

Supply and Duration

E. Glen Weyl

University of Chicago

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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: ironing
 - Producer surplus and profits
- 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
 - Time path of production
 - How things reverse with storability

⇒ Goal: rich sense of how time interacts without dynamics

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?

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

- This is fundamental supply equation:
 - Marginal cost curve typically is supply curve
 - However, two problems can arise:
 - 1 MC cuts price from above, not below (minimum)
 - 2 MC intersects price many times
 - Let's try to solve this in simple way

What if marginal cost are not nicely behaved?

Supply

Runs

Production, Duration and Time

Basic supply decision

Ironing

Producer surplus

Graphical ironing

A mathematical solution to ironing

Let's be slightly more formal now:

- 1 Begin with non-monotone MC
- 2 Construct *ironed* \widetilde{MC} with property that
 - 1 \widetilde{MC} is monotone
 - 2 Everywhere that \widetilde{MC} strictly increases, same as MC
 - 3 Everywhere they disagree are regions $[q_i, \bar{q}_i]$
 - 4 Average value same over regions of disagreement
- 3 Not always possible to construct: economies of scale
 - In this case, firm supplies 0 or infinity; not competitive!
 - Thus we disregard this case
- 4 More broadly, firm acts *exactly as if ironed*
 - \implies Decreasing returns
 - Thus normal supply implied by optimization, competition
 - Only difference: skip over this region (almost never there)

The concept of producer surplus

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

① $[p - AC(q)] q$; why?

② Also area between price and (ironed) MC; prove?

- $TC(q) = \int_0^q \widetilde{MC}(q); pq = \int_0^q p dq$

③ Also measures curvature of costs; $\int_{q=0}^{q^*} qMC'(q) dq$; prove?

- Integrate by parts:

$$\int_0^{S(p)} p - MC(q) dq = \int_0^{S(p)} qMC'(q) dq - q[p - MC(p)] \Big|_0^{S(p)}$$

⇒ Curvature of costs/slope of marginal cost creates rents

④ Also area between y-axis and $S(p)$; prove?

- U-substitution: $p = \widetilde{MC}(q), dp = \widetilde{MC}'(q) dq$

$$\int_{q=0}^{q^*} qMC'(q) dq = \int_{\widetilde{MC}(0)}^p S(p) dp$$

Graphical equivalents

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 substitutes 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 adjust more, your reactions are greater
- ⇒ 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

⇒ Institutional and legal context *crucial!*

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

Marginal cost curves and elasticities

Envelope conditions and average costs

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
 - Seasonal 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

What makes a factor fixed v. variable?

Previously we treated factors as exogenously in a bucket

- Now we can see a factor's role depends on duration
- If factor's durability is small relative to run, close to variable
- If factor's durability is long relative to run, close to fixed
- Let us consider some examples:
 - ① 5-year run, factor is iPad?
 - Extremely variable
 - ② 2-year run, new corporate campus?
 - Extremely fixed
 - ③ 1-year run, hiring new investment banking analysts?
 - Quite fixed, though not entirely
 - ④ 15-year run, soldiers for to fight foreign wars?
 - A bit of a trick: storable factor so very fixed over this horizon
- Thus always consider *duration* to determine *role*

Relative utilization of fixed and variable factors

Another important impact of analysis is relative factor utilization

- The more variable/storable factors adjust more quickly
- The more durable factors adjust more slowly
- Thus relative uses adjust over time
- Let's consider some examples
 - 1 Short- and long-run adjustments to energy demand?
 - Increased oil extraction v. development of shale
 - 2 Seasonal adjustments in agriculture?
 - Increased pickers, same amount of land
 - 3 Adjustment to secular trends in medicine?
 - Not just more doctors trained, but more schools to train
 - 4 Cyclical demand for gold v. end of gold standard?
 - Mines shut down v. supply diverted from jewelry
 - 5 Local government v. corporate response to crisis?
 - Many more lay-offs in local government (fear of tea party)

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

⇒ 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 cyclicity
 - Foreign imports and change in California migration patterns

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

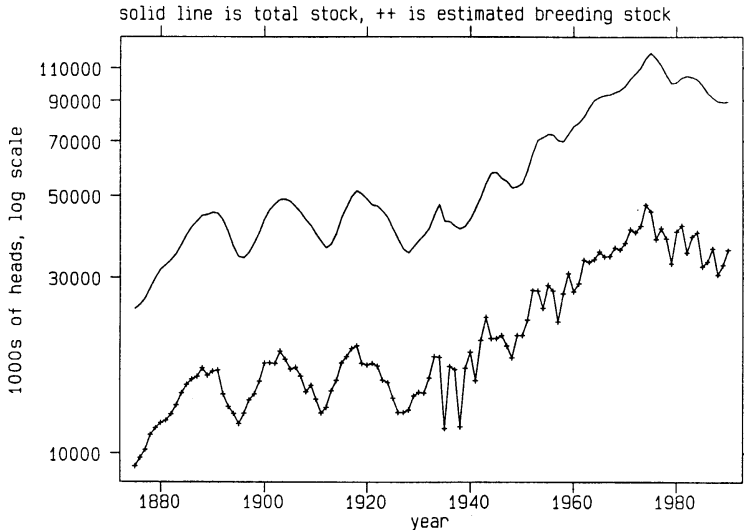


Figure 1: Beef Cattle Stocks

Uncertainty and learning

Uncertainty may also play a role in lags

- Suppose demand for Xbox surges around Christmas time
 - Natural response is to borrow, rather than build, factories
 - But if persists long after Christmas, may learn should build
 - Other industries might have built more quickly
 - Confusion about past cyclical muddles
 - More generally, past experience influences interpretation
- ⇒ Broader information, not just observing market, can matter
- Hellwig (2011) proposes important application
 - For macro, important question why price don't adjust
 - "Menu costs" (durability of prices) alone not big enough
 - Difficulty gathering info not either: just follow market
 - But if you are usually transitory shifts...
 - Then together information and price durability important

(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

⇒ 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

⇒ 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

⇒ 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*
- ⇒ 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*