Session 1. Producer's Problem

Tao Wang

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1 Overture: what (micro)economics is about

In a nutshell, economics is a subject about resource allocation under scarcity. This is well known by most of the students of economics already. Simple as it may seem, there are some important points worth clarifying.

- First. Why scarcity?
  - There is no problem of allocation if the resource is unlimited. Imagine we live in a utopian where everything desirable is available infinitely, the question who gets what and how becomes trivial.
  - Not just physical goods we consume are scarce, but also the time is.
  - There are different ways of describing the fundamental feature of the world and human life: scarcity.
    - Most of the decisions involve a trade-off.
      - Today versus tomorrow.
    - Opportunity cost. In order to do this, need to give up that.
    - "No free lunch." If something has benefit but no cost, then it is trivial.
- Second, what do we mean by allocation?
  - Allocation is, to use plain words, who gets what and how.
  - There are many mechanisms via which potentially we allocate resources. Economists are particularly interested in one of the mechanisms: the market.

    There are non-market mechanisms.
    - Covid vaccine distribution.
    - Kidney exchange. The law prohibits market exchange of the kidney. Then how do we match the donor and the receiver of a kidney?
    - College admission. To school: limited cohort size but more applications. To the applicant: apply for many, but just need to go to the most preferred school. How to make the match happen?

    - In a central-planned economy, every household goes to the distribution station run by the government, gets the assigned amount of necessities. No market.
    - Not just price as a mechanism. So is the time, i.e. the queue in front of the box office of a concert of a superstar.
    - Within the government, bureaucratic system. Not through the market as well.
    - Economists, conventionally, are only interested in the market mechanisms. But the emerging field, the mechanism design, studies broadly non-market mechanisms.
    - There is also a philosophical question worth debating whether everything should be allocated through the market mechanism.
  - Who allocates?
    - The problem of allocation under scarcity is not only a problem of the society but also pervasive for each individual's daily decision.
      - How to allocate time.
      - How to spend the money.

      Therefore, economics have something insightful to say about these as well.
    - On the society level, the word allocate makes it sound like someone is in charge of allocation. But not necessarily so. Adam Smith would say, no one really allocates things as if a powerful god. It is the "invisible hand", the magical force of the market, which allocates the resources.
    - If the invisible hand does not work perfectly due to well-known market failures such as externality and information asymmetry, economists like to invite an imagined social planer to the thought experiment, a benevolent and powerful God who is assumed to know what is the desirable for the society and can allocate the resources on behalf of the society's interest.

2 The producer's problem

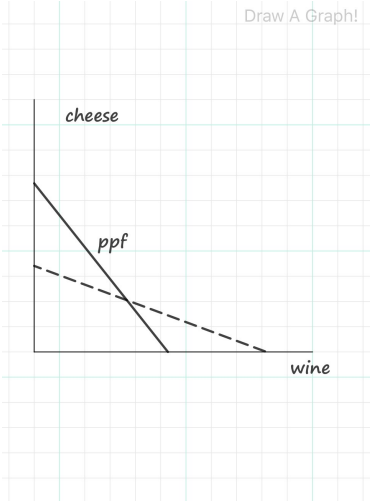
In a highly stylized world as far as economics is concerned, there are two types of agents in a market: consumers and producers.

Both are faced with a problem of allocating resources subject to certain constraints on their own. Producers maximize profits(revenue) subject to their production capacity. Consumers maximize their utility subject to budget constraints. We first study the producer's problem.

- PPF: production possibility frontier.
  - The trade-off between producing either wine or cheese, two goods.

- The (negative) slope of the PPF: opportunity cost. The steeper the PPF is, the more productive producing the good on the vertical axis, i.e. the higher opportunity cost of producing the good on the horizontal axis. See Figure 2.
- Combining the PPF of N producers. (See the other lecture note on absolute and comparative advantage.)
  - Same slopes, then no kinks.
  - Different slopes: N-1 kinks.
  - A smoothed curve if combining infinitely large number of producers.
    - A non-linear curve of PPF has different opportunity costs at different points of the curve.
    - Bowed outward (linear): a. always let the flattest individual PPF(who has the comparative advantage on horizontal good) to produce the horizontal good first. b. diminishing(constant) marginal return.
  - The gains from trade: there is gain from trade as long as the two producers trade at a price in between the opportunity costs of the two participants.
  - About exactly at which price the trade occurs, we need to know more to determine, thus beyond the scope here.

Figure 1: PPFs of different opportunity costs

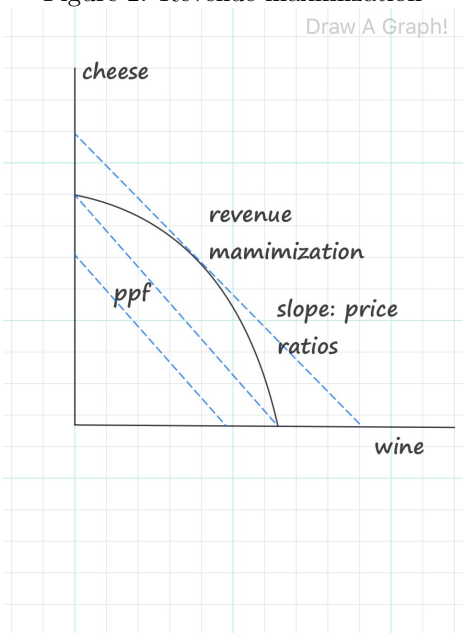


- Equal revenue line.
  - Given the total revenue, a pair of the quantity of both goods.

  - The slope of the line: the price ratio of the horizontal good and horizontal good.
  - Steeper revenue line implies the horizontal good becomes more expensive.

- Revenue maximization. See Figure 2

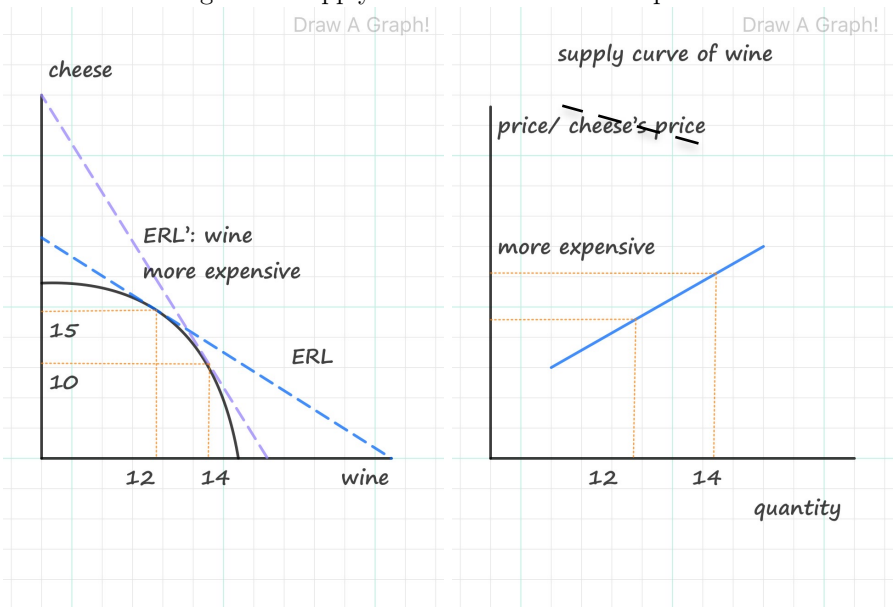
Figure 2: Revenue maximization



  - A given a price pair of the two determines a buddle of parallel equal revenue lines. The revenue line has a constant slope being the price ratio of the two goods.
  - Then move the line in parallel so that it is tangent with the PPF. It is at that point when the revenue is maximized for the producer.
  - Why not further away? beyond the production possibility frontier.
  - Why not inward? not maximizing the revenue and can do better.
  - Special case: a linear PPF. Just a corner solution. Produce whatever is more expensive.

- From revenue maximization to supply curve. See Figure 2.

Figure 3: Supply of wine under different prices



Session 2. Consumer's Problem

Tao Wang

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1 The consumer's problem

Consumers maximize their utility subject to budget constraints. Again, it is to attain the most of what one **wants** subject to what one **can** afford. The former is expressed by the indifference curve, and the latter by a budget line. We study them, separately.

- Indifference curve (IC).

  There are different ways of describing the consumer's preferences. The indifference curve is one of them. (In more advanced economics, we also work with explicitly specified utility functions.)

- Before delving into the technicalities, let us try to reflect on what psychological laws we as economic animals either consciously or unconsciously follow in daily life decisions.

  - The more, the better.
  - For each additional pizza you eat, the additional happiness it brings about is smaller as you eat more pizzas.
  - Diversity is good.

  Let us try to study these properties more formally.

  Why is it called the indifference curve? The meaning of indifference: neither better, nor worse.

  Also be noted that we are now talking about an individual consumer, i.e. everyone's income and preference may be different from each other.

  There is a list of basic properties that the normal preference of a consumer needs to obey for economics to work with. Although these are broadly consistent with the psychological laws seen in life, still bear in mind, they are assumptions instead of a perfect representative of the reality.

  Below are some important graphic properties of IC and their economic implications.

  - Downward sloping. If one good is reduced, there has to be more of the other so that you stay equally happy.
  - Bowed inward. People are more willing to trade away goods that they have in abundance and less willing to trade away goods of which they have little.
    * The absolute value of the slope at a particular point of the IC: **marginal rate of substitution** (MRS). How much of Y you are willing to give up in exchange for another unit of X so as to stay equally happy.
  - The IC does not intersect with either ax, i.e., even an infinite amount of Y cannot convince me to give up X, entirely, to stay equally happy.
  - Two extreme cases.
    * Perfect substitutes. Linear IC, i.e. the slope of the two are the same in any point of the IC. Therefore, one good can substitute the other up until zero.
    * Perfect complements. An outward 90-degree angle. Only more of both is better. More of only one does not make a difference.
  - Two ICs do not cross with each other. By definition, different ICs represent different levels of utility. Two ICs crossing means that a particular pair brings you about different levels of utility, which is impossible.
  - Two ICs of different utility levels are not exactly parallel, the distance of two indifference curves are not exactly equal in each point. (We study this in future.)

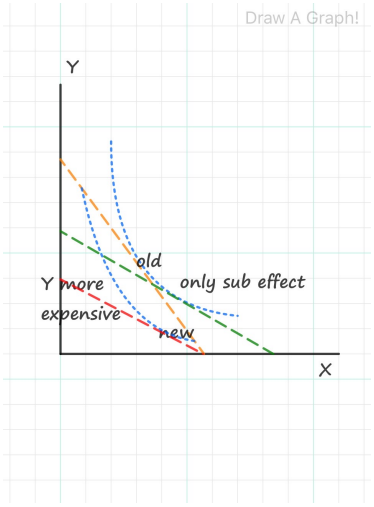
- Budget line.
  - (Negative) slope: price ratio. Again, a flatter budget line means the vertical good becomes more expensive relative to horizontal good.
  - Again, prices are taken as given by the consumer.
  - Besides, income is taken as well.
  - Therefore, the location of a budget line is given already.

- Utility maximization.
  - The consumer desires the IC to be as far as possible from the origin, subject to the budget constraint.
  - Move IC so that it is tangent with the budget line. At the point of tangency, mathematically, the marginal rate of substitution is equal to the price ratio.

- Income and substitution effect.

- Now let us imagine Y is suddenly more expensive relative to X. What would this mean for the optimal demand of the consumer for X and Y?
- First, we may expect, not surprisingly, the consumer demands less Y relative to X. This is straightforward. We called the substitution effect.
- The second effect is more subtle. Since the price of Y is more expensive, the *real* income of the consumer measured by the price of Y is lower. This will make her feel poorer and thus willing to buy less of both X and Y. This is called the income effect.
- Graphically, how do we show the two effects separately? (See Figure 1.)

Figure 1: Substitution and Income Effect



  * Starting from the old point, move along the same IC to find the point in which it is tangent with a budget line under the new price ratio. Since at this point, she attains the same level of utility at a different price. The move from old optimum to this point only comes from substitution effect, i.e. given the new price, how would substitute between two goods to stay as equally happy.
  * From the new point only from the substitution effect, move the budget line inward to equal the same level of total income. Then the new tangent point with the IC at a lower level of utility is the new optimum resulting from both sub and income effect.

- Demand curve from consumer's problem.

- Why is the demand curve downward sloping?
  - Substitution effect. Unambiguous. P $\uparrow$, $D \downarrow$. Higher price leads to substitution away from the good which becomes more expensive. Therefore, less demand.
  - Income effect. Ambiguous. It depends on the type of good.
    1. **Normal good**. Income effect is such that higher income leads to **higher** demand. So Income $\uparrow \rightarrow D \uparrow$.
    2. **Inferior good**. Income effect is such that higher income leads to **lower** demand. So Income $\uparrow \rightarrow D \downarrow$. For instance: discounted and low-quality goods from Walmart. Fast food. Low-quality car. Public transportation service, etc.
       - **Giffen good**. Negative income effect is so strong that it dominates the substitution effect. As a result, demand curve is upward sloping. Lower price leads to lower demand. So $P \uparrow \rightarrow D \uparrow$.

Session 3. Consumers Meet the Producer

Tao Wang

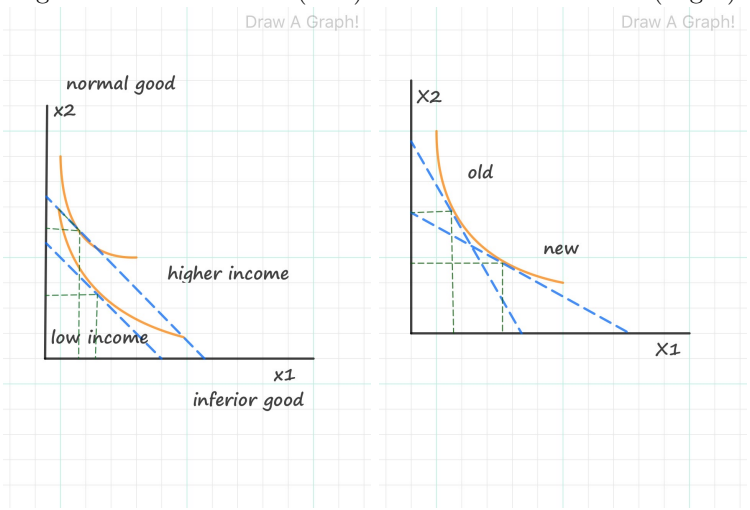
February 18, 2021

1 More illustration of income and substitution effect

- The key difference between the two effects lies in which to fix and which to play with.
- For income effect, keep the relative price of two good unchanged and only change the level of income. This means shifting outward or inward the budget line but let it stay parallel with the original one. Find the indifference curve that is tangent with the new budget line. Depending on the good being normal or inferior, we will end up seeing the different directions of the change in demand for each of the two goods.

  For instance, see the left diagram in Figure 1. X1 is inferior because higher income brings down the demand for it. X2 is a normal good.

Figure 1: Income Effect (Left) and Substitution Effect (Right)

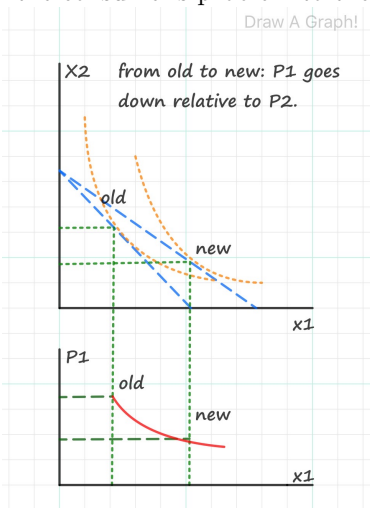


- For substitution effect, you change the slope of the budget line, i.e. the relative price, but fix the indifference curve. You ask yourself if I want to stay equally happy under the new pair of relative price, how should I shift my demand between the two goods? This question is partly hypothetical because, for the time being, you put aside the question of whether you can truly afford the new optimal bundle. See the right diagram in Figure 1.

2 From the consumer's problem to a demand curve

- It is important to understand the exact procedure of translating the consumer's optimization problem from the two-good space into a demand curve for either one of the two good. (similarly, for the steps of translating producer's problem to a supply curve.)
- Bear in mind, a consumer takes her income as given. You only play with the price of the good for which you want to draw the demand curve and keep the price of the other fixed.
- The reason why we keep the other good price fixed is that depending on which good for which we draw demand, we implicitly use the price of the other good as the unit of the price.
- Imagine you want to draw the demand curve for horizontal good, say wine. It depicts the relationship between the price of wine and the **optimal** demand for wine determined by the consumer under a *given* income.
- See Figure 2. Keeping P_2 fixed and decrease P_1, the budget line becomes flatter. But notice the new budget line shares the same intercept with the vertical axis because the P_1 and income do not change. As a result, we see a higher demand for X_1.
- The demand curve is typically downward sloping for a normal good and most of the inferior good. The only exception is Giffen good.
- As a further test of your understanding of the projection we did above, think about what would happen to your demand curve if following changes. In particular, a shift in the demand curve, or a move-along? in which direction?
  - Income $\uparrow$ implies the demand curve shifts horizontally to the right $\rightarrow$.
  - Increase in P_1, *move down* along the same demand curve.
  - If $P_2 \uparrow$, the demand curve shifts to right because for any given P_1, good 1 is cheaper.

Figure 2: From the consumer's problem to the demand curve



3 When consumers meet the producer

Each individual consumer makes their respective decision on how much wine and cheese they would like to consume taking their income and prices as given. The producer makes her decisions on how much wine and cheese to produce. A very simple question comes up immediately: when do the two equalize?

The answer is that, for an arbitrary price pair, there is no guarantee that the demand and supply equalize for both wine and cheese. Economists call this market *is not clearing*.

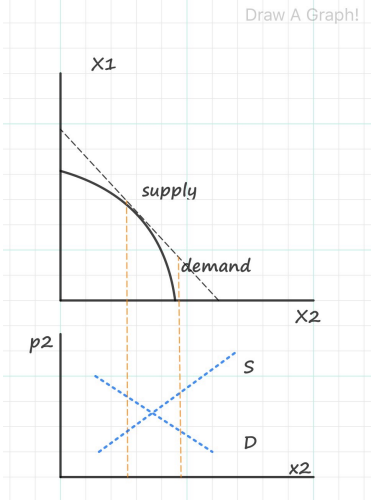
What we know for sure are the following.

- Revenue of the producer is equal to the total income of all consumers. Why?
  - There are only two types of people in this economy, producer and consumers. Whatever is earned by the producer ends up going into the pockets of the consumer. Revenue made by the firms either is paid as the wages directly to consumers who work for the firm or spent on raw materials that are some other consumers' income in the economy, or as profits that are distributed to its ultimate shareholder, namely the consumers.
  - Therefore, we know for sure, for any given price, the equal revenue line overlaps the total budget line. You can think this through by combining all the individual consumers' budget lines (with the same slope for a given price with the equal revenue line.)
  - We can also invoke macroeconomics to understand this. For the same reason, the national income accounting identity holds, i.e. the

GDP of an economy is the same measured by expenditure or income approach.

- Under the assumptions we make so far, there is a magic price that happens to clear the market.
  - Imagine the wine is too cheap relative to cheese. Consumers altogether demand a lot of wine but little cheese. At the same time, the producer is incentivized to produce more cheese relative to wine because the former is more expensive thus profitable. As a consequence, oversupply of cheese and undersupply of wine.
  - Next period, the producers will produce more wine and less cheese. This will make the price of the wine lower and that of cheese higher. So we push the supply and demand all the way to the point where the two exactly equalize. This is when market clears.
  - This process iterates on and on until the price adjusts to the point in which the demand and supply for both goods exactly align.
  - This "magical" process happens as if some god is in charge of adjusting the price by looking at if the market is clearing. This comes all through the voluntary decisions of each participant in the market. It is the market forces instead of **someone** that makes this happen.
  - It is important to illustrate this in the graph, in the process of translating the original two-good space to supply and demand space of both goods. Below is how. See Figure 3.

Figure 3: An example of non-clearing of the market



Session 4. Economic Efficiency

Tao Wang

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1 A Recap

What to know

- Producer's problem
  - The definition of production possibility frontier (PPF).
  - The shape and its implications of individual PPF, i.e. what does the slope represent, what does it mean to be flatter, etc.
  - How to combine individual PPFs of the same and different slopes.
  - The shape of a combined PPF and its implication, i.e. why bowed outward, what does the slope mean at each point of the PPF.
  - The definition of the equal revenue line (ERL). What is taken as given for a particular ERL?
  - The shape of ERL and its implications, i.e. what does the slope represent, what does it mean to be flatter.
  - The general meaning of producer's revenue maximization. What is the constraint and what is the objective?
  - Illustration of the revenue-maximizing in a two-good space, i.e. what does tangency mean, why does it attain revenue-maximization at that point.
    - For general cases of a smooth curved PPF, as well as special cases such as a single-kinked PPF or a linear PPF.
  - Need to project producer's problem into a supply curve for either one good. What is taken as given and what varies? Why upward sloping? What does it mean to shift or move along the supply curve?
- Consumer's problem.
  - The definition of indifference curve (IC), i.e. what is given for a particular IC?

  - Each geometric property of the IC and its economic implications, i.e. why downward sloping, why curved, why bowed inward, why never-crossing, what does the slope represent, what does it mean to be flatter, etc.
  - The difference and relationship between the common-shaped IC and two special cases of perfect substitutes and perfect complements.
  - The definition of the budget line, i.e. what is taken as given for a particular budget line.
  - The shape and its implication, i.e. what does it mean to be flatter, the difference between rotation and parallel shift.
  - Show the optimum in the graph, i.e. find the tangency point fixing the budget line.
  - Show what happens to the optimum when price changes or income changes.
  - The projection from the two-good-space to demand curve. What happens to the demand curve if the prices and income change, respectively? i.e. normal and inferior good means shift in different directions after the change in income.
  - Why generally demand curve is upward sloping and what is a special case of not being so?

- Consumers and producers together.
  - Why a combined budget line of all individuals overlaps the equal revenue line. The aggregate resource constraint shall always hold for any given price.
  - How does price adjust to equalize the supply and demand to clear the market? (Unlike the point above, this only happens for a particular price.)
  - Illustration of the movement toward equilibrium using supply and demand curve.

What we have learned but not important for the quiz.

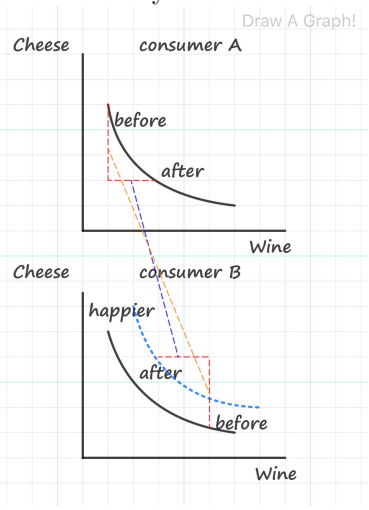
- Some auxiliary jargon such as marginal rate of substitution, opportunity cost, etc. The key is to be able to explain all in plain language.
- The detailed illustration of the substitution and income effect in the graph.

2 Efficiency

- What is economic **efficiency**? The definition: it is impossible to make anyone better off without making at least one worse off. Equivalently, being inefficient means there is a way to make someone happier without hurting anyone else.

- Some concrete examples. One example is that there is inefficiency if two consumers can make a deal to make either one happier without harming the other. Let us try to show it explicitly.
  - Two consumers with two indifference curves (See Figure 2). There exists one trade between the two which can make B happier and A stays equally happy. Therefore, the initial allocation (what I call "before" in the graph) wastes an opportunity of increasing group happiness, thus inefficient.
  - What A gives away (gets) is what B will get (gives away). This is why the triangle on the B's graph is oppositely positioned to the triangle in A's graph. An upward (right) arrow in A's graph becomes a downward (left) arrow in B's graph.
  - Why is there inefficiency when A is in her steep area on IC, and B is in her flat area? Because being steeper means A is willing to trade away cheese (which she has a lot already) in exchange for wine, which is exactly what B is willing to trade away. The two will continue the trade unitil the slopes of their respective ICs are equal.

Figure 1: Inefficiency between two consumers



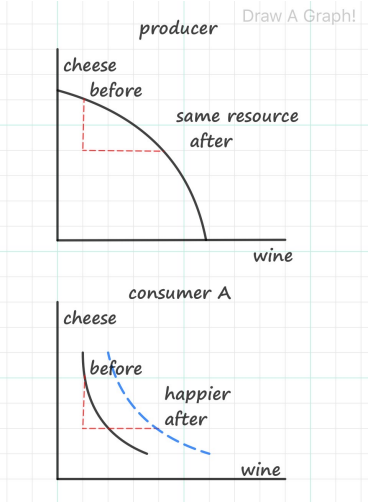
  - For instance, if we consider a case where two people are faced with the same price and each attains the optimum respectively. You should conclude that there is no inefficiency between these two consumers because the slopes are both equal to the price ratio. But, **always remember**, we **do not need** the price and budget lines to talk about efficiency.
  - How do we make the assumption that prices facing everyone are the same in the first place? Economists dare to make that assumption

becasue people in the market tend to take advantage of all opportunities of arbitrage till they are eliminated. For instance, a scenario like Figure 2 shall not exist.

Figure 2: A semi-true example of arbitrage opportunity

- For the same logic, we can talk about efficiency between a producer and a consumer. There is again a way for welfare improvement if the slope of IC where the consumer stays is not equal to the slope of PPF where the producer stays. See Figure 2.

Figure 3: Inefficiency between a producer and a consumer



  - Notice now the triangle in consumer's graph simply mimic that in producer's graph, because what the producer produces is exactly what the consumer gets. More wine produced means more wine is given to the consumer. This is different from the cases of two consumers, in which the triangles are in the opposite direction.

- A few important things to clarify.

  - The discussion about efficiency can be between just two people, or among an infinite number of people altogether.
  - All we need to talk about efficiency is a given allocation of resources, i.e. he has 2 apples and 3 bananas and I have 3 apples and 2 bananas. We do not care about how we reach that allocation. We just start from this outcome and discuss the possibility of welfare improvement.
  - There is inefficiency *as long as there is one* alternative that can make someone better off without hurting others.

3 Efficiency and Equilibrium

- Relationship
  - Only under certain circumstances and assumptions, equilibrium attains the efficiency. There are many equilibria in which there is inefficiency (when market failure is present.).
- Distinctions
  - Efficiency is just one of those criteria considered to be important by economists to evaluate market outcomes. But there are other ones, such as equality, fairness, that are equally important. Traditionally, economists are less concerned about these compared to efficiency.
  - Efficiency is a criterion. Equilibrium is an outcome. The former is normative. The later is positive.
- Why is the equilibrium under perfect market participation **efficient**? Simply put, equal slopes.

  More accurately, each of the consumers chooses the consumption where the slope of the indifference curve is equal to the price ratio, and the producer chooses a point at PPF where the slope is also equal to the price ratio. Therefore, there is no room to improve welfare between two consumers, thus the allocation between any two consumers are *efficient*. And neither is there room for improvement between each consumer and the producer. See Figure 3.
- But again, never naively think efficiency is a property only associated with equilibrium. We can talk about efficiency when the market is not clearing.

  Imagine the price faced with the producer and a consumer are not the market-clearing price at the equilibrium. The allocation between the producer and the consumer is still efficient. because the slopes of the IC and PPF are equal. More generally, as long as producers and consumers are faced with the same price ratio and make their optimal decision respectively, there is no room for welfare improvement. Figure 3 also attains efficiency.

Figure 4: Market attains efficiency when market is at equilibrium

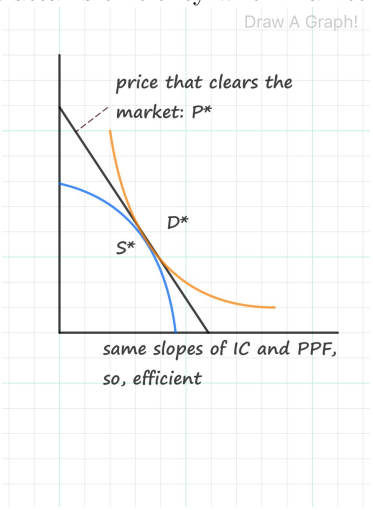
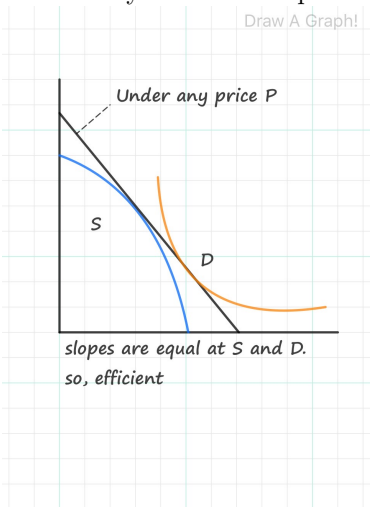


Figure 5: It attains efficiency between the producer and consumer



Session 5. Single-product/competitive firm's behaviors

Tao Wang

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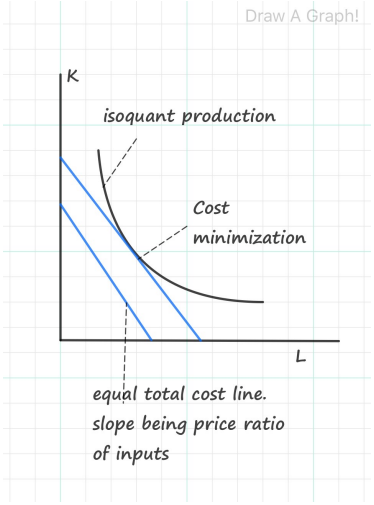
1 Producer's problem through a different perspective

In general, the producer's problem can be framed in two ways.

- Revenue-maximization subject to the production possibility
- Cost-minimization subject to the targeted production, push the production cost line as inward as possible subject to the isoquant production curve. (See Figure 1).

Figure 1: Cost minimization



2 One-product and perfectly competitive firm

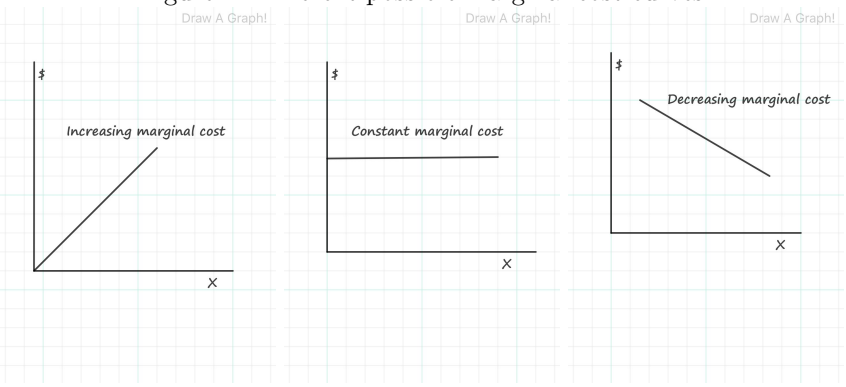
Three keywords: one product, perfectly competitive in the short-run

- What does perfectly competitive mean?
  - price is taken as given. Both the price of the product and price of the production inputs, i.e. wage, capital cost.
  - to put it differently, one firm's decision on how much to produce does not affect the price of that good.
  - notice the decision only depends on "marginal" terms, or the incremental benefits and cost of producing one more unit of the product.
  - If the marginal benefit greater (less) than the marginal cost, produce one more (less).
  - we decide how much to produce optimally by equalizing the marginal cost and price.
  - marginal benefit: just the price of the good, a constant.
  - marginal cost, it may or may not vary with how much you produce.
- What does it mean to be in short-run
  - In the short-run, not all factors of input can be adjusted. For instance, the capital cannot be frictionlessly adjusted, e.g. you cannot build and demolish the plants overnight.
  - Therefore, the firm changes the production by only changing some inputs, i.e. labor.

Let us walk through the producer's problem we study in the class backward.

- Important question if you are a firm manager: should I produce 99 or 100?
  - Things to consider 1: the price of the one additional product.
  - Things to consider 2: the additional cost of producing one more unit of the product.
    - Increasing marginal cost. The more you produce, the more costly for each unit of the product, i.e. it is just harder to make the worker produce the 10th compared to the 9th product. (See left on Figure 2.)
    - Decreasing marginal cost. The more you produce, the less costly to make another unit, i.e. google to provide search service to the 1000th user at a lower cost than to the 999th user; a YouTuber with 1 million followers find it easier to get the next follower. (See right on Figure 2.)
    - Constant marginal cost. (See middle on Figure 2.)

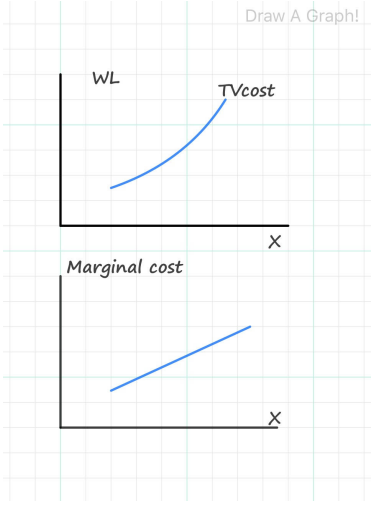
Figure 2: Different possible marginal cost curves



We typically work with an increasing marginal cost case. But we need to understand why exactly this is the case.

  - This boils down to the relationship between total variable cost (TV) and production.
  - An upward sloping marginal cost curve means the slope of the total variable cost curve is ever steeper.

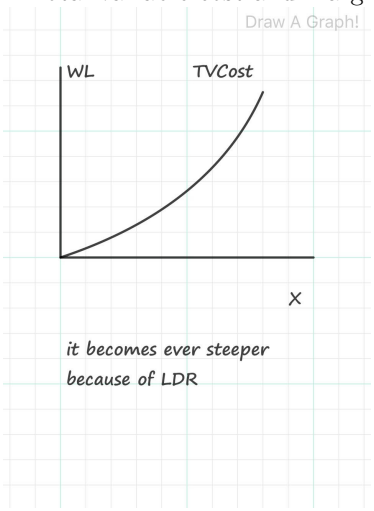
Figure 3: Increasing marginal cost and law of diminishing return



  - Why is it so? It is the best if you flip the vertical and horizontal axes. See Figure 4.

- Law of diminishing return (LDR).

Figure 4: Total variable cost and marginal cost



LDR: after some point, given the fixed input of one, increments of the other input yields smaller increments of output.

A few clarifications.

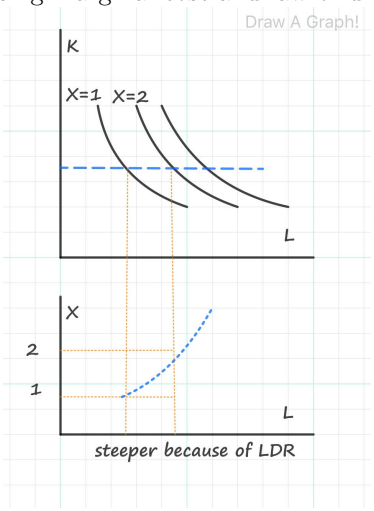
- Why "after some point"? Because when you initially expand the production, it is likely that the marginal cost to decrease for a while. For instance, better coordination among workers, more proficiency due to learning by doing, etc.
- Why "law"? It is law in the sense that it is the mostly common scenario. Pretty much every kind of physical production process is ultimately subject to some natural limitations that brings down the marginal return. But it is not necessarily universal truth. There are secarios for constant or even increasing returns in certain context, like we discussed above.
- Why "given the fixed input of one"? We are not talking about scaling up all inputs simulataneously. That is "return of scale" (we will discuss them seperately.)

3 A different concept: return to scale

Return to scale means scaling up (or down) **all** inputs at the same time by the same proportion. Depending on if the output will correspondingly scale up (or down) by the same proportion, we will have three scenarios.

There are three scenarios.

Figure 5: Increasing marginal cost and law of diminishing return



- Constant return to scale (CRS), i.e. doubling labor and capital *exactly* doubles the output.
- Decreasing return to scale (DRS), i.e. doubling labor and capital exactly leads to less than two times of the output.
- Increasing return to scale (IRS), i.e. doubling labor and capital exactly leads to more than two times the output. For instance, the knowledge and technology that we studied in macroeconomics.

Session 6. Cost functions in the short-run and the long-run

Tao Wang

March 11, 2021

1 Firm's problem under perfect competition and short-run, continued

- Marginal cost curve
  - Upward slopoing because of **the law of diminishing return (LDR)**, i.e. each additional unit of product requires more and more labor inputs $\rightarrow$ each additional unit of product costs more and more as production increases.
  - Some caveat
    - As a firm increases production from nothing to a little bit something, the marginal cost will probably decrease for a while before the LDR kicks in. For instance, making two pizzas makes the team more proficient and improve the productivity compared to making one. This is also why we see some graphs of marginal cost curve being downward sloping first and then upward sloping.
- Marginal cost and firm's profit maximization: $MC = P$.
  - As a profit-maximizing firm, the key decision rule is to compare marginal revenue, namely price P and marginal cost (MC)
  - Produce more if $P > MC$, produce less if $P < MC$. As a result,$P = MC$ at optimum.
  - Therefore, the short-run MC curve happens to be the supply curve in the short-run.
- Average total cost (ATC)
  - The definition

$$ATC = \frac{TC}{Q} = \frac{FC + TVC}{Q} = AFC + AVC$$

- why is AC curve U-shaped? There are different ways of thinking about this.
  - How does each component, AFC or AVC change with production? AFC declines with Q, unambiguously, because the numerator totals fixed cost is a constant (fixed) and the denominator increases. AVC typically falls at the beginning and then rises, i.e. cooking two pizzas makes each pizza less costly than just making one, but making 1000,000 pizzas makes it more expensive to produce each pizza. Combining both components makes the U-shape of ATC, which first declines and then rises. (See Figure 1).
  - Think about two extremes, i.e. producing almost nothing and an infinite amount. When you produce just a little bit, infinitely close to zero, your denominator of the ATC is infinitely small, while your numerator is not zero because of the fixed cost. A division of a positive constant and an infinitely small number is infinitely large. At another extreme, when the quantity goes to infinity since it just becomes more and more costly to produce one more. The total cost will go to infinity. Since both ends of the curve go to $+\infty$, the curve has to drop first and then rise later.
- Average cost (AC or ATC, the same here) and marginal cost (MC). Two important things to know about the relationship between the two. See Figure 2.
  - MC always pull AC toward itself, i.e. when $MC < AC$, AC drops. when $MC > AC$, AC increases.
    - Mankiw's smart example: your grade of the course you take this semester will pull down your GPA by the end of the semester if it is lower than your current GPA, and will lift your GPA if it is higher than your current GPA.
  - MC curve and AC curve crosses at the minimum of the AC curve.
    - Mathematically, this naturally follows the first logic. If you MC pulls AC down if $MC < AC$ and pulls up AC if $MC > AC$, then we know that AC attains its minimum when it is equal to MC.
- Why do we care about the average cost (AC)?
  - MC cannot tell you if you should shut down.
    - Imagine you are a restaurant owner, and the business has been quite slow. But for each additional customer who comes to your place, you are making money. Should you still keep the restaurant open? From the marginal perspective, yes. Because you are still making money. But probably you have lavishly spent money on decoration, renting a decent place

and hiring a widely acclaimed chef. That is sunk cost to you at this moment. The fact that you are making a little bit more from each additional customer who visits do not necessarily tell if you will cover all your costs of opening the restaurant.

  - Supply curve in the short-run.
    * In the short-run, supply curve is basically the portion of the marginal-cost curve that lies above average variable cost (See Figure 3).
    * When the quantity of production for which the average variable cost falls below price, the firm will temporarily shut down, therefore, no production. (See Figure 3).

2 Firms' problem in the long-run

- The major difference between SR and LR **from firm's perspective**.
  - SR: fixed cost is the sunk cost; LR: fixed cost is included. As a result, in the SR, you shut down if $P <$ **AVC**; in the LR, you shut down if $P <$ **ATC**.
  - SR: only decides how much to produce. LR: also decides whether to enter (for an outsider) or exit (for an incumbent) from the industry.
- The difference between SR and LR from the industry's perspective.
  - SR: a fixed number of firms
  - LR: free entry and exit in perfect competition
- Why does long-run equilibrium has zero profit.
  - How to represent profits in the graph. See Figure 4
  - How to combine total supply curves from individual supply curves. Just sum all individual supply curves.
  - How to show the path toward zero profit. See Figure 5.
    * The key condition for LR equilibrium, $P = ATC$, which does not hold in the SR.
    * No matter in SR or LR for individual firms, we also have $P = MC$.
    * As a result $ATC = MC$, which is why the LR equilibrium lies in the minimum of ATC curve, where it intersects with MC curve.

Figure 1: Average total cost: breakdown

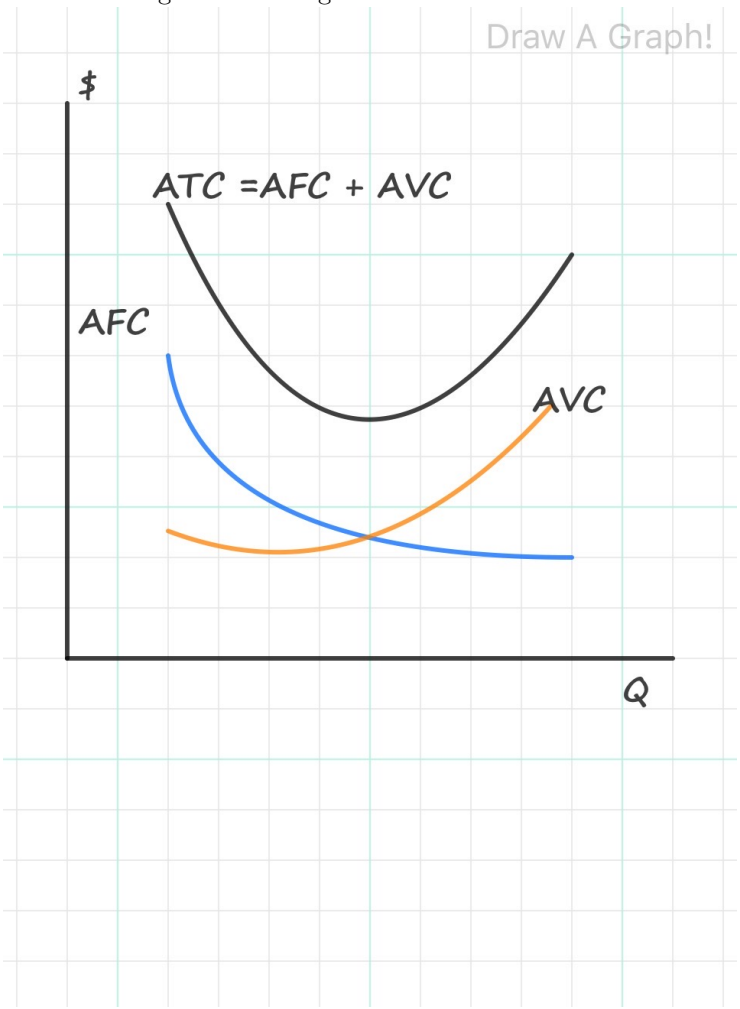


Figure 2: Average total cost and marginal cost

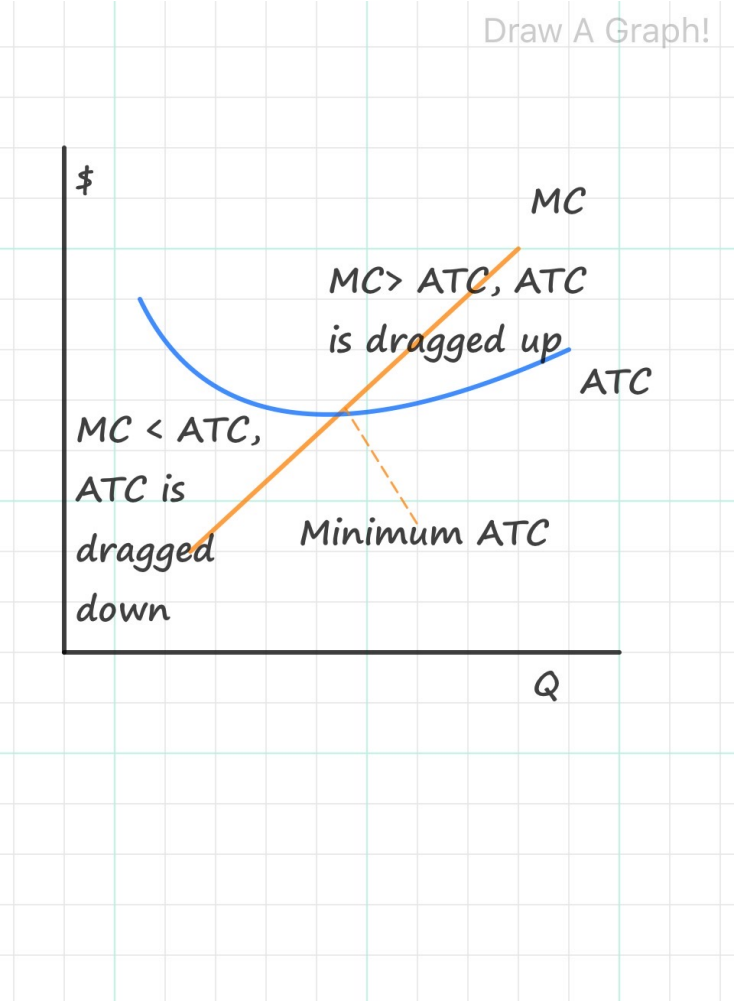


Figure 3: Why is MC the supply curve in the short-run?

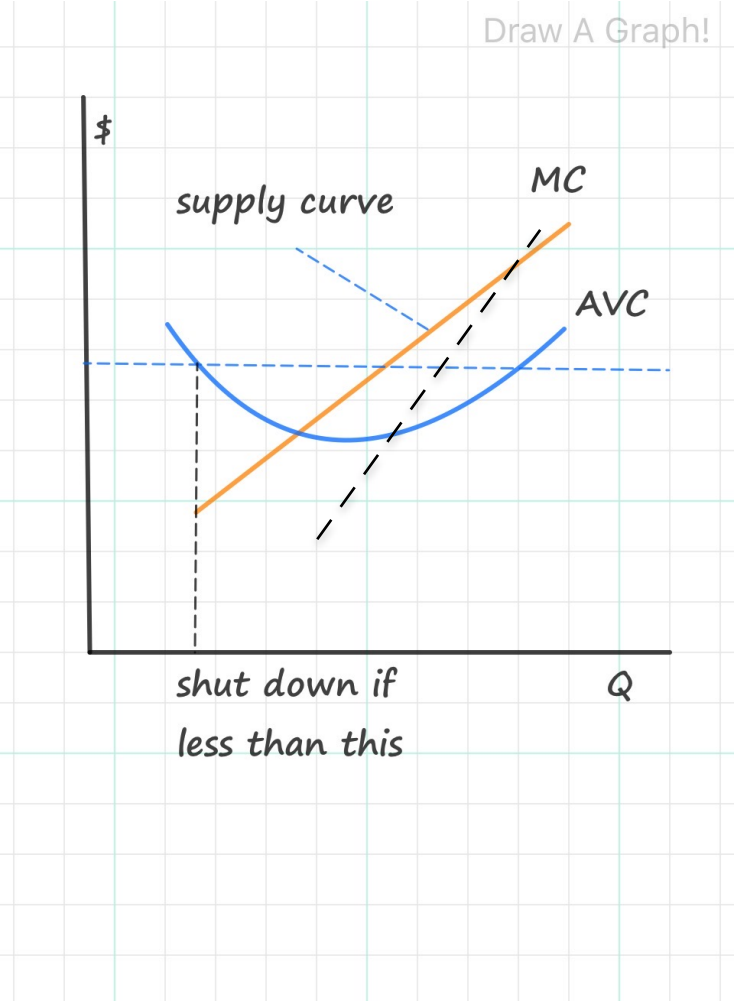


Figure 4: How to reprensent profits, revenue and cost in the graph

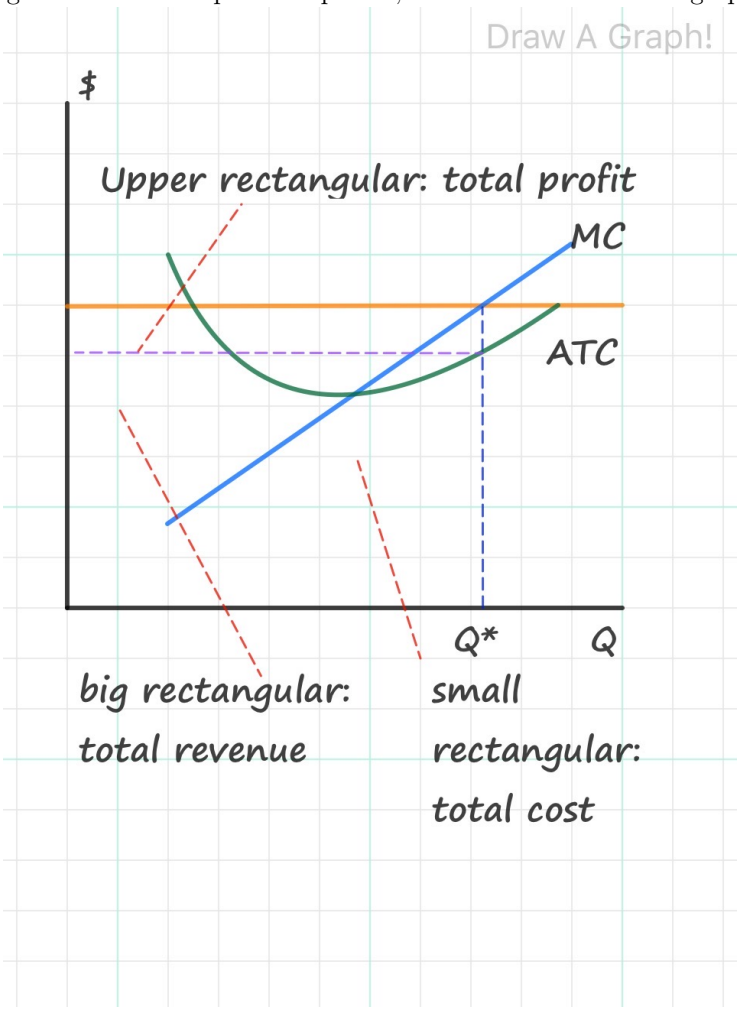
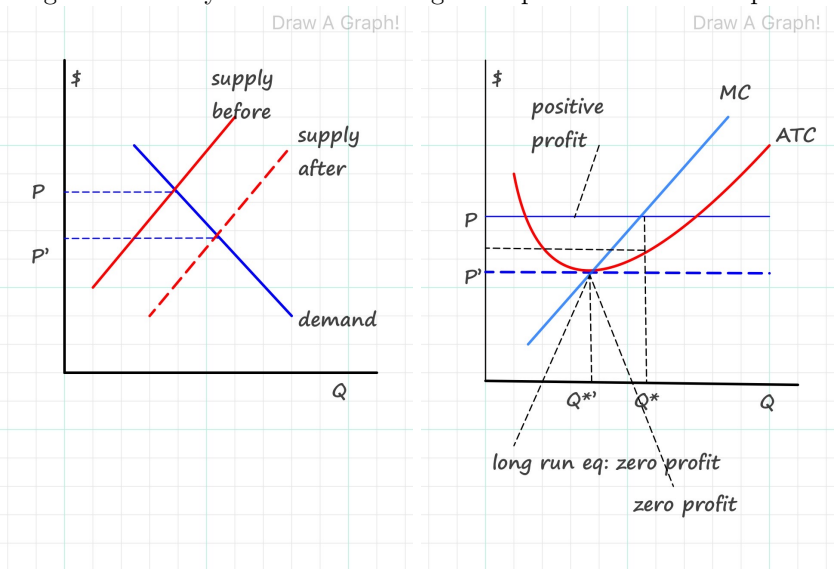


Figure 5: The dynamics toward long-run equilibrium and zero-profit



Session 7. Labor supply, labor demand and wage

Tao Wang

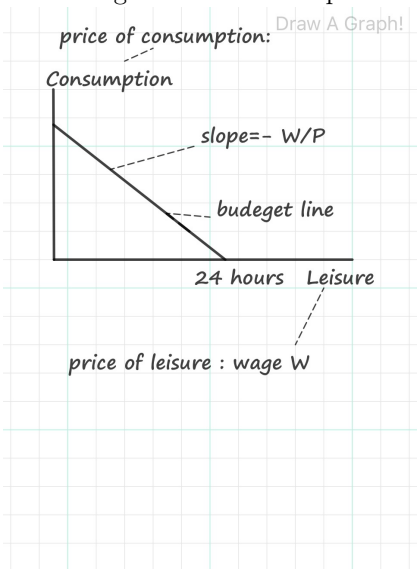
April 29, 2021

1 Labor supply

- We have focused on the goods market so far. There is another equally important type of market that we need to study, which is the market of factors of production: labor, and capital.
- We may think labor is an entirely different object from the good, say apples and bananas. But in the world of economics, we can use the same set of tools to analyze the market for labor.
- Labor supply essentially comes from individual workers' decisions made **according to their preferences** subject to some **constraints**. Therefore, it shares the same nature as the consumer's problem of allocating their money to "apples and bananas".
- Here we have two tricks
  - We do not directly analyze labor, we analyze the opposite of the labor, which is the **leisure**.
  - We no longer care about the differences between apples and bananas. We just bundle all goods we like to have into one thing called **consumption**.
- **Dreams**: both leisure and consumption are desirable.
  - The preference toward these two things of an average consumer is similar toward two goods, apples and bananas.
  - Therefore, we can represent it using indifference curves of the same shapes: downward sloping and bowed inward. See Figure 2
- **Reality**: both leisure and consumption have a price.
  - The price of the leisure = opportunity of the leisure = the wage you give up earning when you lie on the bed = wage, call it W.
  - The price of the consumption is just an overall price measure of everything, say P.

- There are constraints/trade-offs between these two things. Too much leisure instead of work means low income, therefore being able to afford consumption. See Figure 1.

Figure 1: The budget line of consumption and leisure



  - This trade-off can be represented by a budget line.
  - The intercept of the budget line with the axis of leisure is no longer in the unit of the quantity of the goods, but the time. The maximum is 24 hours a day.
  - The slope of the budget line is negative W(horizontal good) divided by the price P (the price of vertical good). Economists also call it the *real wage*.
  - The budget line getting steeper represents a wage **increase** relative to the price of the goods.

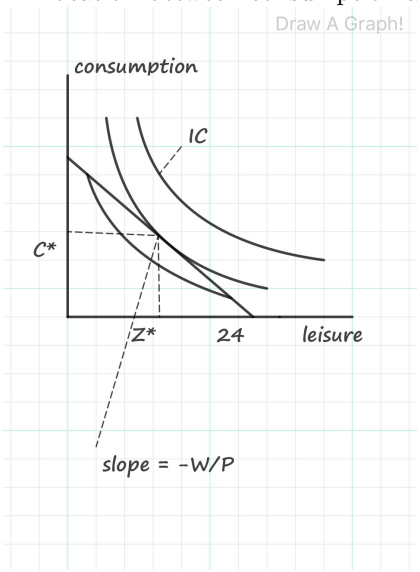
- Using the same tool, we can find the optimal decision of the leisure and consumption by each consumer: when the indifference curve is tangent with the budget line. See Figure 2.

- Once the optimal leisure Z^* is decided, the labor supply of the same worker is basically $L^* = 24 - Z^*$.

- We can study if the consumer decides to supply more or less labor when the wage increases.

  - When the *income effect* dominates, namely higher wage makes you think "I don't need to work as long as before to make the same

Figure 2: Allocation between consumption and labor



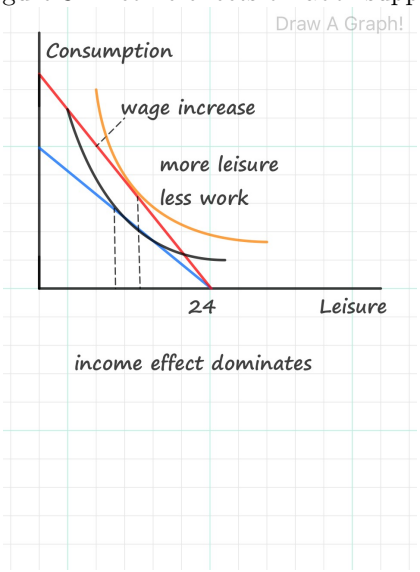
amount of money, hence I can work less", then leisure increases but labor supply decreases. See Figure 3.

– then the *substitution effect* dominates, namely higher wage makes you think "I cannot give up the opportunity of making more if I lie on the bed watching Netflix", then leisure decreases but labor supply increases. In this class, we mostly assume the substitution effect dominates. Therefore, individual labor supply curve is upward sloping. See Figure 4.

2 Labor demand

- It is the firm that demands the labor.
- The decision comes from comparing the marginal benefit of hiring one more worker, i.e. the value of MPL(marginal product of labor multiplied by the price of the good: $MPL * P$) and the marginal cost of hiring that labor: which is wage W.
- We know the curve of MPL is downward sloping due to the law of diminishing return (LDR),. See Figure 5.
- For a given wage W, the firm decides the number of workers to hire where W is equal to $MPL \times P$. See Figure 6.
- This makes the curve for the value of MPL also the short-run demand curve for labor, which is downward sloping. (Remember this is very similar

Figure 3: Income effects of labor supply



to the fact that the short-run MC curve is the firm's supply curve.) See Figure 6.

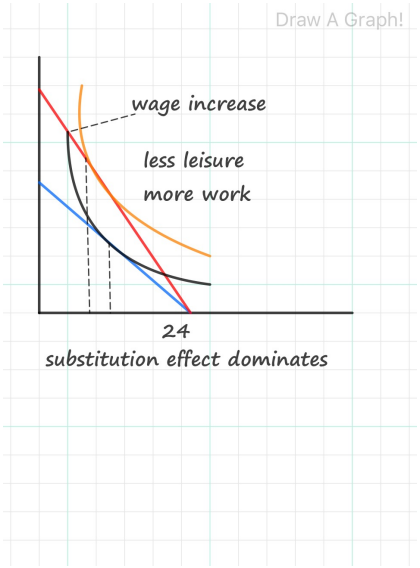
3 Labor market equilibrium

- We have an upward labor supply curve from individuals and the downward sloping demand curves for labor by individual firms.
- By summing individual demand and supply curves up, we can get the market demand and supply curves for labor.
- The intersect of the two give the market equilibrium wage W^*.

4 Efficiency wage

- The equilibrium defined above is not really realistic.
- One of the important aspects on which it is not realistic is that in the real world, the firms tend to pay a higher wage than what could have been thought of as the market wage for the same worker.
- Economists spend three decades studying this phenomenon only to broadly call this **efficiency wage**.
- The rationales for paying efficiency wage, namely paying a wage higher than the market-prevailing wage, are multifold.

Figure 4: Substitution effects of labor supply



  - Preventing workers from slacking by threatening to fire them thus denying their chance to get paid at a higher wage. It is basically saying: if you dare not work hard, you will not find an equally good job like this one.
  - Keeping the morale of the workers high, incentivizing workers to make efforts by compensating them more than how the market would do.
  - A decent wage attracts better workers. A market wage only attracts average workers.

- Because of efficiency wage, the wage offered by firms is higher than market-clearing wage, therefore there is unemployment.
- Some may ask: why don't other firms pay efficiency wage as well? The truth is that if everyone does so, the market-clearing wage will go up and firms will still try to pay higher than that wage as the efficiency wage.

Figure 5: Labor demand

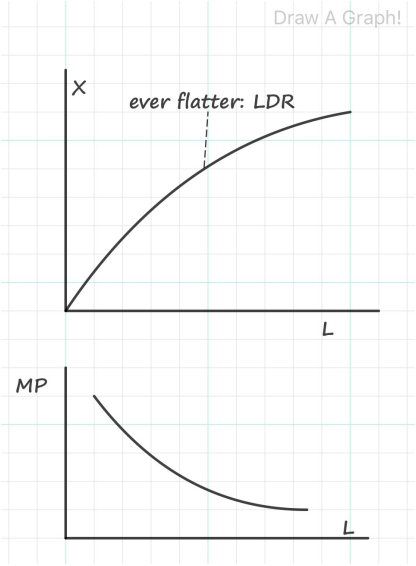
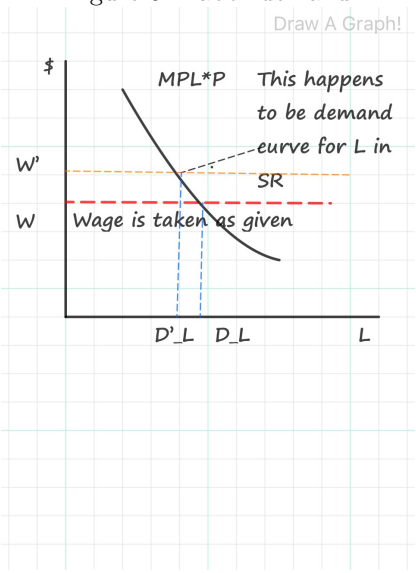


Figure 6: Labor demand



Session 8. Present and Future

Tao Wang

April 29, 2021

1 Present and Future

- Why do we care about the choices between the present and the future? Pretty much every economic decision in real life involves some trade-offs between today and tomorrow, not just between banana and apples. For instance
  - Saving more and consuming less today means more consumption tomorrow.
  - More education investment thus less leisure today means (hopefully) higher income tomorrow.
  - Firms expanding factories instead of throwing a party means higher production and revenue tomorrow.
  - A developing country with more savings and more capital can have higher output tomorrow.
- How to analyze a choice between today and tomorrow?

  This problem appears to be quite different from the choice between apples and bananas. But actually, they are exactly isomorphic in nature. As long as we draw the correct analogy between the two. I call the former one-period choice. The later two-period choice.
  - Budget constraint. For the one-period problem, the total income one can spend is given. For the two-period problem, the total income from today and tomorrow is given.
  - Price ratio. For one period problem, the price ratio is between two goods, namely the price ratio of an apple and a banana. For the two-period problem, it is the price **between today and tomorrow**. What is that price?
    - The (gross) interest rate. $1 + r$.
    - **Interest rate is the price of consumption today**. Or equivalently speaking, it is the opportunity cost of the consumption today, i.e. each dollar of consumption today means you give

up the chance of making (1+r) tomorrow that you can use to consume.

  - Higher interest rate $r \uparrow \rightarrow$ today's consumption c_1 is more expensive.

- Objective. For the one-period problem, the utility from consuming apples and bananas. For the two-period problem, the utility from today and tomorrow.
  - Indifference curve. For the one-period problem, one IC represents all bundles of consumption of apples and bananas that deliver the same level of happiness. For the two-period problem, one IC represents all combinations of consumption today and tomorrow that deliver the same level of happiness.

- Graphical representation.

  c_1 and c_2 represent the consumption today and tomorrow, respectively. y_1 and y_2 represents the income earned today and tomorrow, respectively. r is the interest rate.

  - Indifference curve. (See Figure 2)
    - Downward sloping. Less consumption today has to be compensated by more tomorrow to stay equally happy.
    - Bowed inward. You are more willing to give up consumption today (tomorrow) if you have very little tomorrow (today). The slope of IC starts from being steep all the way to being flat.
    - Not crossing with axes. Consuming zero either today or tomorrow is unbearably painful, so one needs to consume at least a little bit both today and tomorrow.
  - Budget line. All the (c_1, c_2) that your total income allows you to afford. (See Figure 1)
  - The slope, $-1/(1+r)$ if today is in the vertical axis. It is the price ratio of today versus tomorrow.
  - It **passes** (y_2, y_1). It means you consumes what you earn in each period respectively. No saving, no borrowing. Moving up from that point along the budget line means higher c_1 than y_1, thus one needs to borrow. Moving downard from that point along the budget line means $c_1 < y_1$, thus saving.
  - Vertical intercept: $y_1 + \frac{y_2}{1+r}$ Spending all income from today and tomorrow, while the income tomorrow discounted to the price today.
  - Horizontal intercept: $y_2 + y_1(1+r)$. Consuming zero today and save all y_1 for tomorrow to earn $y_1(1+r)$ from the bank.

- Optimal. When IC is tangent with the budget line. (See Figure 2)

  - If it is borrowing ($c_1^* > y_1$) or saving ($c_1^* < y_1$) depends on the shape of indifference curve and the interest rate. Either case could arise.
  - We can also talk about income and substitution effect in this problem.
    * Substitution effect. A higher interest rate makes today's consumption more expensive compared to tomorrow. Therefore, one tends to give up consumption today in exchange for higher consumption tomorrow. This is obviously a substitution of tomorrow for today.
    * Income effect. A higher interest rate makes you earn more from saving. Therefore, your total income increases. Therefore, you can spend more money in both periods. This induces to increase consumption today.
    * The relative size of the two effects determines if it is saving or borrowing in the optimal.

- The implicit assumptions we make. (Extension. Not required for the class).
  - Interest rate is the same for borrowing and lending. Therefore the budget line is a straight line. Otherwise, the budget line will be kinked.
  - No constraint of borrowing. You can borrow against your future income. The banks trust that you can pay back the borrowing. In the real-world, this may not be the case.
  - No uncertainty. You know what your income tomorrow is. What if you do not know?

Figure 1: A problem of two-period choice

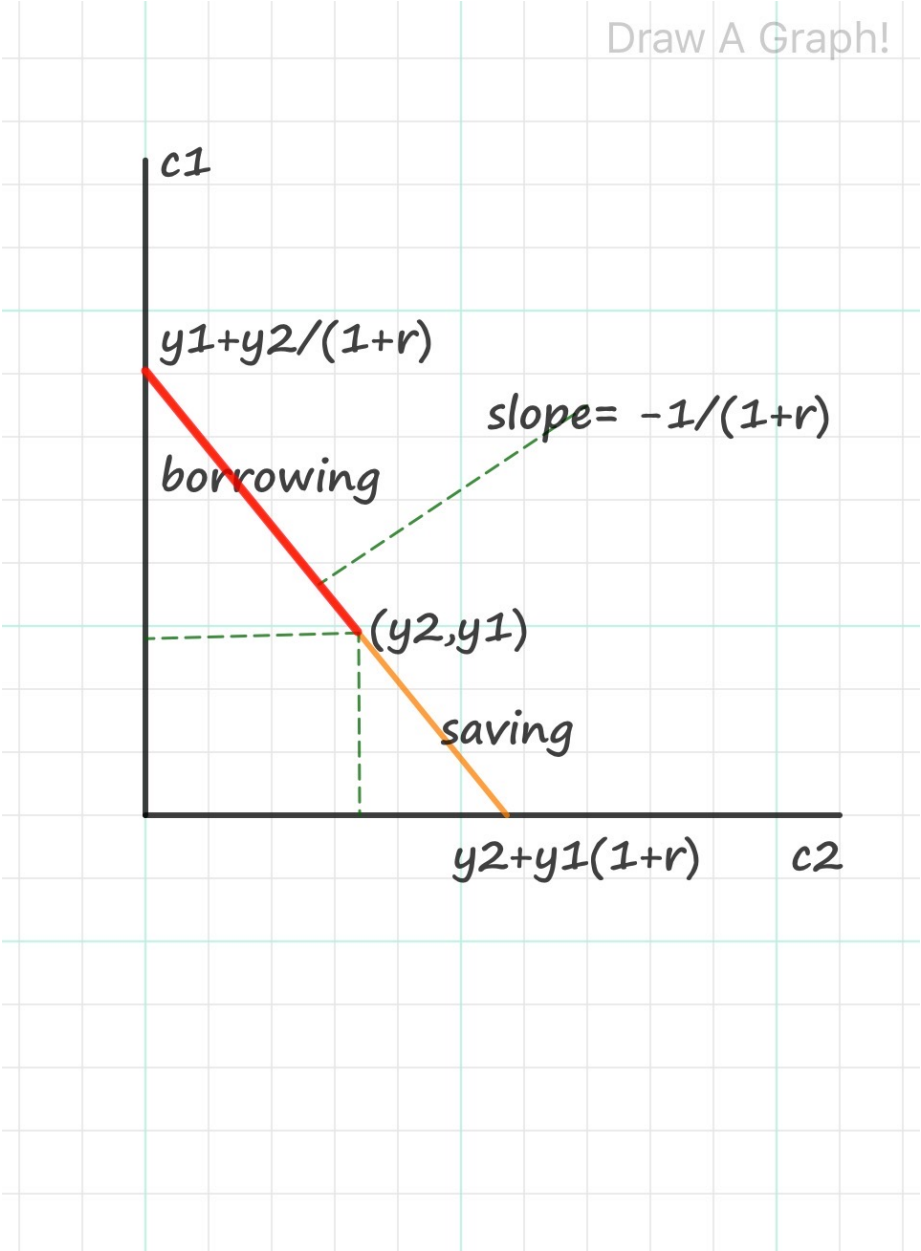
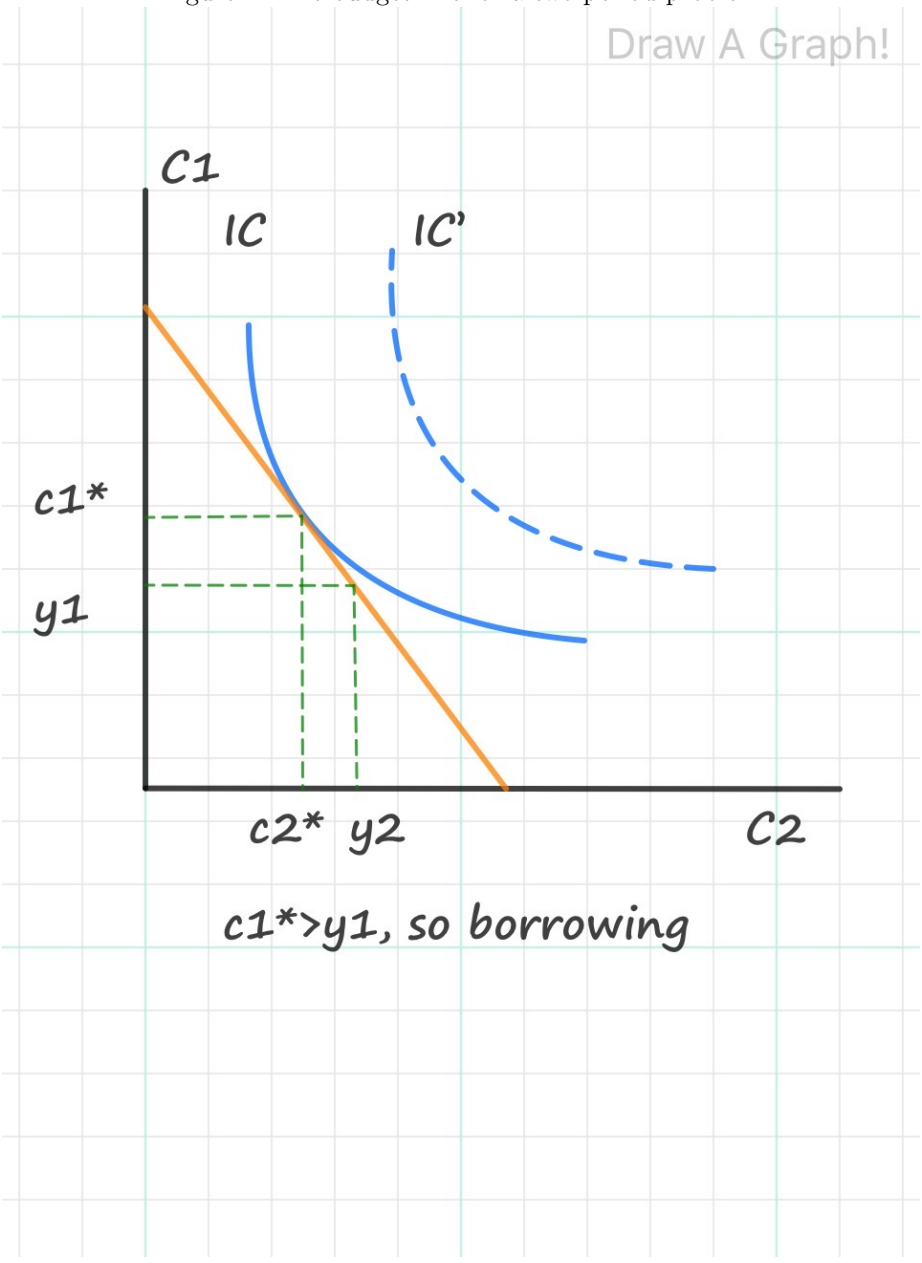


Figure 2: The budget line for a two-period problem



Session 9. Present and Future (Part 2)

Tao Wang

April 29, 2021

1 Firm's investment choice

The market between today and tomorrow involves two groups of people in the economy. In the last session, we consider the first group, the consumers. Some consumers may decide to save money in the bank. The natural question to ask is where does saving money go? The answer: some people's savings will become the borrowing of someone else. Of course, borrowing can be just by individual consumers. But more importantly for the macroeconomy, **firms** need to borrow the money to **undertake investment**. We study here how firms make investment choices.

It turns out the framework used to analyze a firm's production choice can be used here to analyze investment choice.

- The intuition, first.
  - The entrepreneur decides between undertaking an investment project or putting money in the bank. The former gives you a return that depends on the nature of the project. The latter gives you the deposit interest rate r.
  - You compare the return of the project and interest rate in the bank to make the decision. If the return of the project $> r$, you increase the investment. If $<$, you decrease the investment.
- PPF. (See upper graph in Figure 1).
  - The PPF now represents all the possible combinations of consumption between today and tomorrow, which is allowed by the investment choice.
  - It is **bowed outward** because the **marginal return** from increasing the project investment by giving up consumption today is **diminishing**.
  - Any point in the PPF whose slope is **higher** (lower) than the interest rate r makes it **profitable** (a loss) to undertake more investment.
- Equal revenue line. (See upper graph in Figure 1).

  - ERL represents all choices of consumptions that **generate the same total revenue** today and tomorrow altogether.
  - **Slope**. The slope of the equal revenue line is the $-1/(1+r)$. Why? because the trade-off you are faced with is again today versus tomorrow. The **relative price** between today and tomorrow is the **interest rate**.
  - Here, you may be tempted to ask, why we do not consider the return of the project. The answer, that is reflected in your PPF, not in your ERL.

- Optimum. (See upper graph in Figure 1).
  - Therefore, you choose to be exactly where the marginal return of the project represented by the slope of the PPF to be equal to the slope of the equal revenue line. You choose to equalize your marginal return of the project and interest rate in the economy.

- Demand for funds.(See bottom graph in Figure 1).
  - Higher investment in future projects implies higher demand for funds.
  - If the project is self-financed, that means you can only put less money in the bank. If not self-financed, you need to borrow money from the bank.
  - We consider how a change in interest rate induces the change in investment choice, thus the demand for funds. The relationship is the demand curve for funds.
  - Higher interest rate r means you move up along the PPF, which means you undertake less of the project in the optimum. You could either put your money in the bank earning the interest rate than bothering to conduct the project. Or it is just more expensive for you to borrow money to make the investment.
  - This implies a downward sloping demand curve for funds. (See bottom graph in Figure 1).

2 Saving and borrowing

2.1 Supply of the funds and saving

We have a demand curve for funds in the previous section. Now, we need a supply curve for the funds. The consumer's choice between today and tomorrow gives us that. See Figure 2.

- Higher interest rate induces lower consumption and more saving today. (This may not always be the case because of the income effect. But we normally assume so.)

- This gives us an upward sloping supply curve of the funds. (See the bottom graph in Figure 2.)

2.2 Supply and demand of the funds

Combining the consumer and firm's choice, we have a complete picture of the market for funds similar to the good market.

- **Supply**: supply of the funds is saving from households. Upward sloping because a higher interest rate makes you save more.
- Demand demand for the funds is the investment by firms. Doward sloping because a higher interest rate makes it more expensive to borrow.
- **Equilibrium**. Interest rate r^* clears the market for funds.
- **Efficiency**. It is efficient because the slope of the indifference curve and PPF are equal.

Figure 1: Investment choice and borrowing curve

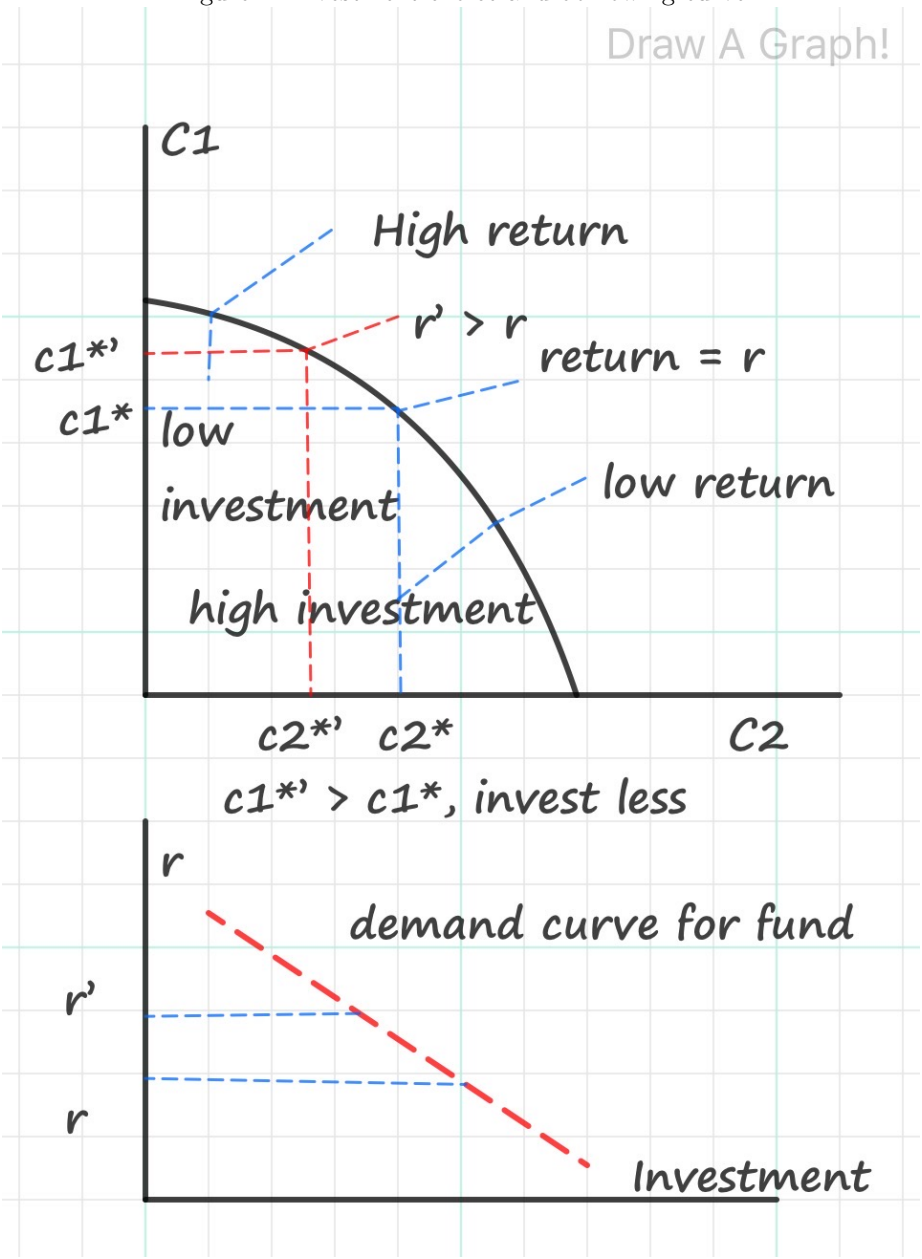


Figure 2: Saving curve (supply curve of the funds)

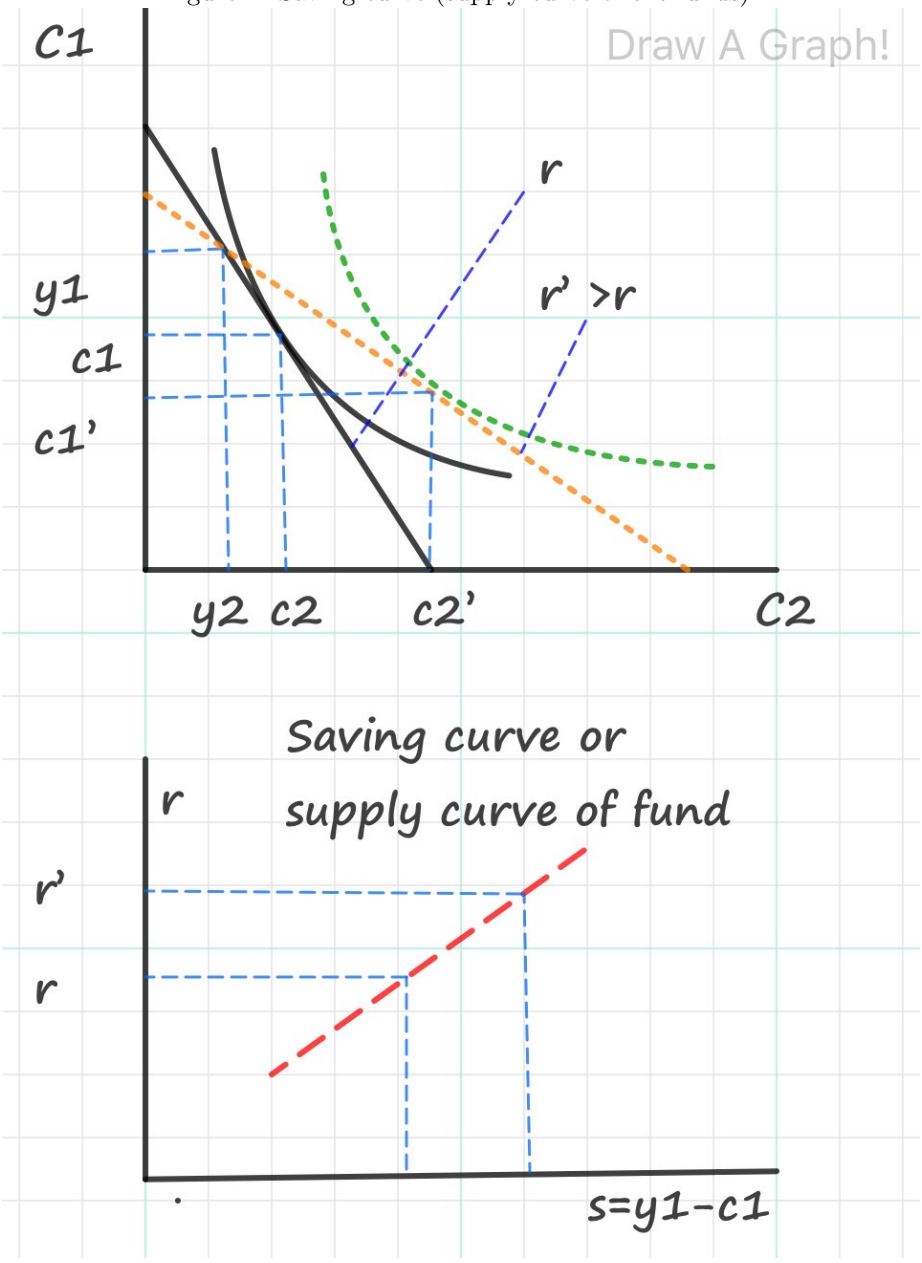
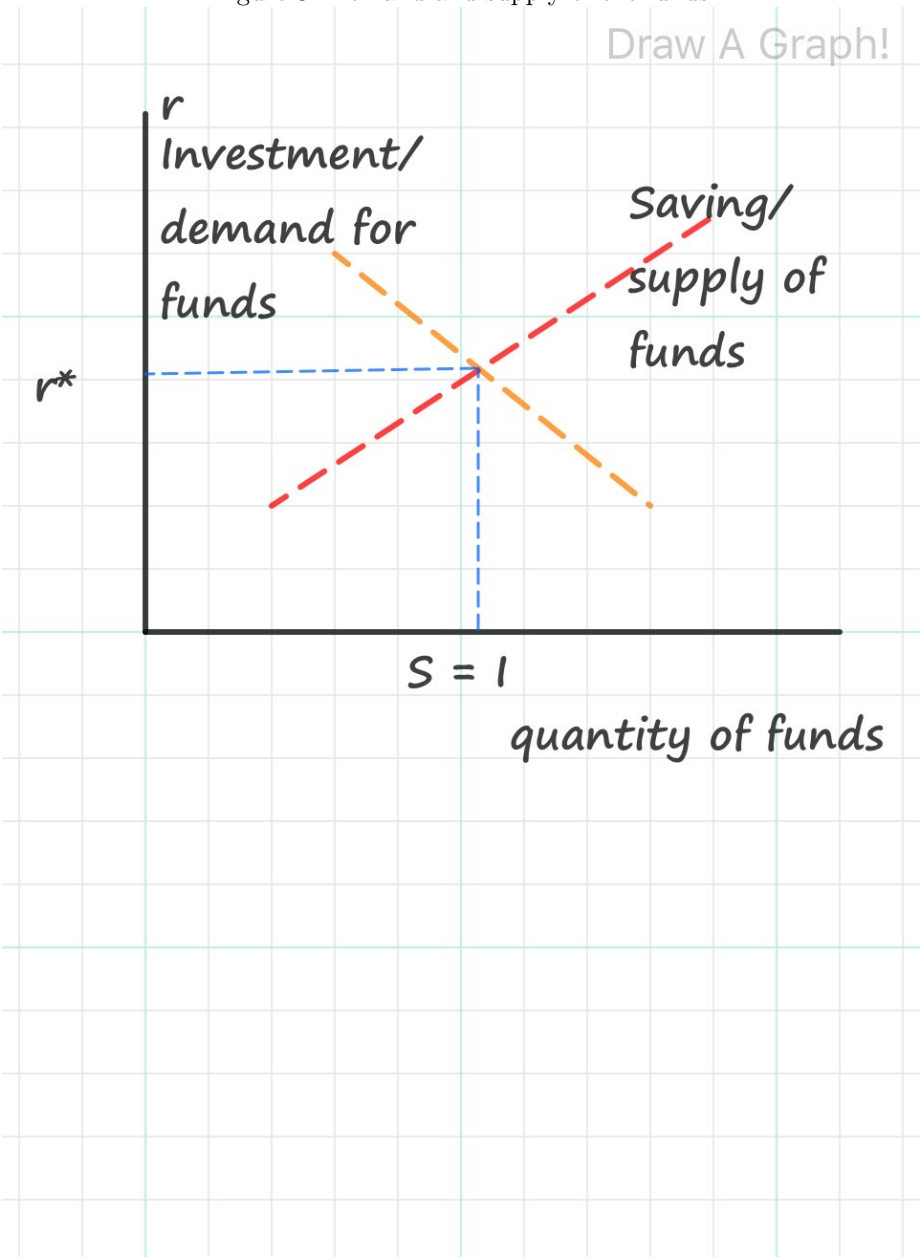


Figure 3: Demand and supply of the funds



Session 10. From the perfect competition to the monopoly

Tao Wang

April 29, 2021

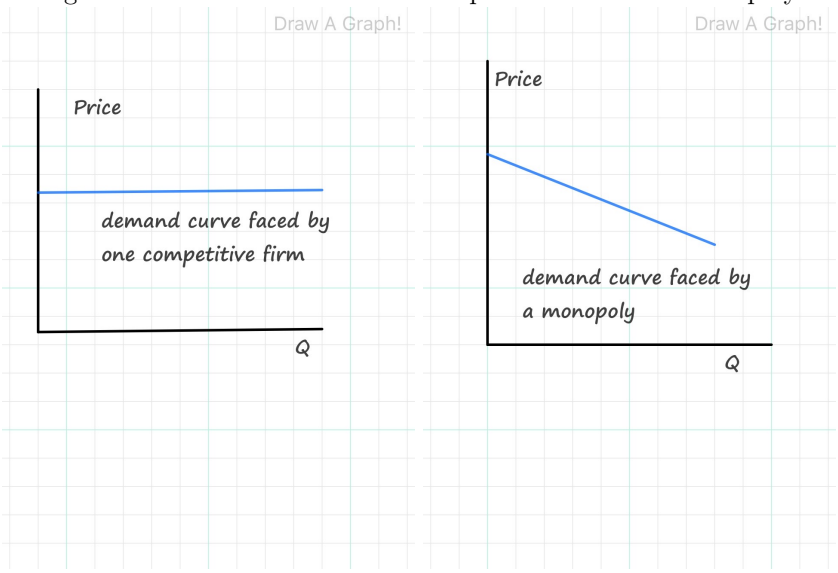
1 A monopoly's problem

- Why aren't some markets perfectly competitive? Or in what circumstances, does a monopoly arise?
  - **Entry barriers**, i.e. huge fixed cost that deters new entrants, airlines, steel and oil company.
  - **Natural monopoly**, i.e. the nature of the industry dictates the economy of scale, average total cost declines with a larger production, i.e. a railway system.
  - **Imperfect substitutability**. You sell a unique product that is not perfectly substitutable, i.e. IOS system, Google search, a luxury brand car, etc.
  - **Government regulation**. issues license for entrance, i.e. mining.
  - **Patent protection** for innovation, i.e. drug company.
- A comparison between perfectly competitive firms and a monopoly
  - What stays the same?
    - Firm still compares marginal revenue and marginal cost to determine the optimal production. Therefore, optimal production Q^* is where $MR = MC$.
    - The marginal cost facing the individual firms are the same.
  - What changes?
    - The key difference: no longer a **price taker** for a monopoly.
    - **The shape of demand curve faced by the firms**. See Figure1. The demand curve is flat for a perfectly competitive firm because from the point of view of the firm, no matter how much you sell, the price stays the same. Therefore the price does not change depending on how much you sell. [1] But for the

[1] Another way of saying this is that the demand curve is perfect elastic.

monopoly, the demand curve is downward sloping. Why? Since the monopoly is the only producer, the demand curve it faces is the **market** demand curve, which is downward sloping typically. (This difference seems counterintuitive. But the key is to understand the demand curve facing the individual firms are not the same as the one facing the whole market when there are many firms.)

Figure 1: The demand curve for competitive firms and monopoly



* In perfect competition, $MR = P$ for whatever Q; in monoploy: $MR \neq P$. Why? See Figure 2. By definition, marginal revenue is how much revenue each one additional unit you produce makes.

$$\text{Total revenue} = PQ$$

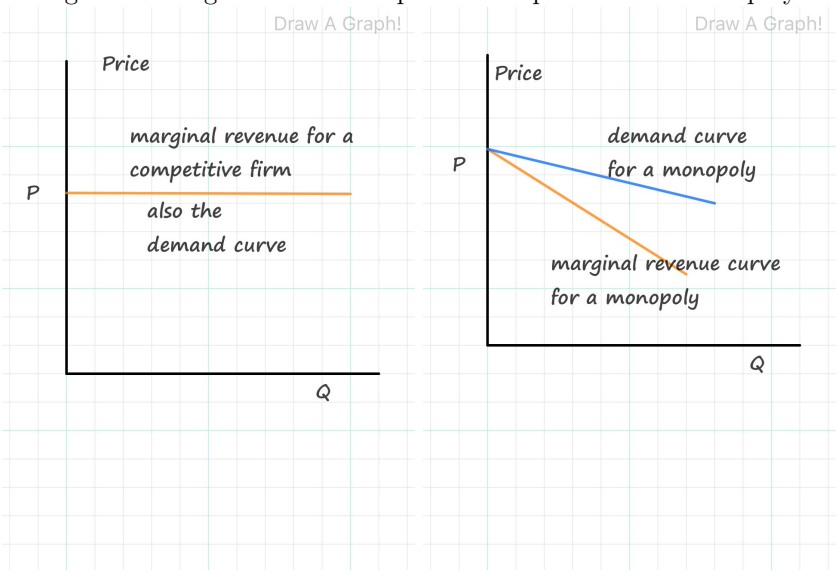
We care about the marginal effect of Q on total revenue. We need to take into account the direct impacts of change in Q and the indirect impacts through P, since now P depends on Q.

  - The direct impact is the quantity effect. Your selling one more pizza means you make P more.
  - The indirect impact is the price effect. The more you produce, the lower the price. But in perfect competition, firms can sell the product taking the price as given, therefore there is no price effect for competitive firms.

What's more important, because of the second effect, marginal revenue is no longer the same as the demand curve.

- In perfect competition, the marginal revenue curve is the same as the demand curve which is a horizontal line.
- To a monopoly, the marginal revenue curve is not the same as the demand curve. They are only equal at Q = 0, i.e. when you produce nothing. Because when you produce nothing, you don't have the price effect mentioned above. [2]

Figure 2: Marginal revenue in perfect competition and monopoly



- Equilibrium under monopoly.

  Once we understand the shape of marginal revenue for monopoly, we can use the principle of optimization, i.e. marginal revenue = marginal cost to find the optimal production of the firms.

- Step 1. Let marginal revenue be equal to marginal cost, and find the Q^{**}. See the right figure in Figure 3

- Step 2. Use that Q^{**} to find the price using the demand curve. See the right figure in Figure 3

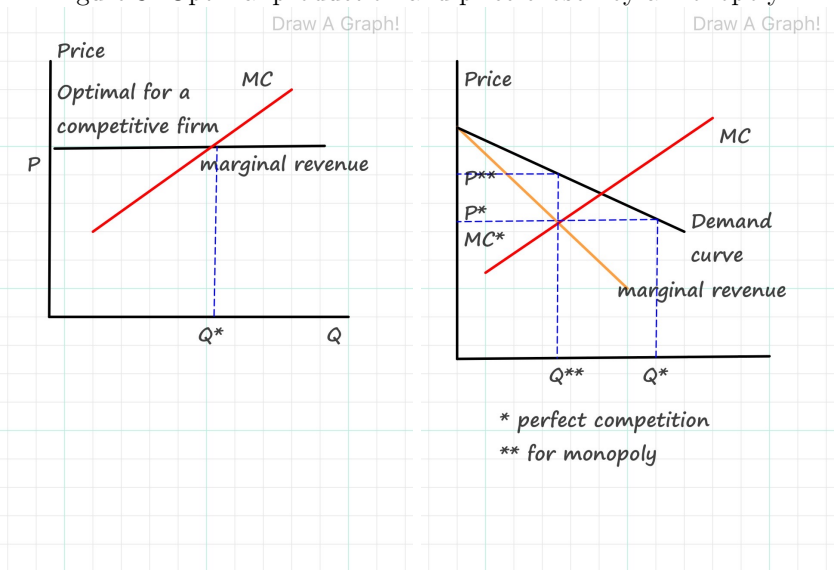
- Understanding the monopoly's optimal choice

  – Price is **higher** than the marginal cost. This is different from perfect competition. Comparing left and right in Figure 3. [3]

[2] Be careful here. This is not the reason why both are downward sloping. Instead, it is because the demand curve is downward sloping in monopoly.

[3] Economists like to call the wedge markup.

Figure 3: Optimal production and price chosen by a monopoly

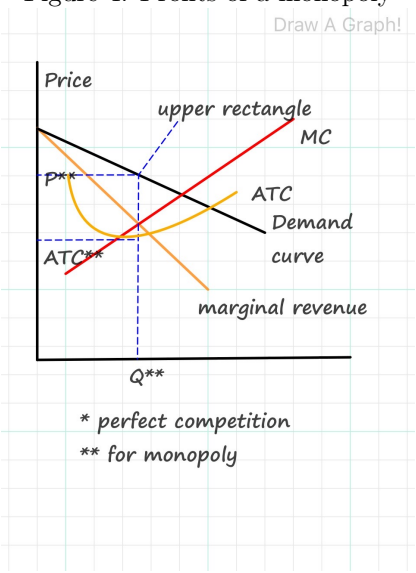


– Production is **lower** than the competitive firm's choice.

– Combining both, a monopoly charges a **higher price** and **produces less**.

– **Positive monopoly profit** exists in the long run. See Figure 4.

Figure 4: Profits of a monopoly



Session 11. Efficiency loss under a monopoly

Tao Wang

April 29, 2021

- One sentence summary of why monopoly causes welfare loss or **inefficiency**: the monopoly could have produced more to make some consumers happier without harming others, but she still does not want to do so.
  - Who are those **some** consumers? Anyone for whom a slightly lower price than the prevailing monopoly price makes it worthwhile to have the good.
  - Why does not the monopoly do so? She only cares about her profit. Producing more means the price she is able to charge is correspondingly lower, the additional consumers she will attract does not compensate for what give up in profits because of a lower price.
- A more formal analysis. (See Figure 1)

  The following steps explain two things, like what we did for perfect competition.
  - Why monopoly equilibrium is still an equilibrium.
  - Why monopoly equilibrium is inefficient.

  1. See the bottom graph in Figure 1. In the perfect competition, the firm chooses the production where $P = MC$. Remember the MC curve is the supply curve of a competitive firm. Combining it with the demand curve, we know what the perfect competition equilibrium is, corresponding to Q^* and P^*.
  2. This optimum can be represented again in the two-good space (the top graph in Figure 1.) The perfect competitive equilibrium is where the PPF is tangent with the price line, the Eq^* in the graph.
     - Supply is equal to demand, $S^* = D^*$. (we know why already)
     - The equilibrium is efficient. (we know why already)
  3. Now, think about the price P^{**}, which is prevailing if good M is a monopoly instead. We know $P^{**} > MC = P^*$. Therefore, the price line representing the monopoly scenario is **steeper** than the one under perfect competition. Therefore, it **crosses**, instead of **being tangent** with the PPF.

4. The intersection of the price line and the PPF is the new equilibrium under monopoly, Eq^{**}. There are two conditions for equilibrium.
   - **Market clearning**. Why supply is still equal to demand here? $S^{**} = D^{**}$.
     * For good M, we show it in the graph, supply is equal to demand where the demand and supply curve intersects with the demand curve.
     * For good C, we do not show it in the graph. But this naturally follows if demand for good M is equal to the supply because consumers will spend all her income either on M and C in this economy.
   - **Individual optimization**.
     * The monopoly chooses the production optimally.
     * For consumers, we do not show it here. But consumers still choose their optimal consumption under the monopoly price line, thus their indifference curves are all tangent with the price line.
5. Why is EQ^{**} inefficient?
   - At Eq^{**}, the slope of PPF is flatter than the slope of the price line, with which consumers' indifference curves are still tangent. Therefore, sliding down PPF will make some consumers better off. (we know how to show this already.)
6. Another way of showing the inefficiency: **deadweight loss**.

   Deadweight loss refers to consumer welfare foregone because of the monopoly compared to the perfect competition. Basically, monopoly sets a higher price than marginal cost and produces less than the perfect competition, some consumers who value the good more than its marginal cost but not as high as the current monopoly price can be better off if the monopoly produces more. This foregone consumer welfare can be represented by the triangle between marginal cost, demand curve and the vertical line of Q^{**}, in Figure 2. [1]

[1] In this class, we do not teach this way of representing the welfare loss because it is no longer so if there are more than one monopoly firms.

Figure 1: Equilibrium under a monopoly and perfectly competitive firms

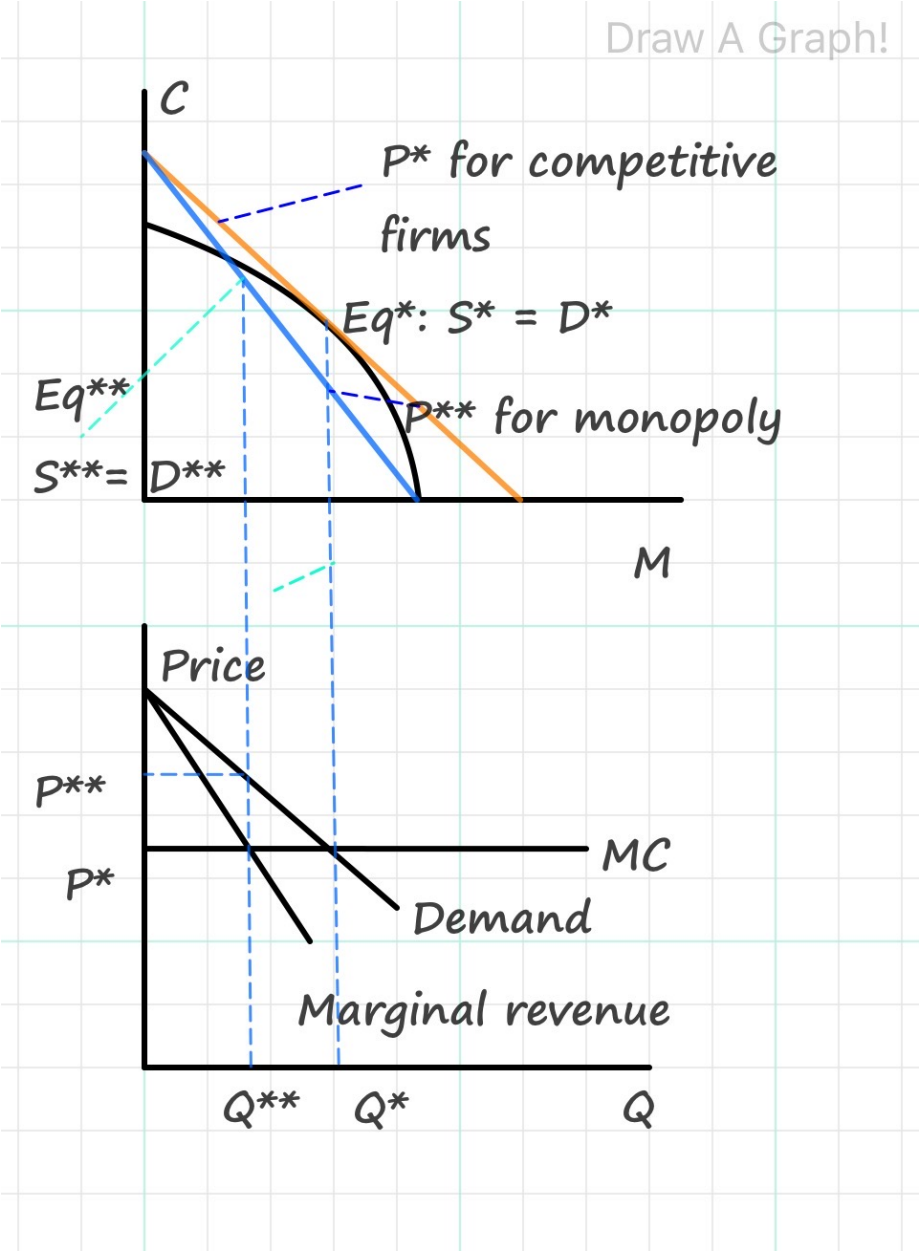
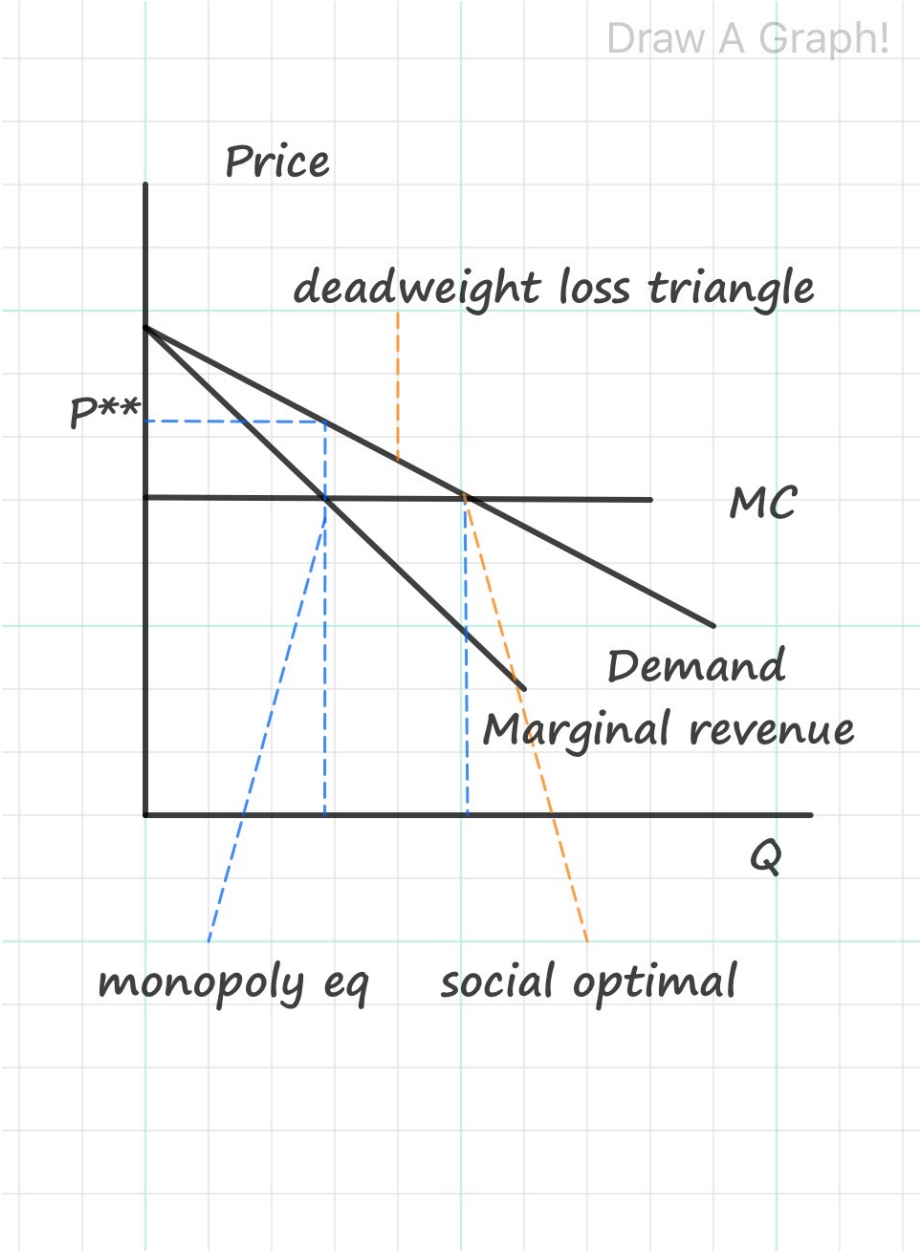


Figure 2: Deadweight loss under a **single** monopoly firm



Session 12. Tax

Tao Wang

April 29, 2021

1 Tax

- Why do we need tax?
  - Redistribution, i.e. progressive income taxes, wealth tax, inheritance tax, estate tax.
  - Achieve other public policy objectives, i.e. soda tax, sin tax, sugary drink tax.
  - Addressing negative externality, i.e. Pigovian tax, carbon tax.
  - Funding government expenditures, tax is the major source of government revenue, in addition to fees, tools, and other revenue from selling public goods.
- Effects of the tax
  - Higher price paid by the buyer and lower price received by the seller.
  - A wedge between the price the buyer pays and the price the seller receive, i.e. $p_b = p_s + tax$,
  - Lower quantity
  - Both consumer and producer are worse off in this market
- How does the tax work?

  Tax is always imposed on some transactions. Some tax to be imposed on the seller of the product while the other on buyers. We consider the effect of tax in these two scenarios, seperately. But we will realize they have the exactly same effects.

  - Scenario 1. Tax on the seller. See left of Figure 1.
    - We need to differentiate two supply curves in this context. One is the supply curve that the buyer is facing. It is the relationship between how the quantity that can be sold to him and the price that he pays (P_b). The second supply curve is the supply curve that truly affects the producer's decision. It is between the

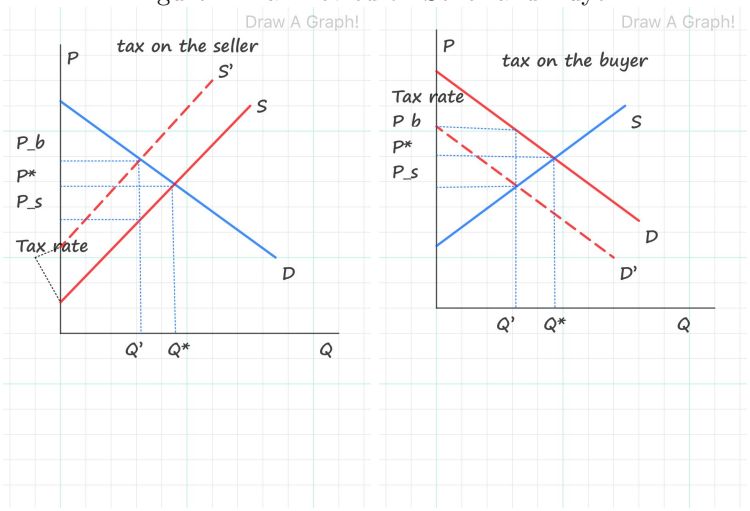
quantity he is willing to supply and the price that really goes to his pocket (P_s). The two are no longer the same in the presence of tax.

  - **A upward/left shift of the supply curve**. For a given quantity of supply, the price the seller need to receive becomes higher by the size of the tax rate, i.e. the seller implicitly adds the tax he needs to pay in the new supply curve: selling 100 ice cream at $2 before the tax, but can only do the same at $2+tax now.
  - **Lower quantity** The buyer is **facing** a lower supply. This leads to the lower quantity that is sold.
  - **Buyer's price** Also, a lower supply leads to a higher price the buyer needs to pay.
  - **Seller's price** However, the price that the seller would receive that truly goes to his pocket is not what the buyer pays, but the one after subtracting the tax. This is the price on the **old** supply curve corresponding to the new quantity being sold[1].
  - **Lower consumer welfare** the buyer only buys less at a higher price (than the market price).
  - **Lower producer welfare** the seller sells less at a lower price (than the market price)
  - **Efficiency loss** some buying and selling that could have happened without tax is foregone.
  - **Tax revenue** Tax rate times the new quantity is the tax revenue. A low tax rate with a higher quantity and a high tax rate with low quantity may end up giving you the same revenue.

- Scenario 2. tax on buyers. See right graph of Figure in 1.
  - Similarly, we need to differentiate two demand curves: one that the seller is facing, the other that actually governs the buyer's decision.
  - **A left/downward shift of demand curve**: for a given qunatity of demand, the price the buyer is willing to take needs to be lower by the size of the tax rate, i.e. the buyer implicitly adds the tax he needs to pay in deciding his demand.
  - **Lower quantity** The seller is facing a lower demand. Less ends up being sold, namely a lower quantity.
  - **Seller's price** The seller would receive a lower price because of lower demand.
  - **Buyer's price** However, the price that the buyer have to pay that really goes out of his pocket is not the price the seller receives, but one adding tax to it. This happens to be the price on the **old** demand curve corresponding to the new quantity.

[1] The key here is understanding why the supply curve facing the buyer is not the same as the one that really affects the seller's supply decision.

Figure 1: Tax Levied on Seller and Buyer

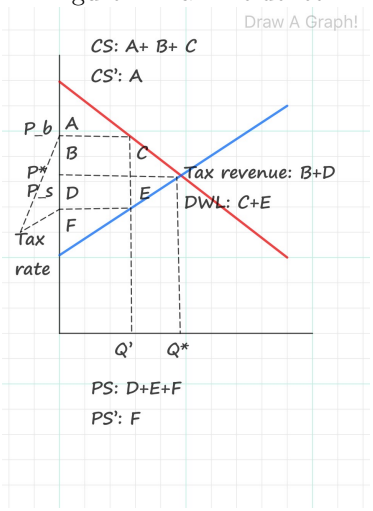


    - The impacts on consumer welfare, producer welfare and social welfare are the same as scenario 1.
  - "Tax incidence". See Figure 2
    - Turns out that scenario 1 and 2 leads to the same price and quantity after the tax for a same tax rate.
    - Same tax revenue.
    - Same tax burden shared by seller and buyer.
    - Same inefficiency.
    - The tax is shared by buyer and seller no matter which side is initially required to pay for the tax.
    - The share of tax burden only depends on the demand and supply elasticity, i.e. whoever is more elastic bears less burden.
      - Cigarrets tax borne mostly by smokers due to high demand elasticity.
      - Payroll tax mostly born by workers (supplier of the labor) due to low supply elasticity.

1.1 Subsidy

- What's the difference between tax and subsidy?
  - Tax is the government **collecting money** from the market while subsidy is government **paying money** to the market participants.
  - Tax leads to **lower quantity** (than market equilibrium) sold, while subsidy leads to **higher quantity**.

Figure 2: Tax Incidence



  - Tax makes buyer pay **more** than what producers receive. Subsidy make the buyer pay **less** than what producer receive.
  - Tax brings a revenue to the government. Subsidy brings spending to the government.

- What's the same between the two?
  - Both induce inefficient outcomes than the market equilibrium, i.e. positive deadweight loss.
    - The inefficiency from tax is there is **not enough trade**, i.e. some consumers would have bought the goods without the tax, while the one from a subsidy is **too much trade**, many producers should have not produced the good without the subsidy.