Supply and Duration

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Introduction

Today we consider firm supply decision; two elements:

1. Price-taking and the role of marginal cost
    - A price taking firm equates price to marginal cost
    - But only where marginal cost is increasing
    - Shut-down conditions and real supply curve
    - Producer surplus and profits
    - Different graphical representations
2. Time and duration
    - Distinction between durable and storable commodities
    - Le Chatelier's principle
    - Durability: supply over various runs
    - Relationship among different run curves
    - Types of demand shocks and firm responses to them
    - How things reverse with storability

Price taking firm, marginal cost and supply

For next two weeks, firms will be “price takers”

- A firm whose output varies over small range
- Not large enough to substantially affect prices
  - Demand curve flat until firm produces a huge amount
- We will give foundations for this in Lecture 16
- Price taker maximizes $pq - TC(q)$; first-order condition?

$$p = MC(q) \iff q = S(p) = MC^{-1}(q)$$

- Let’s return to example from before: Cobb-Douglas
  - Marginal is $MC(o) = ko^{\alpha}$; if not increasing problem...
    - Let’s assume $\alpha > 0$
  - Then what is supply?
    - $S(p) = \left(\frac{p}{k}\right)^{\frac{1}{\alpha}}$

What if costs are not so nicely behaved?

This is fundamental supply equation:

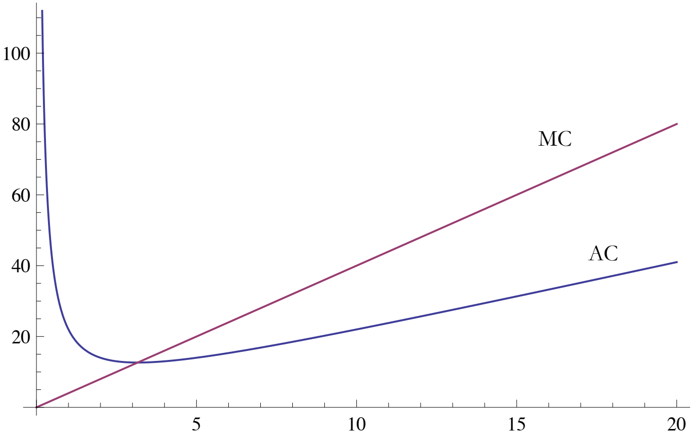
- Marginal cost curve typically is supply curve
- However, two problems can arise:
  1. Firms will not produce unless they make profit
     - Only area above the *AC* curve is supply
     - Many airlines shut down if scale not efficient
  2. MC intersects price many times
     - Firm chooses most profitable point
     - Must intersect from below to above
     - Of all those which do, choose the one with most area
     - May occur with many quasi-fixed factors

$\Longrightarrow$ Never a competitive firm with increasing returns

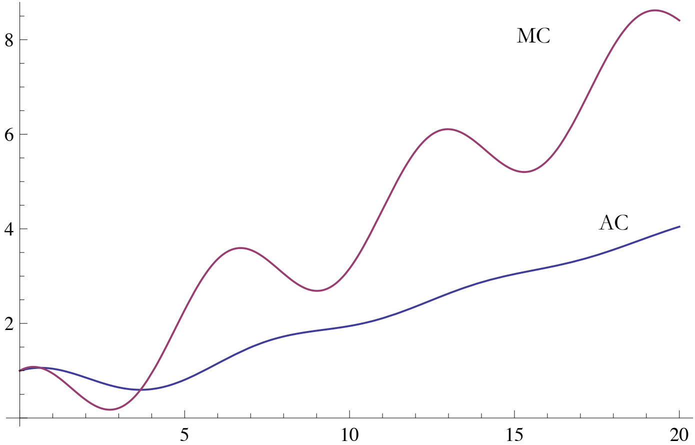
- They would end up producing a large amount...
- Then they would no longer be competitive!

- *No Giffen good/downward sloping firm supply!*

Graphical representation of supply and shutdown



Graphical representation of non-monotone MC



The concept of producer surplus

Producer surplus is firm profits $pq - TC(q)$; also...

1. $[p - AC(q)]\, q$
2. Also area between price and MC
3. Also measures curvature of costs; $\int_{q=0}^{q^\star} qMC'(q)dq$
4. Also area between y-axis and $S(p)$

Let's do this all graphically on the board

Durable and storable factors

Now time: Our cost, supply are *per unit of time*

- But how long are we taking average over?
- Responses to shifts in price, demand depend on *duration*

Factors (inputs) inter-temporal complements or substitutes

1. Inter-temporal complements or *durables*; definition?
    - Last for fixed (non-trivial) period of time: *time* depreciates
    - Doesn't make sense to change frequently
    - *Cheap* to use during *scarce* life span
    - Where you live
2. Inter-temporal substitues or *storables/exhaustibles*?
    - Last but only finite (large) number of uses: *use* depreciates
    - Short-term changes cheap; long-term changes expensive
    - *Expensive* to use during *very long* life
    - Vacations

Standard taxonomy of factors

All of this depends on context, but typically:

1. Very durable
   - Entry by firms into countries or industries, education
   - Culture, political, economic and social institutions
2. Somewhat durable
   - Machines, job experience, physical plants
   - Production procedures, personal relationships, memory
3. Variable (equally durable and storable)
   - Unskilled labor, bulky raw materials, advertising, rentables
4. Somewhat storable
   - Inventory of goods, favors, discontinued consumer goods
5. Very storable
   - Exhaustible resources (for economy): oil, gas, copper
   - Money (for an individual), great bottles of wine

Le Chatelier's principle

Why does all this matter?

- If you can adjustment more, your reactions are greater

$\Longrightarrow$ Supply more elastic to shifts when more adjusts

  - *Independent* of whether factor is complement or substitute
  - Price of gasoline rises: reaction greater if you can change...
    1. Your amount of travel (complement for gasoline)
    2. To a cleaner car (substitute for gasoline)
- This is called *Le Chatelier's principle*
- This is the driving force behind analysis of duration
  - Supply more elastic over time frames when more adjusts
- Key question: adjustment *relative to market opportunities*
  - If a durable cheaply rented for short period, not durable
  - If storable can easily be off-loaded at fair price, not storable
- In this sense, more often durable; main assumption below

Basic definition of runs and duration

Following this (most inputs durable), we can define runs

- These curves denote reactions to price/demand shifts
- Each curve corresponds to different duration shift
- The longer the duration or "run" of production...
  - More durables can be adjusted
  - Thus often various "runs" identified with which factors adjust
  - No universal identification, but often:
    1. Short: variable factors like unskilled labor and raw materials
    2. Medium/intermediate: plant sizes, production methods
    3. Long-term: entry of new firms, supply of factors to firm
  - Note: all heuristics, many counter-examples
    - *Tons* of firms entered Groupon's market immediately
    - Medical industry takes forever for labor, use computers

$\Longrightarrow$ Institutional and legal context *crucial*!

- Actual years, not just short v. long matters in practice

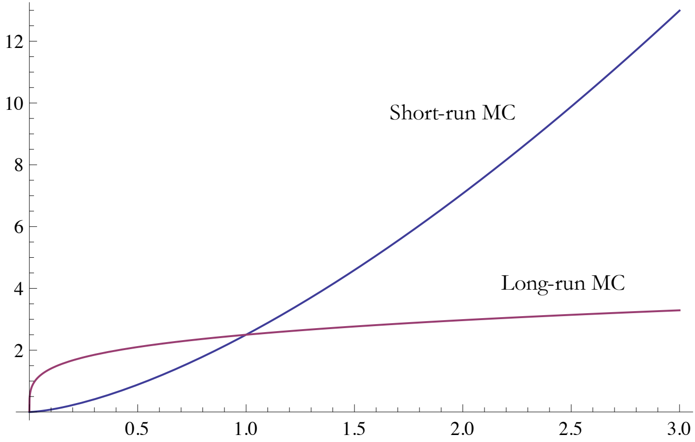
Marginal cost curves and elasticities

Let's consider simple example of Le Chatelier's principle

- Imagine production function $o = x^{.4}y^{.4}$
  1. Both factor prices are 1, so $TC(o) = \frac{.8}{.4}o^{\frac{1}{.8}} = 2o^{1.25}$

     $\implies \quad MC(o) = 2.5o^{.25}$
  2. Long-run equilibrium; price is 2.5, $o = 1$, $x, y = 1$
  3. Suppose y is fixed in the short-term: derive short-term MC
     - Now short-term production function is $o = x^{.4}$
     - So $TC(o) = o^{2.5} + 1, MC(o) = 2.5o^{1.5}$
  4. Two things to note:
     1. Long-run marginal cost *much more elastic* (see graph)
     2. *At equilibrium* exactly the same
- This last principle is called the *envelope theorem*
- We'll shortly see why it is called this...

Cobb-Douglas example of short- and long-run MC

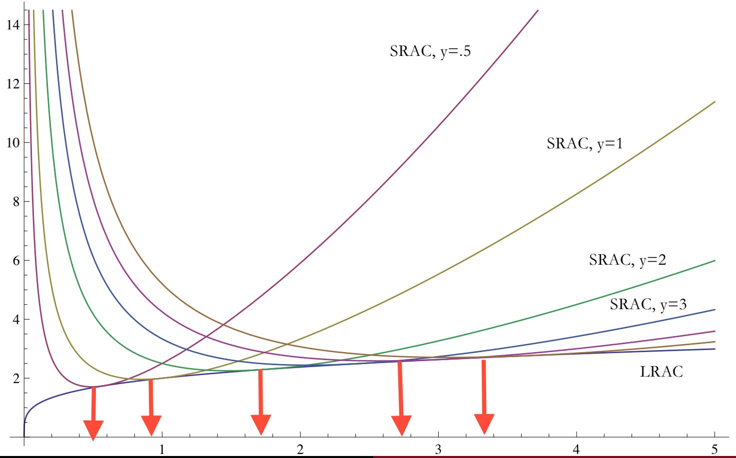


Envelope conditions and average costs

Now, to really understand why it's the envelope theorem...

- Let's compare the long-run and short-run average cost
- Already calculated: $LRAC(o) = 2o^{.25}$
- How about short-run?
  - For any given y, pay y and production $o = x^{.4}y^{.4}$
  - So $SRTC(o) = \frac{o^{2.5}}{y} + y$ and $SRAC(o) = \frac{o^{1.5}}{y} + \frac{y}{o}$
- "Envelope theorem": long-run is envelope of short-run
  1. Marginal cost same at point where long-run optimal
  2. Average cost identical and tangent at long-run optimal
- This principle shows up throughout economics

A graphical demonstration of the envelope theorem



Time, duration and the interpretation of runs

Again, interpret these as responses to different duration shifts

- But taking serious in terms of time raises some questions
  1. What is relationship between length of durability and run?
  2. Short-term reactions to sudden long-term shifts?
  3. What is long-term effect of many short term shifts?
  4. What if it is unclear how long shift endures?
  5. What does actual time path of adjustment look like?
- Popular recent way to explore these is *dynamic model*
  - Such models explicitly have different time periods
  - Can get *very complicated* and confusing
- Instead we'll continue with Marshallian statics but...
  - We'll try to reflect more informally on role of time
  - Hopefully will equip us to handle these issues with care
  - *Static models are averages of very dynamic world*

Types of demand shifts

1. One-time permanent
   - iPad permanently reduces paper demand
2. One-time temporary
   - Trend for cupcakes in major cities
3. In a secular trend
   - Demand for medical care from increased wealth, education
4. In a predictable cycle
   - Sesonal demand for vacations, electricity
   - If many durables, makes production less efficient
5. In an unpredictable cycle
   - Demand for men's underwear over the business cycle
6. Erratically
   - Demand for many fashion items, gold, diamonds

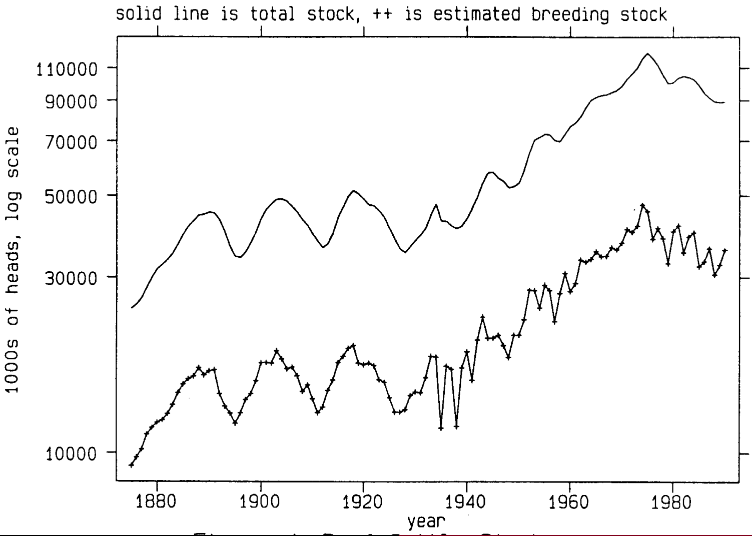
Adjustment and depreciation times

Not only expected duration, but also time since shock matter

1. Lags in returning to pre-shock equilibrium
   - Drug demand through México dramatically increased
   - Crack down made drugs less profitable
     - Competition also expanded
   - But violence has stayed high: diversified into kidnapping
     - Similar with paramilitaries in Colombia after Civil War

   $\Longrightarrow$ Long time for violent human capital to depreciate
2. Lags in getting to post-shock equilibrium
   - Greatest relative demand for Google was 6 years ago
   - But grown to huge size only now
   - Took many years to build up recruiting staff, and then recruit
3. Lags in adjusting to or away from cyclicality
   - Foreign imports and change in California migration patterns

Rosen et al. (1994)'s study of cattle cycles



(Counter-)example: exhaustible resources

So far I've focused mostly on durable inputs

- Now I want to contrast with extreme counter-example: oil
- Oil can be stored essentially costlessly in the ground
- No cost of extraction: then $p_t = (1+r)^t p_0$; why?
  1. If it grew slower, sell all oil today and save money
  2. If it grew faster, borrow and sell all oil tomorrow

$\Longrightarrow$ Temporary shock can only move *all prices together*

- Given that each year is only tiny percent, highly unlikely
- This is why gas prices do not increase much during summer

$\Longrightarrow$ All response from increased production

- On the other hand, unlikely climate policy affects oil
  - Full effect through price: oil is there and we will use it
  - Only likely effect is on timing of use

  $\Longrightarrow$ Time path of carbon tax matters more than level

Broader lessons form exhaustible resources

Oil (and other exhaustibles) are extreme (but important!) case

- But there is a broader lesson here
- In Macro you learn that long-run supply is vertical
  - This is exactly the exhaustible resource model
  - Do you believe this analysis?
- *This is totally inconsistent with standard duration analysis*

$\Longrightarrow$ At least sometimes, storability can be very important

- You should be critical in evaluating economic ideas
  - You never get something for nothing
  - When a result magical, always look for hidden assumption
  - When not transparent, often incorrect or limited
  - *Not a set of results but a toolbox for talking about world*