

Course notes for EE394V

Restructured Electricity Markets: Locational Marginal Pricing

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Microeconomics

- (i) Example of apartment rental,
- (ii) Renters,
- (iii) Supply,
- (iv) Equilibrium,
- (v) Market clearing price,
- (vi) Longer term issues,
- (vii) Operating costs,

- (viii) Inelastic demand,
- (ix) Spot and forward markets.

4.1 Example of apartment rental

4.1.1 Renters

- Consider a number of possible renters in an area.
- Ask each of them their **willingness-to-pay** for an apartment in this area and graph this **reservation price** versus number of apartments, ordered from highest to lowest reservation price.
- The **demand curve** shows the number of renters willing to rent at a given price:
 - if I am willing to pay \$1000 per month then I would be happy to rent at any price at or below \$1000 per month.

Renters, continued

- Standard practice in economics is to graph price on the vertical axis, whether price is the dependent or the independent variable:
 - the “demand function” is a function with price as an argument (the independent variable) and quantity demanded as the dependent variable,
 - the “inverse demand function” is a function (if it exists) with quantity demanded as its argument (the independent variable) and willingness-to-pay as its dependent variable, and
 - the phrase “demand curve” is sometimes used to refer to either or both of these relations without explicitly specifying whether price or quantity is the independent variable.
- See Figures 1.1 and 1.2 of Hal R. Varian, *Intermediate Microeconomics*.
- Figure 1.1 shows the case where there are just a few renters and the inverse demand function does not exist.
- Figure 1.2 shows the case where there are enough renters that we can think of the demand curve as being a continuous curve, so that both the demand curve and the inverse demand curve exists.

Renters, continued

Reservation price

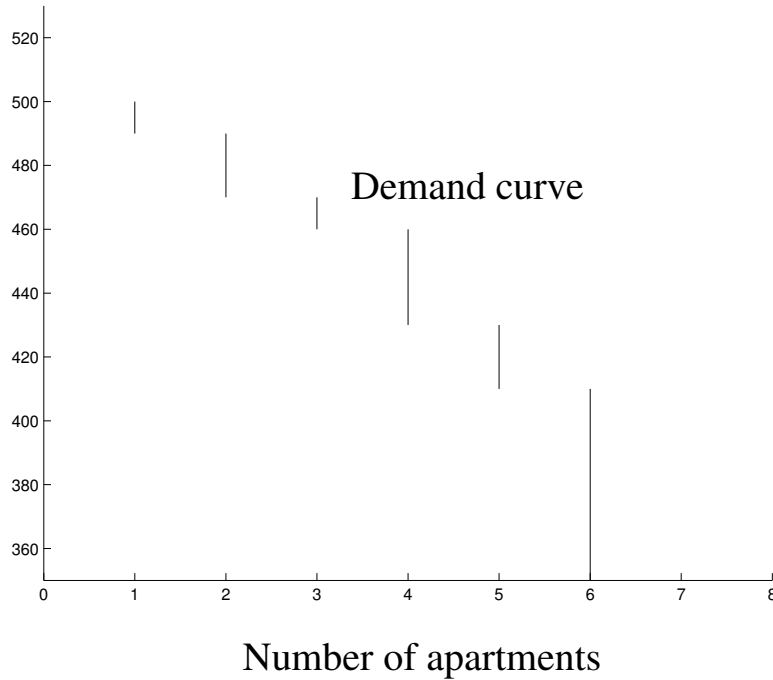


Fig. 4.1. The demand curve for apartments.
Source: This is based on Figure 1.1 of Hal R. Varian, *Intermediate Microeconomics*.

Renters, continued

Reservation price

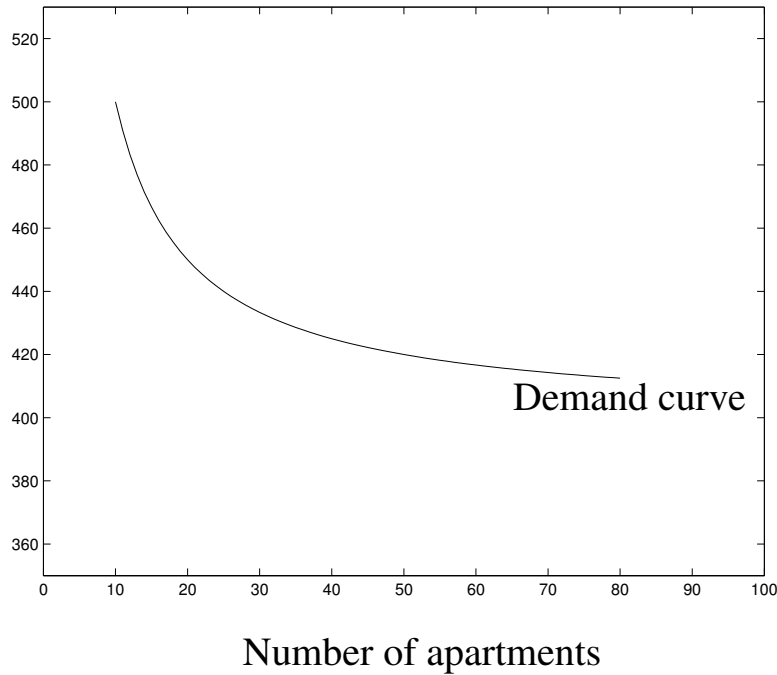


Fig. 4.2. The demand curve for apartments with many “demanders.”

Source: This is based on Figure 1.2 of Hal R. Varian, *Intermediate Microeconomics*.

4.1.2 Supply

- Consider a number, S , of independent landlords offering to rent identical apartments on a month-to-month basis:
 - in the “short-run” this supply is fixed,
 - the supply is **inelastic**, meaning that it stays fixed despite variations in price.
- Assume that there are no “operating costs” of leasing an apartment.
- At what price or prices would they rent?
 - If any two apartments are renting at a different price then the person paying the higher price would have an incentive to cut a deal with the owner of the lower priced apartment to rent at an intermediate price.
 - So, if any rental prices are different, then some renters and landlords desire to change their situation.
- So, all prices paid by the renters must be same in the “equilibrium” where no renter and landlord want to the change:
 - despite lack of any centralized coordination, price will be uniform in the market for apartments.

Supply, continued

- The **supply curve** shows the number of apartments that are available.
 - the “supply function” is a function with price as an argument (the independent variable) and the number of available apartments as the dependent variable,
 - the “inverse supply function” is a function (if it exists) with number of apartments as its argument (the independent variable) and price as its dependent variable, and
 - the phrase “supply curve” is used to refer to the relation without explicitly specifying whether price or quantity is the independent variable.
- Figure 1.3 of Varian shows the supply curve as a vertical line that represents the number, S , of apartments:
 - the inverse supply function does not exist in this case.

Supply, continued

Reservation price

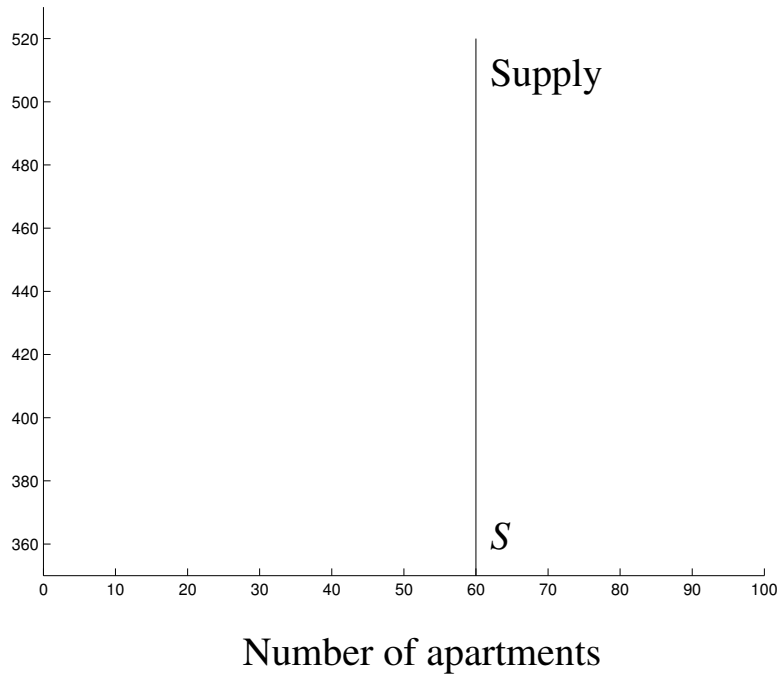


Fig. 4.3. The supply of apartments is fixed in the short-run.

Source: This is based on Figure 1.3 of Hal R. Varian, *Intermediate Microeconomics*.

4.1.3 Equilibrium

- Which possible renters will actually get to rent?
- What price and allocation of apartments to renters would result in no one wanting to change their situation:
 - the equilibrium price and quantity.
- Consider the intersection of demand curve and the vertical line representing the number of apartments.
- The intersection defines a price p^* at the quantity S .
- What price will the renters pay?
- See Figure 1.4 of Varian.

Equilibrium, continued

Reservation price

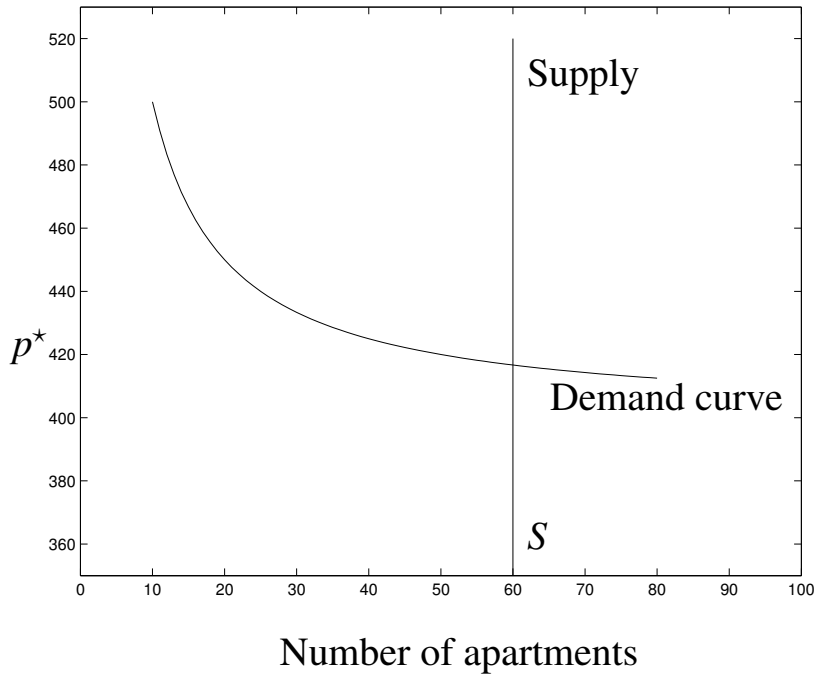


Fig. 4.4. The equilibrium price p^* is determined by the intersection of supply and demand.

Source: This is based on Figure 1.4 of Hal R. Varian, *Intermediate Microeconomics*.

Equilibrium, continued

- We have already argued that there will be a single price in the market that every renter will pay.
- Suppose that the single price is above p^* :
 - only the people with willingness-to-pay above p^* will rent,
 - so less than S apartments would be rented,
 - one of the landlords of the unrented apartments would offer to lease at a cheaper price than p^* to “capture” one of the renters,
 - so not in equilibrium.
- Suppose that the single price is below p^* :
 - More than S renters would want to rent,
 - only S apartments could be rented,
 - some of the unsatisfied renters would be willing to pay above p^* to “capture” one of the apartments,
 - so no in equilibrium.
- So, the price must be p^* in equilibrium with all S apartments rented.

4.2 Market clearing price

- The price p^* is called the **market clearing price**, since it is the price that equates supply to demand.
- At this price:
 - neither renters, potential renters, nor landlords have any desire to change their situation,
 - the potential renters with the highest willingness-to-pay actually rent the apartments,
 - summed across the renters, the total willingness-to-pay, or **welfare** or **surplus**, (strictly speaking, the increase in welfare or surplus per unit time) is maximized,
 - using sensitivity analysis, this price is the sensitivity of welfare (or of surplus) to changes in supply or demand; it is the **marginal surplus**.
- The price p^* provides the correct incentive for actions by individual renters and landlords to result in maximizing the welfare:
 - if a central agent announced this price then the actions of individual renters and landlords in response to this price would result in maximizing the welfare.

Market clearing price, continued

- We can divide the surplus into:
 - consumer surplus, which is the surplus minus the total paid by the renters, and
 - producer surplus, which is the total paid by the renters to the landlords.

4.3 Longer term issues

- In the longer term, new investors may decide to build new apartments (or new generating stations):
 - If the price p^* is high enough to support the investment (and is expected to stay high enough to support the investment) then new apartments will be built.
- In the longer term, there may be more potential renters:
 - this will tend to increase the equilibrium price,
 - but subsequent new investment will tend to decrease the price again.

4.4 Operating costs

- So far, we have assumed that the operating cost is zero.
- What would happen if there were operating costs of renting the apartments were non-zero:
 - apartment 1 has operating cost $c_1 = \$150$ per month,
 - apartment 2 has a slightly higher operating cost $c_2 = \$155$ per month,
 - and so on.
- In this case, instead of a vertical supply curve, the supply curve would equal c_1 at a supply of one apartment, c_2 at a supply of two apartments, etc.
- There would still typically be an intersection of demand and supply:
 - but there would be no intersection if c_1 were above the highest willingness-to-pay of the renters.
- At the intersection, the difference between the total willingness-to-pay for apartments and the cost of supplying apartments is maximized:
 - we generalize the definition of welfare or surplus to be the difference between the total willingness-to-pay minus the cost of supply.
- There are also operating costs of supply in electricity markets.

Operating costs, continued

Reservation price

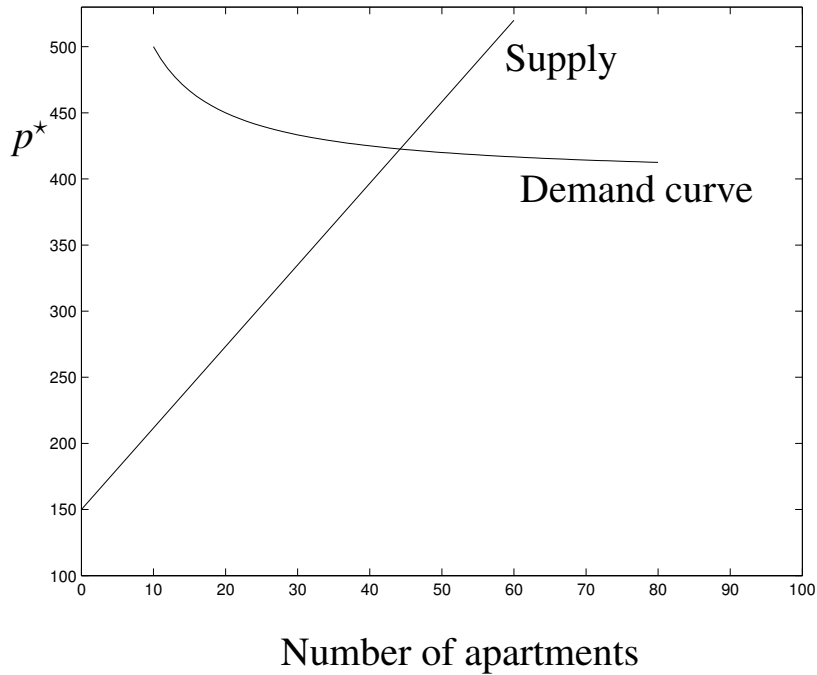


Fig. 4.5. The supply curve and equilibrium with variable costs.

Operating costs, continued

- The surplus is the area between the supply and demand curves up to the quantity supplied.
- We can again divide the surplus into:
 - consumer surplus, which is the surplus minus the total paid by the consumers to the producers, and
 - producer surplus, or operating profit, which is the total paid to the producers minus the cost of production.
- Operating costs in electricity are due to the cost of fuel, as we have discussed in the context of economic dispatch.
- “New” generators tend to have higher efficiency than “old” generators:
 - ignoring changes in fuels and fuel costs, in the long-term, the supply curve tends to shift “down” as new capacity is introduced (and old capacity is retired),
 - changes in fuels and fuel costs can either reinforce and act in opposition to this trend.

4.5 Inelastic demand

- In electricity markets particularly, the demand may not change much with price:
 - demand is said to be **inelastic**,
- Several reasons for demand inelasticity:
 - consumers may not care about price,
 - consumers may not be exposed (directly) to wholesale prices.
- In this case, instead of a “downward sloping” demand curve, the demand curve is vertical.
- There will still usually be an intersection of supply and demand.
- However, for example, in extreme weather conditions there may be no intersection of supply and demand.

Inelastic demand, continued

Reservation price

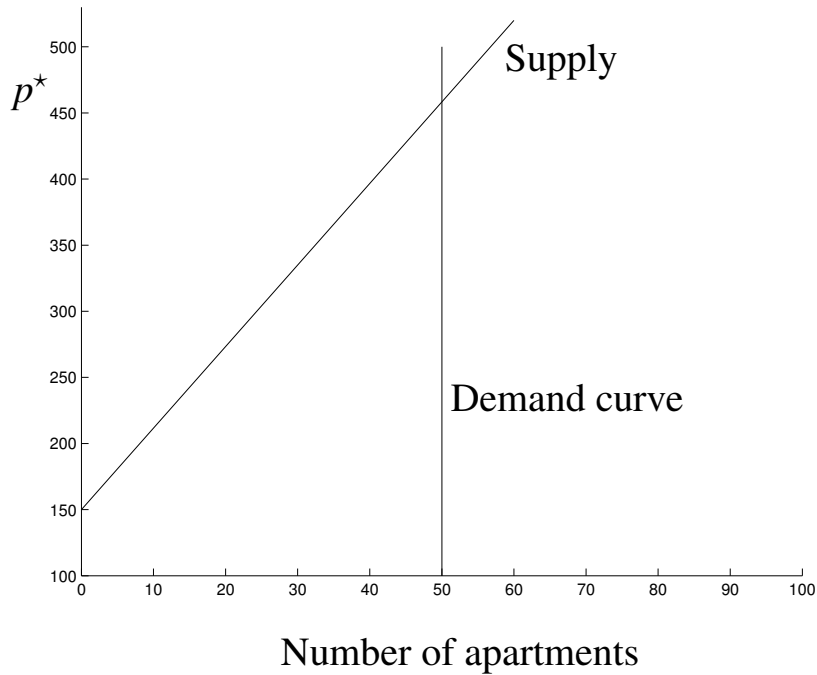


Fig. 4.6. The supply curve and equilibrium with variable costs and inelastic demand.

4.6 Spot and forward markets

- The description so far is most applicable a **spot market** where producers and consumers interact to trade.
- The actual price (and amount traded) will depend on the interaction between supply and demand and is uncertain.
- In a **forward contract** or **future contract** parties decide on an amount to trade and price in advance:
 - enables a quantity to be sold at a fixed price, avoiding the variability of the uncertain “spot” price.
- Future and forward trading is especially important in electricity because the prices are very variable or **volatile**.
- By “locking in” prices it can also help with investment.

4.7 Summary

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This chapter is based on:

- Chapter 1 of Hal R. Varian, *Intermediate Microeconomics*, Norton, 2006,
- Chapter 2 of Daniel S. Kirschen and Goran Strbac, *Power System Economics*, Wiley, 2004.