

When Supply and Demand Just Won't Do: Using the Equilibrium Locus to Think about Comparative Statics *

Meghan R. Busse
Northwestern University and NBER

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Abstract

This paper proposes using the “equilibrium locus” to think about the effect of changes in demand on market outcomes in oligopolistic or monopoly markets where a supply and demand graph is not the appropriate analytical tool.

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1 Introduction

The first tool that almost every economist learns to use is the supply and demand graph. It is the workhorse of the introductory microeconomics textbook, and a good starting point for many “back-of-the-napkin” conversations. One limitation of the supply and demand graph is that, while the demand curve can be drawn to represent a great variety of demand conditions, the supply curve—while it can represent a variety of marginal cost conditions—is only valid for a perfectly competitive market. Monopolistic or oligopolistic markets do not have “supply curves” as such.

In this letter, I define an object which I call the “equilibrium locus,” which is the set of equilibrium price and quantity combinations that arise from different levels of demand in a market. I argue that the “equilibrium locus” is a useful analytical tool in that it can serve the same graphical function for an oligopolistic market as a supply curve does for a perfectly competitive market in thinking about equilibrium effects of changes in market conditions.

I begin with a description of the equilibrium locus in a perfect competitive market. In this case, the equilibrium locus is the same as the supply curve, so this case which establishes a benchmark. I then consider the equilibrium locus in a monopoly market, and conclude with oligopoly markets. The key lesson is that the shape of the equilibrium locus depends on the shape of the demand and marginal cost curves, and on the nature of competition in the market. I conclude with a discussion of the link between these ideas and the empirical estimation of conjectural variations.

2 Perfect competition

Consider a market for a good is perfectly competitive, and consider a set of demand curves each arising from a different level of income or taste for the good. Each demand curve will give rise to a corresponding equilibrium outcome at the intersection of the market demand curve with the market supply curve. Changes in the demand curve, therefore, will trace out the market supply curve, which will be equal the industry marginal cost curve, or the horizontal sum of the individual firm marginal cost curves. The equilibrium locus, in the case of perfect competition, is therefore equal to the industry marginal cost curve, as shown in Figure 1. The equilibrium locus will be flatter or steeper corresponding to the flatness or the steepness of the industry marginal cost curve. In this case, the shape of the demand curve will not affect the shape of the equilibrium locus.

3 Monopoly

Now consider a good supplied by a monopoly. A monopolist has no “supply curve,” but each realization of the demand curve will correspond to a profit-maximizing price and quantity combination

Figure 1: Equilibrium locus for hypothetical competitive market

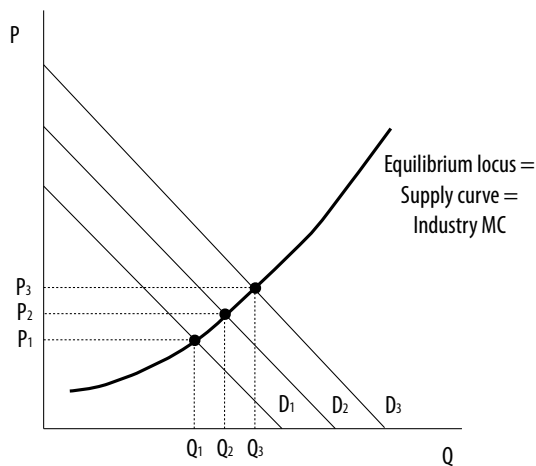
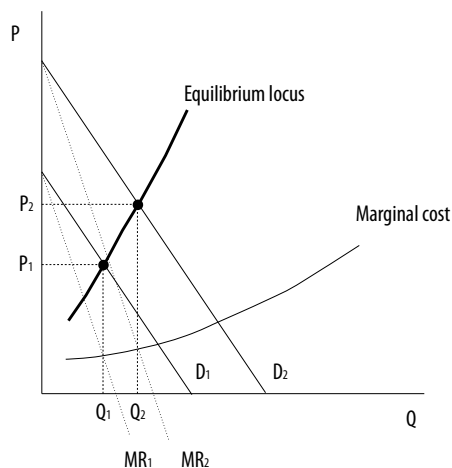


Figure 2: Equilibrium locus for hypothetical monopoly market (inelastic demand)



for the monopolist. The set of all of these price-quantity combinations is the equilibrium locus. In the monopoly case, the equilibrium locus can take a variety of shapes, depending not only on the shape of the marginal cost curve, but also on the shape of the demand curve, and how the demand curve is affected by changes in income, tastes, or the attractiveness of substitute or complementary goods.

For example, as shown in Figures 2 and 3 below, the steeper (or generally more inelastic) the demand curve is for a given marginal cost curve, the steeper the equilibrium locus will be. This means that changes in demand will lead to greater changes in equilibrium prices relative to equilibrium quantities when demand curves are steeper than when demand curves are flatter. The intuition for this result is the following: The monopolist's profit-maximization problem is always

Figure 3: Equilibrium locus for hypothetical monopoly market (elastic demand)

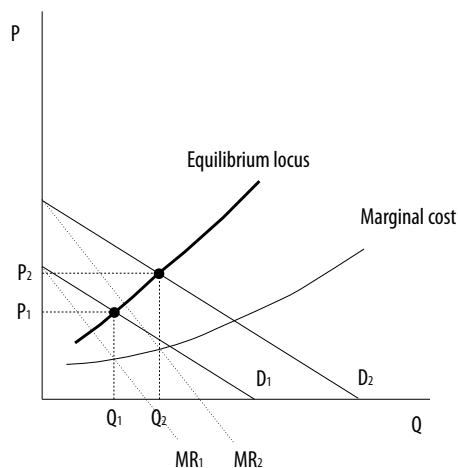
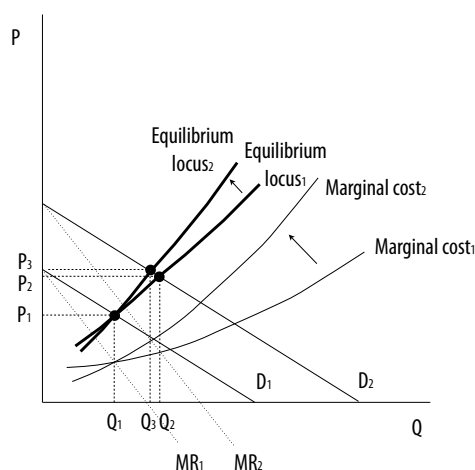


Figure 4: Equilibrium locus for hypothetical monopoly market (steep marginal cost)

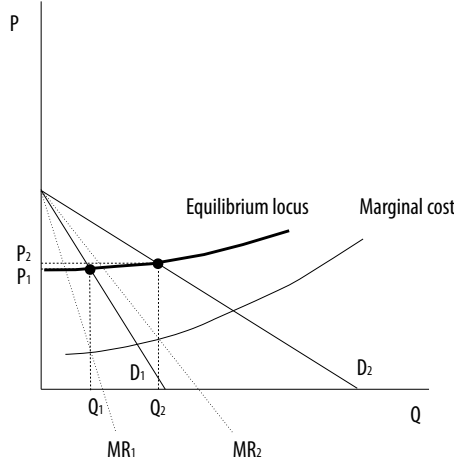


a trade-off between a higher price and a larger quantity. For a monopolist whose product has few substitutes, and who therefore faces an inelastic demand, it is more profitable to respond to an increase in demand by increasing price a lot relative to quantity, and taking advantage of the inelastic demand by earning a higher profit margin. A monopolist facing less elastic demand will be better able to increase profits by raising the price only a little, but benefitting by substantially increased sales.

As Figure 4 shows, the shape of the equilibrium locus is also influenced by the shape of the marginal cost curve. A steeper marginal cost curve will lead to a steeper equilibrium locus.

How changes in demand conditions (income, tastes, substitute goods) affect the equilibrium outcomes also depends on how the demand curve responds to changes in those demand conditions.

Figure 5: Equilibrium locus for hypothetical monopoly market (non-parallel demand)



Figures 2 and 3 show demand curves that make parallel shifts, but this is not the only possibility. Consider for example, a change in tastes (or income or the availability of other goods) that has little effect on the demand for that vehicle by potential buyers with the highest reservation values, but a much bigger effect on the demand that arises from buyers with lower reservation values. If this is the case, the effect of the change in taste on the demand curve might resemble the rotation depicted in Figure 5. This will lead to an equilibrium locus that is relatively flat, meaning that changes in tastes should lead to a large change in the equilibrium quantity relative to the change in the equilibrium price.

We can derive an expression for the equilibrium locus in the familiar case of linear demand ($P = a - bQ$) and constant marginal cost (c). In this case marginal revenue is equal to $a - 2bQ$, which we can set it equal to marginal cost of c , yielding an equilibrium quantity of $Q^* = \frac{a-c}{2b}$. The corresponding equilibrium price will be $P^* = \frac{a+c}{2}$. Suppose that taste changes induce parallel shifts in the demand curve (a changes while b remains fixed, as shown in Figures 2 and 3). By adding and subtracting $\frac{c}{2}$ and multiplying and dividing one of the terms by b , we can express the equilibrium locus as

$$P^* = bQ^* + c. \quad (1)$$

If, instead, we were to assume that taste changes leave a unchanged, but change b , the case shown in Figure 5, then a change in tastes will have no effect on equilibrium price (because $\frac{dP^*}{db} = 0$) and will affect equilibrium quantity according to $\frac{dQ^*}{db} = -\frac{(a-c)}{2b^2}$. This corresponds to a horizontal equilibrium locus.

4 Oligopoly

There are many ways to model oligopoly, and each will give a different equilibrium locus. For the sake of intuition, we describe a benchmark N -firm Cournot equilibrium model, with the same linear demand curve ($P = a - bQ$) and constant marginal cost (c) as we used to describe monopoly.

In this setup, the Cournot equilibrium price is equal to $P^* = \frac{a+Nc}{N+1}$ and the corresponding equilibrium market quantity is $Q^* = (\frac{N}{N+1})\frac{(a-c)}{b}$. Assuming again that taste changes (or other changes in demand conditions) induce parallel shifts in the demand curve, we can take the expression for P^* and then add and subtract $(\frac{b}{N})(\frac{N}{N+1})\frac{c}{b}$, and also multiply and divide part of the expression by $\frac{b}{N}$. Having done so, we can express the equilibrium locus as

$$P^* = \frac{b}{N}Q^* + c. \quad (2)$$

Notice that the monopoly equilibrium locus corresponds to this expression with $N = 1$, while as N grows, this expression will approach the perfectly competitive outcome of $P^* = c$. This implies several things. First, the equilibrium locus will be steeper in a monopoly than in an oligopoly with the same demand and cost conditions, meaning that the greater the market power, the greater the effect we would expect a change in demand to have on the equilibrium price relative to the quantity. Second, in general, in a monopoly as well as an oligopoly, the steeper (or generally more inelastic the demand curve), the greater the effect we would expect a change in demand to have on the equilibrium price relative to the quantity.¹

5 Connection to conjectural variations

Bresnahan (1989) considers the problem of estimating parameters to describe competitive conduct in a market or industry. He notes that, except in perfectly competitive markets, firms do not have supply curves, as such. Instead firms solve the problem of maximizing profits, given the choices of competitors, a problem characterized by the following first order condition:

$$P^* = C'(q) - \theta D'(Q)q \quad (3)$$

where $C'()$ is the marginal cost function, $D'()$ is the derivative of the demand curve with respect to the market output Q , and q is the firm's own output. The parameter theta is the strategic interaction parameter, or "conjectural variations" parameter, which captures the conduct in the

¹The alternate assumption, that changes in gasoline prices change the slope of the demand curve (b) but leave the reservation price (a) unchanged would lead to a horizontal equilibrium locus. As is the case for monopoly, $\frac{dP^*}{db} = 0$.

market. If $\theta = 0$, the condition collapses to a marginal cost pricing rule, which indicates that the conduct in the market is perfectly competitive. As θ increases from 0, the conduct in the market diverges from the perfectly competitive outcome. A particular assumption about the model of oligopolistic behavior being followed in a market would lead to a specific value of θ , but θ is usually measured as a continuously-valued parameter that captures market competitiveness which could also vary continuously.

The equilibrium locus describes how the equilibrium price and quantity in a market change as demand changes. This will be determined in part by the nature of competition in the market, but also by the shape of the marginal cost curve and the shape of the demand curve and how it is shifting. Because of these, it isn't possible to draw a direct correspondence between the value of the "conjectural variations" parameter and the shape of the equilibrium locus. However, generally, one would expect that, all else equal, the equilibrium locus will be flatter the closer the strategic interaction in the market is to perfect competition.

6 Conclusion

In this letter, I have defined the "equilibrium locus" as the set of equilibrium price and quantity combinations that are traced out in a market when demand changes. I have argued that the equilibrium locus is a useful tool for thinking about how changes in demand will affect market outcomes in markets that are not perfectly competitive, and where a supply and demand graph is therefore not an appropriate analytical tool. The shape of the equilibrium locus depends on the shape of the marginal cost curve, the shape of the demand curve, and the nature of competition in the market.

References

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