p, w) = 3225.398 \left( \frac{p}{w} \right)^{2/3} \text{ or } x^s(p) = 437.754p^{2/3} \text{ when } w = 20. \tag{14.10}
\]

Since we are assuming all producers are identical, “adding up” these supply functions to get short run market supply is again equivalent to “multiplying” them by the number of firms that are currently operating in the industry. Suppose that number is 1250 (which we will shortly show is the correct number of firms in long run equilibrium.) Then the short-run industry supply function \( S^M(p) \) is

\[
S^M(p) = 1250x^s(p) = 1250(437.754)p^{2/3} = 547,192p^{2/3}. \tag{14.11}
\]

14B.1.2 Short Run Industry Equilibrium

With market demand and market supply given by equations (14.7) and (14.11) respectively, we can now calculate the short run equilibrium by setting the two equations equal to one another and solving for the equilibrium price; i.e. solve
Chapter 14. Competitive Market Equilibrium

\[ S^M(p) = 547,192p^{2/3} = \frac{40,000,000}{p^2} = D^M(p), \quad (14.12) \]

which gives \( p = 5 \). Thus, with 64,000 consumers and 1,250 producers, with tastes and technologies described by equations (14.1) and (14.3), with short-run capital \( k^A \) fixed at 256 units and with the wage rate given by \( w = 20 \), market demand and supply intersect at an equilibrium price \( p^* = 5 \). Plugging this back into the individual consumer and producer equations, this implies that each consumer in the market consumes 25 units of \( x \), and each producer produces 1,280 units of output by hiring 128 labor hours.

**Exercise 14B.3** Verify these individual production and consumption quantities.

To make sure that each firm is in fact making non-negative short run profits, we can compare total revenues to total short run economic costs. Total revenues are simply given by the output quantity (1,280) times price ($5) — for a total of $6,400. Short run economic costs in this case include only labor costs — 128 labor hours at a wage of $20, or $2,560. Thus, short run profit for each producer is $3,840. At the same time, the producer also incurs fixed short run expenses of $10 for each of the 256 units of capital that are fixed in the short run and the recurring fixed license fee of $1,280 — for a total of $3,840 in total expenditures that are not costs in the short run.

**Exercise 14B.4** We have already indicated that \( k = 256 \) is in fact the optimal long run quantity of capital when \((p, w, r) = (5, 20, 10)\). Can you then conclude that the industry is in long run equilibrium from the information in the previous paragraph? (Hint: This can only be true if no firm has an incentive to enter or exit the industry.)

### 14B.2 An Industry in Long Run Equilibrium

We already concluded after equation (14.6) that the long run \( AC \) curve for each of the firms (assuming \( w = 20 \) and \( r = 10 \)) is U-shaped and attains its lowest point of $5 at output quantity 1,280. As a result, we know that in the long run, the number of firms in the market will adjust to keep the equilibrium price at this lowest point of the \( AC \) curve; i.e. in the long run, equilibrium price is $5. With market demand given by equation (14.7), this implies that the industry will produce a total of 1,600,000 units of \( x \) — the quantity demanded by the market when price is $5. And, since each firm will produce at the lowest point of its \( AC \) curve in long run equilibrium, we know that each individual firm will produce 1,280 units of \( x \) — implying that there will be exactly 1,250 producers in the industry.

The short-run equilibrium we calculated in the previous section is therefore also the long run equilibrium — with the short-run fixed quantity of capital (256 units per firm) exactly equal to how much capital each firm desires to utilize given the current prices. The industry equilibrium is pictured in Graph 14.12, with panel (b) illustrating the short-run industry demand curves whose intersection signals prices to the typical consumer in panel (a) and the typical producer in panel (c). Note that the supply and demand curves are once again actually plotted as inverse supply and demand curves given that they are functions of prices but prices appear on the vertical axes.

The graph looks similar to those we are used to seeing from Section A except for the fact that short-run firm supply curves begin at the origin in panel (b) whereas we drew them as beginning at the lowest point of short run average cost \( AC^{SR} \) in our graphs in Section A. When you think about the underlying assumptions in Graph 14.12, however, the reasons for this difference should become apparent. The short-run production function (given in equation (14.9)) has decreasing
returns to scale throughout — implying increasing $MC$ throughout. In our graphs of Section A, on the other hand, we implicitly assumed an S-shaped short run production function of the type we introduced in Chapter 11 — with an initial portion that has increasing returns to scale before becoming decreasing returns to scale. This assumption then led to a U-shaped $AC^{SR}$, with the portion of the $MC$ above $AC^{SR}$ forming the short-run firm supply curve. In the case of a short-run production function that has decreasing returns to scale throughout, however, the $AC^{SR}$ is not U-shaped and has its lowest point at the origin.

**Exercise 14B.5** Can you graph the $AC^{SR}$ into panel (c) of Graph 14.12?

### 14B.3 Changing Conditions and Changing Equilibrium

At this point in Section A, we proceeded to demonstrate how the short and long run equilibrium changes as different parts of the economic environment change. We began by noting that our starting point will always be an industry in long run equilibrium, and we can think of a short
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run equilibrium lying embedded in this long run equilibrium. This is what we in fact have just calculated and graphed in Graph 14.12: The industry is in long run equilibrium because each firm is producing at the lowest point of (long run) \( AC \), and this lowest point lies on the short run supply curve that is formed from assuming that each firm currently has the long run optimal quantity of capital given its current production of 1,280 units of output. The total number of firms in the industry is then exactly sufficient to cause the short run industry demand curve to intersect the market demand curve at $5 — which keeps the industry in long run equilibrium with no incentive for any firm to enter or exit.

We can then illustrate, beginning at this equilibrium, the impact of changes in long run fixed costs (represented in our example by the recurring license fee), changes in cost associated with inputs that are fixed in the short run but variable in the long run (represented in our example by the cost of capital), changes in costs associated with variable inputs (represented in our example by the cost of labor) and, finally, changes in demand for the industry’s output. As in Section A, we will consider positive changes in each of these and will leave it to you to investigate what happens when these changes are in the opposite direction.

14B.3.1 An Increase in a Long Run Fixed Cost

Suppose, then, that the government seeks to cover a deficit by raising all license fees by 75% — implying an increase in the recurring license fee for our firms from $1,280 to $2,240. Since the license fee does not appear in the short-run firm supply functions in equation (14.10), the short run market supply does not shift and nothing changes in the short run. In the long run, however, firms would experience a negative profit of $960 each period — giving an incentive for some of them to exit the industry. This will cause an upward shift in the market supply curve until profits are once again zero in the industry.

**Exercise 14B.6 Why does the long run profit become negative $960 if nothing changes?**

To see at what output price profits will be zero, we simply have to see where the new lowest point of each producer’s \( AC \) curve lies. Instead of the \( AC \) in equation (14.6), the increase in the license fee causes the new \( AC’ \) curve to be

\[
AC'(x) = 0.66874x^{1/4} + \frac{2240}{x},
\]

which is once again U-shaped but now has its lowest point at approximately \( x = 2000 \) where average cost is approximately $5.59 per unit. We therefore know that the new long-run equilibrium will have an output price of approximately $5.59 (up from the previous price of $5.00 per unit), with each firm that remains in the industry producing approximately 2,000 units of output each period (up from the previous 1,280 units produced by each firm in the industry). Plugging this new price into the market demand curve in equation (14.7), we find that consumers will demand approximately 1,280,000 units of output each period at this new long-run equilibrium price. With each firm in the industry producing approximately 2,000 units, this implies that the new long run equilibrium will have approximately 640 firms, down from 1,250 before the increase in the license fee. Finally, we can insert the new price into the individual demand curves in equation (14.2) to conclude that each consumer will lower her consumption from 25 to approximately 20 units of \( x \) each period.

**Exercise 14B.7 Verify these calculations.**
Exercise 14B.8 Compare the changes set off by an increase in the license fee to those predicted in Graph 14.8.

14B.3.2 An Increase in the Cost of Capital

Next suppose that, instead of an increase in the license fee, the cost of capital \( r \) increases from $10 per unit to $15 per unit. Since capital is a fixed input in the short run, this change once again does not alter the short run supply curve of firms (equation (14.10)) and thus has not impact on the short run market equilibrium. However, as capital becomes a variable input in the long run, it becomes an economic cost — and profit for each firm becomes negative unless output price rises. Thus, firms have an incentive to exit the industry, causing price to rise until long run profit is zero for all firms that remain in the industry.

How high the price rises again depends on how far up the lowest point of the producers’ (long run) \( AC \) curve has shifted. Plugging in the wage \( w = 20 \) and the new rental rate \( r' = 15 \) into the general cost function in equation (14.5), we get cost as a function of output given by

\[
C(x) = 0.819036x^{5/4} + 1280 \tag{14.14}
\]

with accompanying average cost given by

\[
AC'(x) = 0.819036x^{1/4} + \frac{1280}{x}. \tag{14.15}
\]

This new \( AC' \) curve reaches its lowest point at approximately \( x = 1088 \) where average cost is approximately $5.88 per unit, up from $5.00 per unit before the increase in \( r \). Thus, the new long run equilibrium price has to be approximately $5.88, with each firm that remains in the industry producing 1,088 units of \( x \) each period. At this price, the market demand function tells us that consumers will demand approximately 1,156,925 units of \( x \), which implies that the new long run equilibrium will have approximately 1,063 producers, down from the initial 1,250.

Exercise 14B.9 Verify these calculations.

Exercise 14B.10 Are these results consistent with Graph 14.9?

Exercise 14B.11 How much capital and labor are hired in the industry before and after the increase in \( r \)?

14B.3.3 An Increase in the Cost of Labor

The most complicated cost change we analyzed in Section A was that of an increase in the wage rate \( w \)—because labor can be adjusted in both the short and long run. Suppose, for instance, that the wage rate increases from $20 to $30 (with the cost of capital remaining at $10 and the license fee remaining at $1,280). From equation (14.10), we know that the short run supply function for each producer is \( x(p, w) = 3225.398(p/w)^{2/3} \), which implies that the supply curve shifts from \( x^s(p) = 437.754p^{2/3} \) when \( w = 20 \) to

\[
x^s'(p) = 334.069p^{2/3} \tag{14.16}
\]

With 1,250 producers in the industry, this implies that short run industry supply shifts from \( SM(p) = 547,192p^{2/3} \) to

\[
SM'(p) = 417,586p^{2/3}. \tag{14.17}
\]
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When set equal to the (unchanged) market demand \( D_M(p) = 40,000,000/p^2 \), we get a short run equilibrium price of approximately $5.53 (up from the initial equilibrium price of $5.00 before the wage increase). At this price, each firm produces approximately 1,045 units of output (down from 1,280), earning revenue of approximately $5,782 each period.

**Exercise 14B.12** Verify these calculations.

In the short run, expenses associated with capital and license fees are not economic costs — and labor costs are the only short run economic costs. With each firm’s capital fixed at 256 units, approximately 77 units of labor are hired by each firm to produce the 1,045 units of output, implying that short run economic costs are approximately $2,310. Given $5,782 in revenue, this leaves a short run economic profit of $3,472.

**Exercise 14B.13** How much does the industry production change in the short run?

In the long run, however, license costs and costs associated with capital become economic costs. Were each firm to continue to produce as it does in short run equilibrium, total costs would therefore include $2,560 for capital inputs and $1280 for the license to operate — implying that each firm would earn a long run economic profit of -$367 each period. Thus, firms have an incentive to exit until long run profit is once again zero for all firms that remain in the industry. This will occur when price reaches the lowest point of the new (long run) \( AC' \) curve — which happens when long run output price settles at approximately $5.88 (up from $5.53 in the short run). At this long run equilibrium price, each producer that remains in the market will produce approximately 1,088 units of output (up from 1,045 in the short run) while the market demand for output falls to approximately 1,156,925 (from 1,306,395 in the short run). This leaves room for approximately 1,063 producers in the industry (down from 1,250).

**Exercise 14B.14** Verify these calculations and compare the results to our graphical analysis of an increase in the wage rate in Graph 14.10.

### 14B.3.4 An Increase in Market Demand

Finally, we concluded Section A with a brief analysis of how the industry changes in the short and long run when there is an increase in market demand. Suppose, for instance, that some unexpected news coverage of the health benefits of consuming our mythical \( x \) good increases the number of consumers in our market from 64,000 to 100,000. Market demand, initially equal to \( D_M(p) = 64000x^d(p) = 40,000,000/p^2 \) then shifts to the new \( D'_M(p) \) given by

\[
D'_M(p) = 100,000x^d(p) = 100,000 \left( \frac{625}{p^2} \right) = \frac{62,500,000}{p^2}.
\]  

(14.18)

The short run market supply function \( S_M(p) = 547,192p^2/3 \) remains unchanged (since each firm’s cost curves remain unchanged). Setting this equal to the new demand function above, we then get a new short run equilibrium price of approximately $5.91 (up from $5.00). At this price, each of the 1,250 existing firms produce (given their short run supply curves from equation (14.10)) approximately 1,431 units of output (up from 1,280), with industry supply rising to approximately 1,789,234 (from 1,600,000).

**Exercise 14B.15** How much does individual consumption by consumers who were originally in the market change in the short run?
At the new short-run equilibrium price, each firm earns positive economic profits — thus providing an incentive for new firms to enter the industry until price is driven back to $5.00 when all firms in the industry make zero profits. At $5, the new market demand curve tells us that consumers demand 2,500,000 units of x. With each firm once again producing at the lowest point of its average cost curve (where $x = 1,280$), this implies that there will be approximately 1,953 producers in the new long run equilibrium (up from 1,250).

**Exercise 14B.16** Verify these calculations and compare the results with Graph 14.11 where we graphically illustrated the impact of an increase in market demand.

**Conclusion**

In this chapter, we have combined for the first time the results from consumer and producer models to illustrate how competitive or decentralized market equilibria arise. These equilibria are based on the assumption that individuals — producers and consumers — are “small” relative to the economy and thus cannot individually influence the economic environment in which they operate. Put differently, competitive equilibrium arises when individuals are price-takers with no incentive to think strategically about how their own actions influence prices. Later on, we will see how the notion of an equilibrium changes when some individuals in an economy are not “small”.

While the difference between the short and long run for firms is defined by the time it takes for all inputs to become variable, the difference between the short and long run for the industry is defined by the time it takes for new firms to enter or old ones to exit. Firms can exit once they can release the inputs that are fixed in the short run — which implies that the time horizon for the short run to turn into the long run is the same from the firm’s and the industry’s perspective (if the fixed input is fixed for the same time period for all firms). Firms can enter once they can release their fixed inputs in other industries and convert them to inputs in the industry they wish to enter — and it is convenient as well as plausible to assume that this, too, is similar to the period during which inputs are fixed in the industry we are analyzing. The most important insight to emerge from all this is that the short run equilibrium emerges from the intersection of demand and supply of existing firms in the industry while the long run equilibrium is entirely derived from the entry/exit decisions that drive long run profits to zero.

The competitive equilibrium that we have described is, as we noted at the beginning of the chapter, remarkable in that it describes a “spontaneous order”. By “order” we mean that a mechanism is put in place to signal, through market prices, to millions of individual actors in the market how they should cooperate with others in that market. By “spontaneous” we mean that the order arises without anyone planning it — each individual simply considers her own economic circumstances and makes the best decision she can. We will now turn to another remarkable result: Under certain conditions, this spontaneous order turns out to maximize the overall gains to society from the scarce resources that are available to the society.

**End of Chapter Exercises**

14.1 In Table 14.1, the last column indicates the predicted change in the number of firms within an industry when economic conditions change.

A: In two cases, the table makes a definitive prediction, whereas in two other cases it does not.

(a) Explain first why we can say definitively that the number of firms falls as a fixed cost (i.e. license fee) increases? Relate your answer to what we know about firm output and price in the long run.
(b) Repeat (a) for the case of an increase in demand.
(c) Now consider an increase in the wage rate and suppose first that this causes the long run AC curve to shift up without changing the output level at which the curve reaches its lowest point. In this case, can you predict whether the number of firms increases or decreases?
(d) Repeat (c) but assume that the lowest point of the AC curve shifts up and to the right.
(e) Repeat (c) again but this time assume that the lowest point of the AC curve shifts up and to the left.
(f) Is the analysis regarding the new equilibrium number of firms any different for a change in $r$?

(g) Which way would the lowest point of the AC curve have to shift in order for us not to be sure whether the number of firms increases or decreases when $w$ falls?

B: Consider the case of a firm that operates with a Cobb-Douglas production function $f(t,k) = A t^\alpha k^\beta$ where $\alpha, \beta > 0$ and $\alpha + \beta < 1$.

(a) The cost function for such a production process – assuming no fixed costs – was given in equation (13.45) of exercise 13.5. Assuming an additional recurring fixed cost $F$, what is the average cost function for this firm?
(b) Derive the equation for the output level $x^*$ at which the long run AC curve reaches its lowest point.
(c) How does $x^*$ change with $F$, $w$ and $r$?
(d) True or False: For industries in which firms face Cobb-Douglas production processes with recurring fixed costs, we can predict that the number of firms in the industry increases with $F$ but we cannot predict whether the number of firms will increase or decrease with $w$ or $r$.

14.2 Table 14.1 was constructed under the assumption that all firms in the industry are identical.

A: Suppose that all firms in an industry have U-shaped long run average cost curves.

(a) Leaving aside the column labeled “Firm Output”, what would change in the table if firms have different cost structures – i.e. some firms have lower marginal and average costs than others?
(b) Industries such as those described in (a) are sometimes called increasing cost industries compared to constant cost industries where all firms are identical. Can you derive a rationale for these terms?
(c) It has been argued that, in some industries, the average and marginal costs of all firms decline as more firms enter the market. For instance, such industries might make use of an unusual labor market skill that becomes more plentiful in the market as more workers train for this skill when many firms demand it. How would the long run industry supply curve differ in this case from that discussed in the text as well as that described in (a)?
(d) Industries such as those described in (c) are sometimes referred to as decreasing cost industries. Can you explain why?

14.3 Everyday and Business Application: Fast Food Restaurants and Grease (cont’d): In exercise 12.8, you investigated the impact of hybrid vehicles that can run partially on grease from hamburger production on the number of hamburgers produced by a fast food restaurant. You did so, however, in the absence of considering the equilibrium impact on prices – assuming instead that prices for hamburgers are unaffected by the change in demand for grease.

A: Suppose again that you use a decreasing returns to scale production process for producing hamburgers using only labor and that you produce 1 ounce of grease for every hamburger. In addition, suppose that you are part of a competitive industry and that each firm also incurs a recurring fixed cost $F$ every week.

(a) Suppose that the cost of hauling away grease is $q > 0$ per ounce. Illustrate the shape of your marginal and average cost curve (given that you also face a recurring fixed cost.)
(b) Assuming all restaurants are identical, illustrate the number of hamburgers you produce in long run equilibrium.
(c) Now suppose that, as a result of the increased use of hybrid vehicles, the company you previously hired to haul away your grease is now willing to pay for the grease it hauls away. How do your cost curves change?
(d) Describe the impact this will have on the equilibrium price of hamburgers and the number of hamburgers you produce in the short run.
(e) How does your answer change in the long run?
(f) Would your answers change if you instead assumed that restaurants used both labor and capital in the production of hamburgers?
(g) In exercise 12.8, you concluded that the cholesterol level in hamburgers will increase as a result of these hybrid vehicles if restaurants can choose more or less fatty meat. Does your conclusion still hold?

B: Suppose, as in exercise 12.8, that your production function is given by \( f(\ell) = A\ell^\alpha \) (with \( 0 < \alpha < 1 \)) and that the cost of hauling away grease is \( q \). In addition, suppose now that each restaurant incurs a recurring fixed cost of \( F \).

(a) Derive the cost function for your restaurant.
(b) Derive the marginal and average cost functions.
(c) How many hamburgers will you produce in the long run?
(d) What is the long run equilibrium price of hamburgers?
(e) From your results, determine how the long run equilibrium price and output level of each restaurant changes as \( q \) changes.

14.4 Business Application: Brand Names and Franchise Fees: Suppose you are currently operating a hamburger restaurant that is part of a competitive industry in your city.

A: Your restaurant is identical to others in its homothetic production technology which employs labor \( \ell \) and capital \( k \) and has decreasing returns to scale.

(a) In addition to paying for labor and capital each week, each restaurant also has to pay recurring weekly fees \( F \) in order to operate. Illustrate the average weekly long run cost curve for your restaurant.
(b) On a separate graph, illustrate the weekly demand curve for hamburgers in your city as well as the short run industry supply curve assuming that the industry is in long run equilibrium. How many hamburgers do you sell each week?
(c) As you are happily producing burgers in this long run equilibrium, a representative from the national MacWendy’s chain comes to your restaurant and asks you to convert your restaurant to a MacWendy’s. It turns out, this would require no effort on your part – you would simply have to allow the MacWendy’s company to install a MacWendy’s sign, change some of the furniture and provide your employees with new uniforms – all of which the MacWendy’s parent company is happy to pay for. MacWendy’s would, however, charge you a weekly franchise fee of \( G \) for the privilege of being the only MacWendy’s restaurant in town. When you wonder why you would agree to this, the MacWendy’s representative pulls out his marketing research that convincingly documents that consumers are willing to pay \$y more per hamburger when it carries the MacWendy’s brand name. If you accept this deal, will the market price for hamburgers in your city change?
(d) On your average cost curve graph, illustrate how many hamburgers you would produce if you accepted the MacWendy’s deal.
(e) Next, for a given \( y \), illustrate the largest that \( G \) could be in order for you to accept the MacWendy’s deal.
(f) If you accept the deal, will you end up hiring more or fewer workers? Will you hire more or less capital?
(g) Does your decision on how many workers and capital to hire under the MacWendy’s deal depend on the size of the franchise fee \( G \)?
(h) * Suppose that you accepted the MacWendy’s deal and, because of the increased sales of hamburgers at your restaurant, one hamburger restaurant in the city closes down. Assuming that the total number of hamburgers consumed remains the same, can you speculate whether total employment (of labor) in the hamburger industry went up or down in the city? (Hint: Think about the fact that all restaurants operate under the same decreasing returns to scale technology.)

B: Suppose all restaurants in the industry use the same technology that has a long run cost function \( C(w,r,x) = 0.028486(w^{0.5}r^{0.5}x^{1.25}) \) which, as a function of wage \( w \) and rental rate \( r \), gives the weekly cost of producing \( x \) hamburgers.\(^5\)

(a) Suppose that each hamburger restaurant has to pay a recurring weekly fee of \$4,320 to operate in the city in which you are located and that \( w = 15 \) and \( r = 20 \). If the restaurant industry is in long run equilibrium in your city, how many hamburgers does each restaurant sell each week?
(b) At what price do hamburgers sell in your city?
(c) Suppose that the weekly demand for hamburgers in your city is \( x(p) = 100,040 - 1000p \). How many hamburger restaurants are there in the city?

\(^5\)For those who find unending amusement in proving such things, you can check that this cost function arises from the Cobb-Douglas production function \( f(\ell,k) = 30\ell^{0.4}k^{0.4} \).
(d) Now consider the MacWendy’s offer described in A(c) of this exercise. In particular, suppose that the franchise fee required by MacWendy’s is $F = 5,000$ and that consumers are willing to pay 94 cents more per hamburger when it carries the MacWendy’s brand name. How many hamburgers would you end up producing if you accept MacWendy’s deal?

(e) Will you accept the MacWendy’s deal?

(f) Assuming that the total number of hamburgers sold in your city will remain roughly the same, would the number of hamburger restaurants in the city change as a result of you accepting the deal?

(g) What is the most that the MacWendy’s representative could have charged you for you to have been willing to accept the deal?

(h) Suppose the average employee works for 36 hours per week. Can you use Shephard’s Lemma to determine how many employees you hire if you accept the deal? Does this depend on how high a franchise fee you are paying?

(i) How does this compare to the number of employees hired by the competing non-MacWendy’s hamburger restaurants? In light of your answer to (f), will overall employment in the hamburger industry increase or decrease in your city as a result of you becoming a MacWendy’s restaurant?

14.5 Business Application: “Economic Rent” and Profiting from Entrepreneurial Skill: Suppose, as in exercise 14.4, that you are operating a hamburger restaurant that is part of a competitive industry. Now you are also the owner, and suppose throughout that the owner of a restaurant is also one of the workers in the restaurant and collects the same wage as other workers for the time he/she puts into the business each week. (In addition, of course, the owner keeps any weekly profits.)

A: Again, assume that all the restaurants are using the same homothetic decreasing returns to scale technology, but now the inputs include the level of entrepreneurial capital $c$ in addition to weekly labor $\ell$ and capital $k$. As in exercise 14.4, assume also that all restaurants are required to pay a recurring weekly fixed cost $F$.

(a) First assume that all restaurant owners possess the same level of entrepreneurial skill $c$. Draw the long run $AC$ curve (for weekly hamburger production) for a restaurant and indicate how many weekly hamburgers the restaurant will sell and at what price assuming that the industry is in long run equilibrium.

(b) Suppose next that you are special and possess more entrepreneurial and management skill than all those other restaurant owners. As a result of your higher level of $c$, the marginal product of labor and capital is 20% greater for any bundle of $\ell$ and $k$ than it is for any of your competitors. Will the long run equilibrium price be any different as a result?

(c) If your entrepreneurial skill causes the marginal product of capital and labor to be 20% greater for any combination of $\ell$ and $k$ than for your competitors, how does your isoquant map differ from theirs? For a given wage and rental rate, will you employ the same labor to capital ratio as your competitors?

(d) Will you produce more or less than your competitors? Illustrate this on your graph by determining where the long run $MC$ and $AC$ curves for your restaurant will lie relative to the $AC$ curve of your competitors.

(e) Illustrate in your graph how much weekly profit you will earn from your unusually high entrepreneurial skill.

(f) Suppose the owner of MacroSoft, a new computer firm, is interested in hiring you as the manager of one of its branches. How high a weekly salary would it have to offer you in order for you to quit the restaurant business assuming you would work for 36 hours per week in either case and assuming the wage rate in the restaurant business is $15 per hour?

(g) The benefit that an entrepreneur receives from his skill is sometimes referred to as the economic rent of that skill – because the entrepreneur could be renting his skill out (to someone like MacroSoft) instead of using it in his own business. If the economic rent of entrepreneurial skill is included as a cost to the restaurant business you run, how much profit are you making in the restaurant business?

(h) Would counting this economic rent on your skill as a cost in the restaurant business affect how many hamburgers you produce? How would it change the $AC$ curve in your graph?

B: Suppose that all restaurants are employing the production function $f(\ell, k, c) = 30^{0.4}k^{0.4}c$ where $\ell$ stands for weekly labor hours, $k$ stands for weekly hours of rented capital and $c$ stands for the entrepreneurial skill of the owner. Note that, with the exception of the $c$ term, this is the same production technology used in exercise 14.4. The weekly demand for hamburgers in your city is, again as in exercise 14.4, $x(p) = 100,040 - 1,000p$. 

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(a) First, suppose that \( c = 1 \) for all restaurant owners, that \( w = 15 \) and \( r = 20 \), that there is a fixed weekly cost \$4,320\) of operating a restaurant, and the industry is in long run equilibrium. Determine the weekly number of hamburgers sold in each restaurant, the price at which hamburgers sell, and the number of restaurants that are operating. (If you have done exercise 14.4, you should be able to use your results from there.)

(b) Next, suppose that you are the only restaurant owner that is different from all the others in that you are a better manager and entrepreneur and that this is reflected in \( c = 1.24573 \) for you. Determine your long run AC and MC functions. (Be careful not to use the cost function given in exercise 14.4 since \( c \) is no longer equal to 1. You can instead rely on the cost function derived for Cobb-Douglas technologies given in equation (13.45) in exercise 13.5 (and remember to add the fixed cost).)

(c) How many hamburgers will you produce in long run equilibrium?

(d) How many restaurants will there be in long run equilibrium given your higher level of \( c \)?

(e) How many workers (including yourself) and units of capital are you hiring in your business compared to those hired by your competitors? (Recall that the average worker is assumed to work 36 hours per week.)

(f) How does your restaurant’s weekly long run profit differ from that of the other restaurants?

(g) Suppose Macrosoft is interested in hiring you as described in part A(f). How high a weekly salary would MacroSoft have to offer you in order for you to quit the restaurant business and accept the MacroSoft offer?

(h) If you decide to accept the MacroSoft offer and you exit the restaurant business, will total employment in the restaurant business go up or down?

14.6 Business and Policy Application: Capital Gains Taxes

A: Suppose you are running a gas station in a competitive market where all firms are identical. You employ weekly labor \( \ell \) and capital \( k \) using a homothetic decreasing returns to scale production function, and you incur a weekly fixed cost of \( F \).

(a) Begin with your firm’s long run weekly average cost curve and relate it to the weekly demand curve for gasoline in your city as well as the short run weekly aggregate supply curve assuming the industry is in long run equilibrium. Indicate by \( x^* \) how much weekly gasoline you sell, by \( p^* \) the price at which you sell it, and by \( X^* \) the total number of gallons of gasoline sold in the city per week.

(b) Now suppose that an increase in the capital gains tax raises the rental rate on capital \( k \) (which is fixed for each gas station in the short run). Does anything change in the short run?

(c) What happens to \( x^* \), \( p^* \) and \( X^* \) in the long run? Explain how this emerges from your graph.

(d) Is it possible for you to tell whether you will hire more or fewer workers as a result of the capital gains tax-induced increase in the rental rate? To the extent that it is not possible, what information could help clarify this?

(e) Is it possible for you to be able to tell whether the number of gasoline stations in the city increases or decreases as a result of the increase in the rental rate? What factors might your answer depend on?

(f) Can you tell whether employment of labor in gasoline stations increases or decreases? What about employment of capital?

B: Suppose that your production function is given by \( f(\ell, k) = 30\ell^{0.4}k^{0.4} \), \( F = 1080 \) and the weekly city-wide demand for gallons of gasoline is \( x(p) = 100,040 - 1,000p \). Furthermore, suppose that the wage is \( w = 15 \) and the current rental rate is 32.1568. Gasoline prices are typically in terms of tenths of cents – so express your answer accordingly.

(a) Suppose the industry is in long run equilibrium in the absence of capital gains taxes. Assuming that you can hire fractions of hours of capital and produce fractions of gallons of gasoline, how much gasoline will you produce and at what price do you sell your gasoline? (Use the cost function derived for Cobb-Douglas technologies given in equation (13.45) in exercise 13.5 (and remember to add the fixed cost).)

(b) How many gasoline stations are there in your city?
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(c) Now suppose the government’s capital gains tax increases the rental rate of capital by 24.39% to $40. How will your sales of gasoline be affected in the new long run equilibrium?

(d) What is the new price of gasoline?

(e) Will you change the number of workers you hire? How about the hours of capital you rent?

(f) Will there be more or fewer gasoline stations in the city? How is your answer consistent with the change in the total sales of gasoline in the city?

(g) What happens to total employment at gasoline stations as a result of the capital gains tax? Explain intuitively how this can happen.

(h) * Which of your conclusions do you think is qualitatively independent of the production function used (so long as it is decreasing returns to scale), and which do you think is not?

(i) * Which of your conclusions do you think is qualitatively independent of the demand function, and which do you think is not?

14.7 Business and Policy Application: Using License Fees to Make Positive Profit: Suppose you own one of many identical pharmaceutical companies producing a particular drug x.

A: Your production process has decreasing returns to scale but you incur an annually recurring fixed cost $F$ for operating your business.

(a) Begin by illustrating your firm’s average long run cost curve and identify your output level assuming that the output price is such that you make zero long run profit.

(b) Next to your graph, illustrate the market demand and short run market supply curves that justify the zero-profit price as an equilibrium price.

(c) Next, suppose that the government introduces an annually recurring license fee $G$ for any firm that produces this drug. Assume that your firm remains in the industry. What changes in your firm and in the market in both the short and long run as a result of the introduction of $G$ and assuming that long run profits will again be zero in the new long run equilibrium?

(d) Now suppose that $G$ is such that the number of firms required to sustain the zero-profit price in the new long run equilibrium is not an integer. In particular, suppose that we would require 6.5 firms to sustain this price as an equilibrium in the market. Given that fractions of firms cannot exist, how many firms will actually exist in the long run?

(e) How does this affect the long run equilibrium price, the long run production level in your firm (assuming yours is one of the firms that remains in the market), and the long run profits for your firm?

(f) True or False: Sufficiently large fixed costs may in fact allow identical firms in a competitive industry to make positive long run profits.

(g) True or False: Sufficiently large license fees can cause a competitive industry to become more concentrated — where by “concentrated” we mean fewer firms competing for each customer.

B: Suppose that each firm in the industry uses the production function $f(\ell, k) = 10^{0.4} \ell^{0.4} k^{0.4}$ and each incurs a recurring annual fixed cost of $175,646.

(a) Determine how much each firm produces in the long run equilibrium if $w = r = 20$. (You can use the cost function derived for Cobb-Douglas technologies given in equation (13.45) in exercise 13.5 (and remember to add the fixed cost).)

(b) What price are consumers paying for the drugs produced in this industry?

(c) Suppose consumer demand is given by the aggregate demand function $x(p) = 1,000,000 - 10,000p$. How many firms are in this industry?

(d) Suppose the government introduces a requirement that each company has to purchase an annual operating license costing $824,354. How do your answers to (a), (b) and (c) change in the short and long run?

(e) Are any of the firms that remain active in the industry better or worse off in the new long run equilibrium?

(f) Suppose instead that the government’s annual fee were set at $558,258. Calculate the price at which long run profits are equal to zero.

(g) How many firms would this imply will survive in the long run assuming fractions of firms can operate?

(h) Since fractions of firms cannot operate, how many firms will actually exist in the long run? Verify that this should imply an equilibrium price of approximately $48.2. (Hint: Use the supply function given for a Cobb-Douglas production process in equation (13.49) found in the footnote to exercise 13.7.)
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(i) What does this imply for how much profit each of the remaining firms can actually make?

14.8 Policy and Business Application: Business Taxes (cont’d): In exercise 13.11, we introduced a number of possible business taxes and asked what a firm’s response would be assuming that prices $w$, $r$ and $p$ remained unchanged. Now that we have introduced the notion of equilibrium price formation, we can revisit the exercise.

A: Suppose the restaurant industry is in long run equilibrium, all restaurants use the same homothetic decreasing returns to scale technology and all have to pay a fixed annual franchise fee $F$.

(a) Illustrate the average cost curve for a restaurant and the related (short run) supply and demand graph for the industry.

(b) Revisit parts A(b) through A(h) of exercise 13.11 and explain whether the assumption that prices remained unchanged was warranted and, if not, why not.

B: Consider the same technology as the one used in exercise 13.11 as well as the recurring fixed cost $F$.

(a) Determine the long run equilibrium price $p^*$ and output level $x^*$ as a function of $A$, $\alpha$, $\beta$, $w$ and $r$. (You can use the cost function given in equation (13.45) in exercise 13.5 as well as the profit function given equation (13.48) in exercise 13.7.)

(b) In exercise 13.11, we focused on the impact of policies from A(b) through A(h) on output supply and input demand functions. Now use your result from (a) to determine the impact of each of these policies on the long run equilibrium price and firm output level.

14.9 Policy and Business Application: Minimum Wage Labor Subsidy (cont’d): In exercise 13.10, we investigated the firm’s decisions in the presence of a government subsidy for hiring minimum wage workers. Implicitly, we assumed that the policy has no impact on the prices faced by the firm in question.

A: Suppose again that you operate a business that uses minimum wage workers $\ell$ and capital $k$. The minimum wage is $w$, the rental rate for capital is $r$ and you are one of many identical businesses in the industry, each using a homothetic, decreasing returns to scale production process and each facing a recurring fixed cost $F$.

(a) Begin by drawing the average cost curve of one firm and relating it to the (short run) supply and demand in the industry assuming we are in long run equilibrium.

(b) Now the government introduces a wage subsidy $s$ that lowers the effective cost of hiring minimum wage workers from $w$ to $(1-s)w$. What happens in the firm and in the industry in the short run?

(c) What happens to price and output (in the firm and the market) in the long run compared to the original quantities?

(d) Is it possible to tell whether there will be more or fewer firms in the new long run equilibrium?

(e) Is it possible to tell whether the long run price will be higher or lower than the short run price? How does this relate to your answer to part (d)?

B: Suppose that the firms in the industry use the production technology $x = f(\ell, k) = 100^{0.25}k^{0.25}$ and pay a recurring fixed cost of $F = 2,210$. Suppose further that the minimum wage is $10 and the rental rate of capital is $r = 20$.

(a) What is the initial long run equilibrium price and firm output level?

(b) Suppose that $s = 0.5$ – implying that the cost of hiring minimum wage labor falls to $5$. How does your answer to (a) change?

(c) How much more or less of each input does the firm buy in the new long run equilibrium compared to the original one? (The input demand functions for a Cobb-Douglas production process were previously derived and given in equation (13.50) of exercise 13.8.)

(d) If price does not affect the quantity of $x$ demanded very much, will the number of firms increase or decrease in the long run?

(e) Suppose that demand is given by $x(d) = 200,048 - 2,000p$. How many firms are there in the initial long run equilibrium?

(f) Derive the short run market supply function and illustrate that it results in the initial long run equilibrium price.

(g) Verify that the short run equilibrium price falls to approximately $2.69 when the wage is subsidized.

(h) How much does each firm’s output change in the short run?

(i) Determine the change in the long run equilibrium number of firms when the wage is subsidized and make sense of this in light of the short run equilibrium results.
14.10 Policy Application: School Vouchers and the Private School Market: In the U.S., private schools charge tuition and compete against public schools that do not. One policy proposal that is often discussed involves increasing demand for private schools through school vouchers. A school voucher is simply a piece of paper with a dollar amount \( V \) that is given to parents who can pay for some portion of private school tuition with the voucher if they send their child to a private school. (Private schools can then redeem the vouchers for a payment of \( V \) from the government.) Assume throughout that private schools strive to maximize profit.

**A**: Suppose private schools have U-shaped average (long run) cost curves, and the private school market in a metropolitan area is currently in long run equilibrium (in the absence of private school vouchers).

(a) Begin by drawing a school’s average long run cost curve (with the number of private school seats on the horizontal axis). Then, in a separate graph next to this, illustrate the city-wide demand curve for seats in private schools as a function of the tuition price \( p \). Finally, include the short run aggregate supply curve that intersects with demand at a price that causes the private school market to be in long run equilibrium.

(b) Illustrate what happens to the demand curve as a result of the government making available vouchers in the amount of \( V \) to all families who live in the city. What happens to the number of seats made available in each existing private school, and what happens to the tuition level \( p \) in the short run?

(c) Next, consider the long run when additional private schools can enter the market. How does the tuition level \( p \), the number of seats in each school and the overall number of children attending private schools change?

(d) Opponents of private school vouchers sometimes express concern that the implementation of vouchers will simply cause private schools to increase their tuition level and thus cause no real change in who attends private school. Evaluate this concern from both a short and long run perspective.

(e) Proponents of private school vouchers often argue that the increased availability of private schools will cause public schools to offer higher quality education. If this is true, how would your answers to (b) and (c) change as a result?

(f) If private school vouchers are made available to anyone who lives within the city boundaries (but not to those who live in suburbs), some families who previously chose to live in suburbs to send their children to suburban public schools might choose instead to live in the city and send their children to private schools. How would this affect your answers to (b) and (c)?

**B**: In the following, all dollar values are expressed in thousands of dollars. Suppose that the total city-wide demand function for private school seats \( x \) is given by \( x(p) = 24,710 - 2500p \) and each private school’s average long run cost function is given by \( AC(x) = 0.655x^{1/3} + (900/x) \).

(a) Verify that \( AC(x) \) arises from a Cobb-Douglas production function \( x = f(\ell, k) = 35\ell^{0.5}k^{0.25} \) when \( w = 50 \) and \( r = 25 \) and when private schools face a fixed cost of 900. One unit of \( x \) is interpreted as one seat (or one child) in the school, and \( \ell \) is interpreted here as a teacher. Since dollar values are expressed in thousands, \( w \) represents a teacher’s salary of $50,000 and the fixed cost represents a recurring annual cost of $900,000.

(b) In order for the private school market to be in long run equilibrium, how many children are served in each private school? What is the tuition (per seat in the school) charged in each private school? What happens to private school class size in the short run? (Hint: You already determined the total number of children in part (a) and now need to determine the number of teachers in each private school.)

(c) Given that you know the underlying production function, can you determine the class size in each private school? (Hint: You already determined the total number of children in part (a) and now need to determine the number of teachers in each private school.)

(d) How many private schools are operating?

(e) Now suppose that the government makes private school vouchers in the amount of 5.35 (i.e. $5,350) per child available to parents. How will this change the demand function for seats in private schools? (Hint: Be careful to add the voucher in the correct way – i.e. to make the demand curve shift up.)

(f) Given this change in demand, what will happen to tuition and the number of children served in existing private schools in the short run assuming the number of schools is fixed and no new schools can enter in the short run? (Hint: You will need to know the current level of capital, derive the short run supply function for private schools, then aggregate them across the existing private schools.)

(g) What happens to private school class size in the short run?

(h) How do your answers change in the long run when new schools can enter?

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\(^5\)It may be helpful to check equation (13.50) in exercise 13.8.
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14.11 Policy Application: Public School Teacher Salaries, Class Size and Private School Markets: In exercise 14.10, we noted that private schools that charge tuition operate alongside public schools in U.S. cities. There is much discussion in policy circles regarding the appropriate level of public school teacher salaries (which are set by the local or state government) as well as the appropriate number of public school teachers (that determines class size in public schools).

A: Suppose again that private schools face U-shaped long-run AC curves for providing seats to children and that the private school market is currently in long run equilibrium.

(a) Begin by drawing two graphs – one with the long run AC curve for a representative private school and a second with the demand and (short run) aggregate supply curves (for private school seats) that are consistent with the private school market being in long run equilibrium (with private school tuition \( p \) on the vertical axis).

(b) Now suppose the government initiates a major investment in public education by raising public school teacher salaries. In the market for private school teachers (with private school teacher salaries on the vertical and private school teachers on the horizontal), what would you expect to happen as a result of this public school investment?

(c) How will this impact private school tuition levels, the number of seats in private schools and the overall number of children attending private schools in the short run?

(d) How does your answer change in the long run as private schools can enter and exit the industry?

(e) Suppose that instead of this teacher salary initiative, the city government decides to channel its public school investment initiative into hiring more public school teachers (as the city government is simply recruiting additional teachers from other states) and thus reducing class size. Assuming that this has no impact on the equilibrium salaries for teachers but does cause parents to feel more positively about public schools, how will the private school market be impacted in the short and long run?

(f) How will your long run answer to (e) be affected if the government push for more public school teachers also causes equilibrium teacher salaries to increase?

B: As in exercise 14.10, assume a total city-wide demand function \( x(p) = 24,710 - 2500p \) for private school seats and let each private school’s average long run cost function be given by \( AC(x) = 0.655x^{1/3} + (900/x) \). Again, interpret all dollar values in thousands of dollars.

(a) If you have not already done so, calculate the initial long run equilibrium size of each school, what tuition price they charge and how many private schools there are in the market.

(b) If you did B(a) in exercise 14.10, you have already shown that this \( AC(x) \) curve arises from the Cobb-Douglas production function \( x = f(\ell, k) = 35\ell^{0.5}k^{0.25} \) when \( w = 50 \) and \( r = 25 \) and when private schools face a fixed cost of 900. If you have not already done so, use this information to determine how many teachers and how much capital each school hires.

(c) Suppose that the increased pay for public school teachers drives up the equilibrium wage for private school teachers from 50 to 60 (i.e. from $50,000 to $60,000 per year). What happens to the equilibrium tuition price in the short run?

(d) What happens to school size and class size?

(e) How will your answers on school size, tuition level and class size change in the long run? (Hint: You can use the cost function given in equation (13.45) of exercise 13.5 to derive the \( AC \) function – just make sure you keep track of the fixed cost of 900!)

(f) How many private schools will remain in the market in the long run?

14.12 Policy Application: Pollution Taxes on Output: Suppose you are one of many firms that refine crude oil into gasoline. Not surprisingly, this process is one that creates pollution. The government therefore announces a new tax of $\( t \) on each gallon of gasoline that leaves a refinery (to be paid by the refinery.)

A: For purposes of this exercise, assume that the refinement process of crude oil into gasoline has decreasing returns to scale but entails a recurring fixed cost.

(a) Begin by illustrating the industry in pre-tax equilibrium – showing one firm’s average cost curve as well as the (short run) market supply and demand that supports an industry in long run equilibrium.

(b) What changes for each firm and in the industry in the short run when the tax is introduced?

(c) What changes in the long run?
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(d) True or False: While refineries bear some of the burden of this tax in the short run, they will pass all of the tax on to consumers in the long run.

(e) I recently heard the following comment on one of the TV news shows (regarding a tax similar to the one we are analyzing here): “Regulators are particularly concerned about reports that companies in the industry managed to pass the pollution tax fully onto consumers and view this as a sign that the industry is not competitive but is rather engaged in strategic manipulation of gasoline prices.” What do you make of this TV wisdom?

(f) Will refineries change the mix of labor and capital in the long run (assuming they continue operating)?

(g) Here is another quote from a recent TV analysis: “In talking to this refinery’s owner, it seems that there are no plans in place to lay off any workers in response to the pollution tax on refined gasoline. Jobs in the industry therefore appear to be safe for now.” Do you agree?

B: Once again suppose that the production function used by firms in the gasoline refinery industry is \( f(\ell, k) = A\ell^\alpha k^\beta \) with \( \alpha, \beta > 0 \) and \( \alpha + \beta < 1 \), and suppose that each refinery pays a recurring fixed cost \( F \).

(a) If you did not already do so in exercise 14.1, derive the expression for the output level \( x^* \) at which the long run \( AC \) curve reaches its lowest point. (This should be a function of \( A, \alpha, \beta, w \) and \( r \).)

(b) How does \( x^* \) change under the per-gallon tax on gasoline leaving the refinery?

(c) Can you use your answer to determine whether the number of gasoline refineries will increase or decrease as a result of the tax?

(d) If you have not already done so in exercise 14.1, determine the long run equilibrium price \( p^* \) before the tax (a function of \( A, \alpha, \beta, w \) and \( r \).) How does this change under the tax?

(e) Can you use your answer to determine who actually pays the tax?

(f) Will the tax result in less pollution? If so, why?