

# Week 2: solutions

## ECON 1-01

**TA** Allegra Saggese  
**Date** January 12, 2026

**Professor:** KC Fung  
**Topic:** economic principles and maths

### Problem 0

#### **Solution 0: Principles of economy wide interactions**

The three economy wide interactions are laid out in the Krugman textbook, and include:

- One person's spending is another person's income
- Spending may outpace productivity, requiring government intervention
- Increasing economic capacity allows the economy to grow.

One important example of the third principle is that with new technologies - such as generative AI, or early, the internet - firms are able to do a lot more with less inputs. This results in more output for similar costs, and what we describe as *economic growth*.

### Problem 1

#### **Solution 1: PPF**

Economic growth is an outward shift of the PPF. That means the curve itself shifts further into space away from the origin of the graph. This often occurs with an improvement in the allocation or increased productivity of factors of input into production.

Recall the PPF allows us to graphically represent the tradeoff between producing two different goods. Therefore, the PPF allows us to see the relative opportunity cost, or the value of forfeiting production of one good in favor of another.

## Problem 2

**Solution 2: California** California's economy is estimated to be \$4.1 trillion in size. This is measured in gross domestic product (GDP) which is an aggregate measure of the monetary value of all goods and services traded within the country in one year (2024). CA imports mostly from China, Taiwan and Mexico while CA exports to Mexico, Canada and China.

## Problem 3

### Solution 3: Fractions

1.  $x\%$  of 40 is 5,  $x \rightarrow 12.5\%$
2. 25% of 1800 is  $x$ ,  $x \rightarrow 450$
3. 12% of  $x$  is 96,  $x \rightarrow 800$

## Problem 4

### Solution 4: First derivatives

1.  $2x + 2$
2.  $\frac{1}{x}$
3.  $12x^3y^2$
4.  $3x + 16$

# Week 3: solutions

## ECON 1-01

TA Allegra Saggese  
Date January 19, 2026

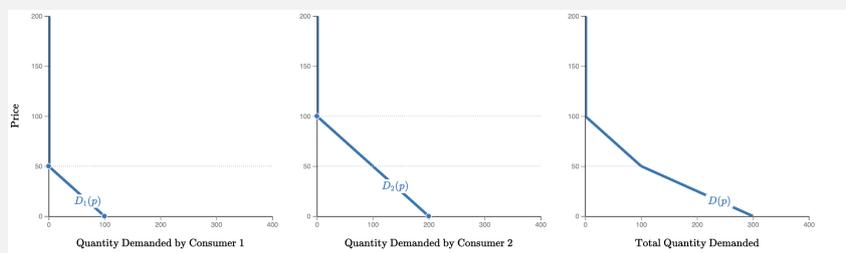
Professor: KC Fung  
Topic: consumer, producer surplus, supply and demand

### Problem 0

#### Solution 0: Demand curve

The market demand curve is the combined quantity demanded of a good, given a certain price, of all consumers in the market. To calculate the market demand curve, we take the *horizontal sum* of all the individual demand curves. Where the individual demand curve is the relationship between the quantity demanded and the price of a good for one consumer, the market demand captures the aggregate demand, so the quantity demanded from ever consumer, in the market.

The below graphic shows two individual quantities demanded by two individuals. Then the third graph shows the horizontal sum of the demand.



## Problem 1

### Solution 1 (part a): European economies

The three main points made by the author are:

1. The global economy is rapidly changing in terms of technological progress and immigration. These changes present threats and opportunities to the European economy that must be met by changing policy.
2. There are actually four European social models, not one homogenous model, and each has its own equity-efficiency tradeoffs. The phrase *social model* is capturing the way a government chooses to develop social and economic policies, and thus prioritizes different objectives in their society.
3. Europe should coordinate more effectively across nation states to create aligned social and economic policies. With differences in labor policies at the national level, there are inefficiencies.

**Table 1**  
**The Four European Models: A Typology**

		EFFICIENCY	
		<i>Low</i>	<i>High</i>
EQUITY	<i>High</i>	Continental	Nordic
	<i>Low</i>	Mediterranean	Anglo-Saxon

## Solution 1 (part b): European economies

These relate to the equity-efficiency tradeoff in the following manner:

1. Because developing economies, primarily in East Asia, are becoming increasingly productive, they threaten the economic productivity of Europe. This is because European countries are struggling to compete with low cost labor and intensive manufacturing that is occurring in developing countries. This means that policies aimed at increasing productivity, or expanding the size of the pie, may be difficult to obtain as they compete against countries with lower labor costs and increasing shares of export. Therefore, governments must identify what industries they should support to continue to realize economic growth. In order to achieve enhanced efficiency in the economy, they should invest in sectors that are not currently dominated by their trading partners. These investments in things like high skilled labor, research and development (R&D) and infrastructure are often expensive. These investments will come at the cost of equity considerations (distributing the pie more equally).
2. As discussed as a key point, each European social model has a different equity-efficiency trade-off. European social models primarily have more social insurance programs, where the government program protects people against major economic risks by pooling tax money from contributing populations to pay out benefits when specific events occur. The American model is focused more on labor market insurance, such as paying out workers who lose their job.
  - Nordic model: High social welfare programs and government intervention in labor markets. This focus is on equity.
  - Anglo-Saxon model: Competitive wages, and social safety net programs as a policy of last resort. This results in more transfers towards the working age population. This model focuses more on efficiency - or growth.
  - Continental model: Strong unions, insurance-based social protection, and high pensions. This is a social program focused economy, with some competition in the transfer space. This economy is quite mixed, but leans towards equity.
  - Mediterranean model: High worker protection, social spending is focused on retirement age individuals. These societies tilt more towards equity, as there are a number of distortions in the labor market as a result of the welfare spending programs.
3. There are a number of incentives in the European social model that are detrimental to increasing the number of workers in the economy. With more people working, more people produce output, and the economy grows. Therefore, the social model of providing generous social insurance policies seems to have backfired in Europe - there are high rates of unemployment in the Mediterranean and Continental areas. Offering unemployment benefits may be more effective for protecting or insuring workers against being fired, as opposed to offering transfers that may distort a worker's decision to gain employment.

## Problem 2

### Solution 2: Math review part (a)

1  $A = 40, B = 50$

(a)

$$\frac{B - A}{A} = \frac{50 - 40}{40} = \frac{10}{40} = \frac{1}{4} = 0.25$$

(b)

$$\frac{A - B}{B} = \frac{40 - 50}{50} = \frac{-10}{50} = -\frac{1}{5} = -0.20$$

(c)

$$\frac{B - A}{(A + B)/2} = \frac{10}{(40 + 50)/2} = \frac{10}{45} = \frac{2}{9} \approx 0.2222$$

2 Linear function such that:  $f(x) = 120 - 3x$ , and  $g(x) = 20 + 2x$ :

(a) The slope of  $f(x)$  is  $-3$ , this comes from looking at the term attached to  $x$ .

(b) The slope of  $g(x)$  is  $2$ , similarly this comes from the term attached to  $x$ . Recall the formula for a slope of a line is  $y = mx + b$  where  $m =$  slope,  $y =$  point along the  $y$  axis,  $x =$  point along the  $x$  axis, and  $b =$  the intercept of the line with the  $y$  axis (i.e. when  $x = 0$ ).

(c) Solve  $120 - 3x = 20 + 2x$ :

$$120 - 20 = 2x + 3x \Rightarrow 100 = 5x \Rightarrow x = 20$$

(d) Plug in  $x = 20$ :

$$y = f(20) = 120 - 3(20) = 120 - 60 = 60$$

3 Slope calculation, such that:  $y_1 = 30 - x$ ,  $y_2 = 6$

(a)  $x$ -intercept of  $y_1$ : set  $30 - x = 0$ , so  $x = 30$ . The intercept is  $(30, 0)$

(b) Intersection: solve  $30 - x = 6$ , so  $x = 24$ . Then  $y = 6$ . Intersection is  $(24, 6)$

(c) The region is a trapezoid, where the sides are given as  $x = 0$  and  $x = 24$

- At  $x = 0$ ,  $y_1 - y_2 = 30 - 6 = 24$
- At  $x = 24$ ,  $y_1 - y_2 = 6 - 6 = 0$

To calculate the area, we use the standard formula:

$$\text{Area} = \frac{1}{2}(24 + 0) \cdot 24 = 288$$

## Solution 2: Math review part (b)

4 Percent change, such that:  $X = 25, Y = 40$ :

(a)

$$\frac{Y - X}{X} = \frac{40 - 25}{25} = \frac{15}{25} = \frac{3}{5} = 0.60$$

(b)

$$\frac{X - Y}{Y} = \frac{25 - 40}{40} = \frac{-15}{40} = -\frac{3}{8} = -0.375$$

(c)

$$\frac{Y - X}{(X + Y)/2} = \frac{15}{(25 + 40)/2} = \frac{15}{32.5} = \frac{30}{65} = \frac{6}{13} \approx 0.4615$$

(d) Positive (since  $Y - X > 0$ )

1. **Percent change** where  $M = 12, N = 3$

(a)

$$\frac{N - M}{M} = \frac{3 - 12}{12} = \frac{-9}{12} = -\frac{3}{4} = -0.75$$

(b)

$$\frac{M - N}{N} = \frac{12 - 3}{3} = \frac{9}{3} = 3$$

(c)

$$\frac{N - M}{(M + N)/2} = \frac{-9}{(12 + 3)/2} = \frac{-9}{7.5} = -\frac{18}{15} = -\frac{6}{5} = -1.2$$

(d) Negative (since  $N - M < 0$ ).

## Problem 3

### Solution 3: Calculating surplus values

#### 1. Competitive equilibrium

$$\begin{aligned}Q_d &= Q_s \\100 - 2p &= 4p \\100 &= 6p \rightarrow \text{rearrange for } p \\p^* &= \frac{100}{6} \approx 16.67\end{aligned}$$

Substitute  $p^*$  into either curve to get  $Q^* = 4p^* = 4(16.67) \approx 66.67$  and the resulting competitive equilibrium price and quantity are:  $(p^*, Q^*) = (16.67, 66.67)$ .

#### 2. Consumer surplus

First find the choke price where quantity demanded is zero, by setting the function for the demand,  $Q_d = 0 \rightarrow 100 - 2p = 0$ . From this we see that  $p_{\max} = 50$ . Now we calculate consumer surplus using the area of triangle formula, applying it to the area under the demand curve, but above the market price:

$$\begin{aligned}CS &= \frac{1}{2} \times Q^* \times (p_{\max} - p^*) \\CS &= \frac{1}{2} \times 66.67 \times (50 - 16.67) \\CS &= \frac{1}{2} \times 66.67 \times 33.33 \\CS &\approx 1111.11\end{aligned}$$

#### 3. Producer surplus

First find the price where quantity supplied is zero  $Q_s = 4p = 0 \Rightarrow p_{\min} = 0$ . Recall producer surplus is the area of the triangle above the supply curve and below the price:

$$\begin{aligned}PS &= \frac{1}{2} \times Q^* \times (p^* - p_{\min}) \\PS &= \frac{1}{2} \times 66.67 \times 16.67 \\PS &\approx 555.56\end{aligned}$$

#### 4. Total surplus

$$\begin{aligned}TS &= CS + PS \\TS &= 1111.11 + 555.56 \\TS &\approx 1666.67\end{aligned}$$

What's the intuition? At the competitive price, the subscription TV market maximizes total gains from trade. Consumer and producer surplus measure how much buyers and sellers benefit from participating in the market.

# Week 4: solutions

## ECON 1-01

**TA:** Allegra Saggese  
**Date:** January 24, 2026

**Professor:** KC Fung  
**Topic:** Midterm #1 review

*The topics covered in the lead up to the first midterm include Krugman & Wells chapter Parts 1,2,3 or chapters 1-8.*

### Problem 1

#### Solution 1: Price elasticity of demand

(a) To start, let's assign the numbers given in the question to variables, or representative letters. We let all  $P$  values represent prices, and all  $Q$  values represent quantities. We use the  $_1$ , also called a subscript, to represent the time period. Therefore  $Q_1$  is the quantity in the first period, and  $Q_2$  is the quantity in the second period (after the price reduction). You can use this to make the formula easier to read.

$$P_1 = 25, \quad P_2 = 35, \quad Q_1 = 1200, \quad Q_2 = 900$$

Midpoint changes:

$$\begin{aligned}\% \Delta Q &= \frac{Q_2 - Q_1}{(Q_1 + Q_2)/2} = \frac{900 - 1200}{(1200 + 900)/2} = \frac{-300}{1050} = -\frac{2}{7} \\ \% \Delta P &= \frac{P_2 - P_1}{(P_1 + P_2)/2} = \frac{35 - 25}{(25 + 35)/2} = \frac{10}{30} = \frac{1}{3}\end{aligned}$$

Elasticity:

$$\varepsilon_D = \frac{\% \Delta Q}{\% \Delta P} = \frac{-2/7}{1/3} = -\frac{6}{7}$$

(b) Now we have the elasticity, we classify based on whether it is greater than or equal to 1 in absolute value terms:

$$|\varepsilon_D| = \frac{6}{7} < 1 \quad \rightarrow \quad \text{Demand is inelastic}$$

(c) Now calculate the total revenue in both periods. We will want to see the difference in revenue before and after the change in price and quantity, so  $TR_2 - TR_1 = \Delta TR$ :

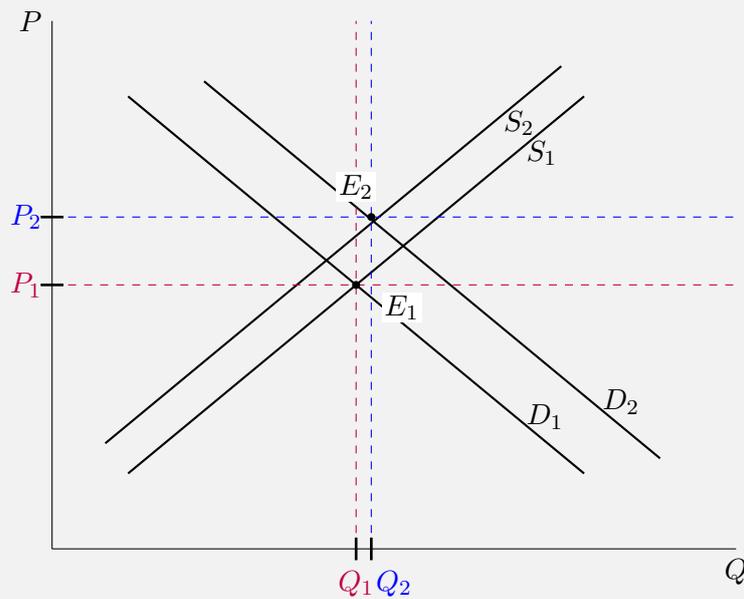
$$\begin{aligned}TR_1 &= P_1 Q_1 &= 25 \cdot 1200 &= 30000 \\ TR_2 &= P_2 Q_2 &= 35 \cdot 900 &= 31500 \\ \Delta TR &= TR_1 - TR_2 &= 31500 - 30000 &= 1500 > 0 \rightarrow TR > 0, \text{ revenue increases}\end{aligned}$$

## Problem 2

### Solution 2: Supply and demand

(a) As income rises, if we know that laptops are a normal good then  $\Rightarrow$  demand increases  $\Rightarrow D_1$  shifts right to  $D_2$ . Note  $D_2$  is a shift *outward* from the origin, we would say, because demand increases. If the input price rises, then  $\Rightarrow$  costs for the firm to produce the supply at a given quantity rises  $\Rightarrow$  supply will decrease  $\Rightarrow$  so  $S_1$  shifts left to  $S_2$ . This is a shift *inward* towards the origin as supply contracts.

(b) Diagram:



(c) Equilibrium price rises, but equilibrium quantity is ambiguous. This is because we know that a shift of demand drives the price up, and a shift of supply drives the price up as well. So, we know for a fact that prices will rise. But, whether the quantity rises depends on the relative size of the shift of both curves, and so in my diagram I show that quantity rises, but because the shift of the demand is greater than the contraction of the supply. This is specific to this case, and could be different.

### Problem 3

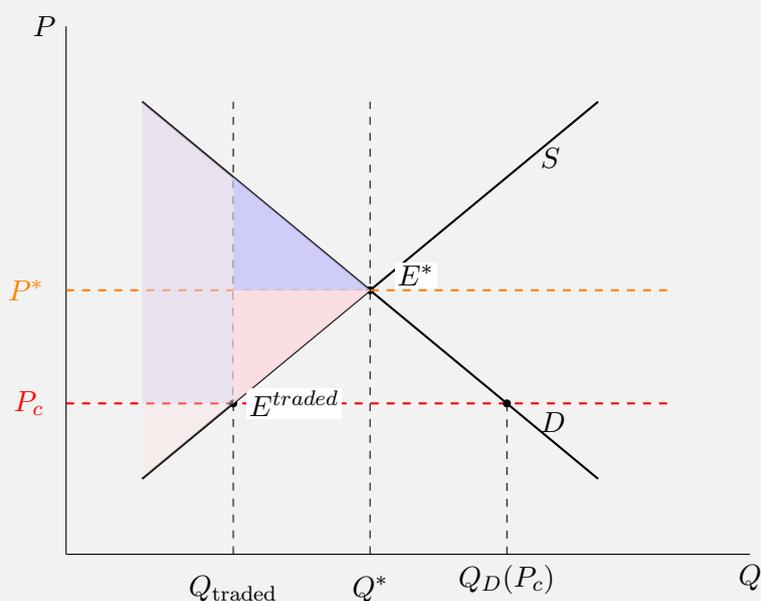
#### Solution 3: Price floors and ceilings

(a) Recall that a binding ceiling means

$$P_c < P^*$$

At  $P_c$ , there will be a shortage since  $Q_D(P_c) > Q_S(P_c)$ . This means the quantity demanded, at price,  $P_c$  is greater than the quantity supplied. Therefore, the traded quantity is equal to the lower of the two:

$$Q_{\text{traded}} = Q_S(P_c)$$



(b) From the graph, we see that consumer surplus (CS) is under  $D$  and above  $P_c$  up to  $Q_{\text{traded}}$ . It is the entire area shaded blue-ish. Producer surplus (PS) is above  $S$  and below  $P^*$  up to  $Q_{\text{traded}}$ , it the entire area shaded pink-ish. Finally, deadweight loss (DWL) is the lost gains from trade on units between  $Q_{\text{traded}}$  and  $Q^*$ . This is because both consumers and producers would like to be trading at  $Q^*$ , but instead they get stuck at  $Q_{\text{traded}}$ , i.e. there is a shortage. So DWL is the entire wedge or triangle, between  $Q_{\text{traded}}$  to  $Q^*$ , and between the supply and demand curves. Producer loss is the dark pink and the consumer loss is dark blue.

(c) Deadweight loss occurs because there is lost gains from the traded units between the total amount you would like to trade and the optimal amount, given the price ceiling. Because of the price ceiling, some people do not get to participate in the *ideal* version of the market, at the price given. Therefore, we assume there is some inefficiency in the market, thus resulting in DWL.

## Problem 4

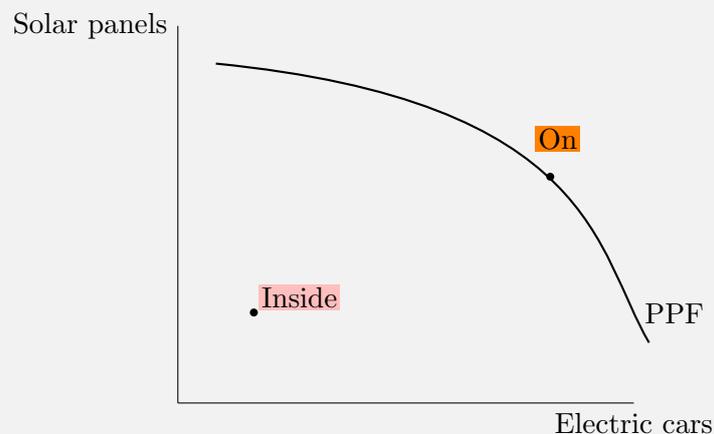
### Solution 4: Opportunity costs

(a) Recall what a PPF is. It is an economic model that allows economists to think about the trade-offs in an economy. The PPF represents a simplified economy, one in which there are only two goods. In this case, solar panels and EVs. Bowed-out or a rounded PPF  $\Rightarrow$  increasing opportunity cost as production shifts toward one good. This means that the more you produce of one good, let's say EVs, the more solar panels per EV you will have to forfeit. This is different than the case of a *linear PPF*, such that the opportunity cost is constant.

(b) Inside the PPF  $\Rightarrow$  there is inefficiency and unused resources or misallocation. If an economy is producing strictly inside the PPF, they are not using all of their available resources. Producing inside of the PPF is still *feasible*, but as economists we would consider this not desirable. It is not desirable because it is **inefficient**, i.e. not all the resources are being used to create something new.

(c) Examples that move the economy from inside to on the frontier itself include:

- Reducing unemployment, such as removing barriers to participating in the labor force. This could be through the government improving matching - such as setting up job fairs so that companies may meet prospective new hires quicker - or through investing in infrastructure. If the government invests in building a new bridge, they will need to hire a firm, or directly hire workers to build the bridge, thus stimulating job growth.
- Reducing the cost of capital. Sometimes firms may not be able to realize their full potential because the cost of investment is risky or plagued by fees and 'red tape.' These fees, either imposed by the government or banks or other lenders themselves may make it difficult to borrow money to invest in a business. Therefore, the government can help push the point of production towards the frontier by reducing the cost of capital through removing barriers to accessing credit.



## Problem 5

### Solution 5: Cross elasticities

(a) Cross-price elasticity is defined as the following, substituting in the values given:

$$\varepsilon_{Q,P_E} = \frac{\% \Delta Q_{\text{coffee}}}{\% \Delta P_{\text{energy}}} = \frac{10\%}{20\%} = 0.5$$

(b) The positive sign on the elasticity indicates  $\Rightarrow$  the goods are substitutes. The magnitude at 0.5 means quantity of coffee responds by about half as many percent as the energy drink price change. So when an energy drink changes by **a single percentage point**, the quantity of coffee sold increases by **one half of a unit**. Or more plainly, a 2% increase in the price of energy drinks means consumers buy one more cup of coffee, as a substitute.

(c) If income rises and coffee demand increases, income elasticity is positive

$$\varepsilon_I > 0$$

This means that people buy more coffee with a rise in income, and the income elasticity of the good is positive. We use  $\varepsilon$  to denote the elasticity. It's just a mathematical expression, or the greek letter, we often assign to elasticity in economics. If demand rises more than proportionally with income, then  $\varepsilon_I > 1$ . That means if you get a 1% increase in your income, your spending on coffee will increase by more than 1%.

## Problem 6

### Solution 6: Tarrifs

Given

$$P_w = 400, \quad t = 100$$

(a) Small importing country  $\Rightarrow$  domestic price rises by the tariff:

$$P_{\text{after}} = P_w + t = 400 + 100 = 500$$

(b) Consumers pay higher price and buy less  $\Rightarrow$  consumer surplus falls. Even though the consumers are hurt by the tariff, this forces domestic producers to sell at \$500, so some producers may be able to reduce costs. So, those who are able to sell at \$500 receive a higher price compared to the original global price of \$400, and produce more  $\Rightarrow$  producer surplus rises.

Government revenue equals tariff multiplied by the number of imports after the tariff:

$$GR = t \cdot M_{\text{after}}$$

where

$$M_{\text{after}} = Q_D(P_{\text{after}}) - Q_S(P_{\text{after}})$$

(c) Deadweight loss is two triangles: one from inefficient extra domestic production and one from inefficiently reduced consumption. Producers are producing inefficiently because they have a higher cost, so it would be more efficient for the market if the steel was produced at its lowest cost, the foreign price. And, again, the consumers lose out because they must pay more for the imported steel, due to the imposition of the tariff.

# Week 6: solutions

## ECON 1-01

**TA:** Allegra Saggese  
**Date:** February 9, 2026

**Professor:** KC Fung  
**Topic:** Chapter 8-9

### Problem 1: Costs

#### Solution 1

- (a) Accounting profit equals revenue minus explicit costs

$$\pi_A = 3200 - (700 + 300) = 3200 - 1000 = 2200$$

- (b) Implicit cost equals foregone job income plus foregone interest

$$\text{Foregone income} = 1500$$

$$\text{Foregone interest} = 0.02 \cdot 2000 = 40$$

$$\text{Implicit cost} = 1500 + 40 = 1540$$

- (c) Economic profit equals revenue minus explicit minus implicit

$$\pi_E = \pi_A - \text{Implicit cost} = 2200 - 1540 = 660$$

- (d) Here we get that profit,  $\pi$  is positive. Because it is expected to make economic profits (after factoring in the foregone income and interest - opportunity cost - as well as the explicit costs) against the costs, it is rational to open the business.

## Problem 2: Marginal cost

### Solution 2

(a) The marginal benefit curve depicts the benefit from producing one more unit depends on the quantity that has already been produced. This means each point along the curve depicts the additional utility (or dollar) benefit that you get from producing **one more item**, relative to the previous quantity along the curve. Often marginal benefit is *decreasing*, meaning the benefit you get from making one more item gets smaller, or shrinks, as you produce or consume more.

(b) Solve  $MB(q) = MC(q)$

$$\begin{aligned}50 - 0.5q &= 10 + 0.25q \\40 &= 0.75q \\q^* &= \frac{40}{0.75} = \frac{160}{3}\end{aligned}$$

(c) Compare at  $q = 40$

$$\begin{aligned}MB(40) &= 50 - 0.5(40) = 30 \\MC(40) &= 10 + 0.25(40) = 20\end{aligned}$$

So  $MB(40) > MC(40)$

(c) Here we use the **Profit-maximizing principle of marginal analysis**. We produce up to the point where the next unit adds at least as much benefit as cost, and stop once additional units would add more cost than benefit. So, when a firm is deciding to produce, the optimal quantity is the largest possible quantity you can produce where the marginal benefit is greater than or equal to marginal cost.

### Problem 3: Comparative advantage

#### Solution 3

- (a) Home: 1 laptop uses 10 hours, which could produce  $10/2 = 5$  shirts

$$OC_H(1 \text{ laptop}) = 5 \text{ shirts}$$

- (b) Foreign: 1 laptop uses 12 hours, which could produce  $12/4 = 3$  shirts

$$OC_F(1 \text{ laptop}) = 3 \text{ shirts}$$

- (c) The Foreign country has comparative advantage in laptops since its opportunity cost is lower. Here, Home has comparative advantage in shirts. The takeaway here is that with two countries who produce, each making different items, they are able to specialize in the task that they are good at, and trade. When they do so, both countries **consume more** of both goods, so they are both better off. We call this a **welfare improvement** where both countries are made better off via trade, and neither have to sacrifice anything in order to consume a different amount of the goods. Recall the definition of free trade is the opposite of autarky. Where autarky is a *closed economy*, meaning they do not engage in trade.

- (d) Mutually beneficial terms of trade for 1 laptop in shirts must lie between opportunity costs

$$3 < \text{shirts per laptop} < 5$$

Any value within this range makes both countries better off. As long as the benefits from trade lie between the opportunity cost of both countries, trading is the rational choice.

## Problem 4: Quota

### Solution 4a-c

Given

$$\begin{aligned}Q_D &= 80 - P \\Q_S &= 5 + 0.5P \\P_w &= 30\end{aligned}$$

(a) Free trade price is  $P_w$

$$\begin{aligned}Q_D(P_w) &= 80 - 30 = 50 \\Q_S(P_w) &= 5 + 0.5(30) = 5 + 15 = 20 \\M_{FT} &= Q_D - Q_S = 50 - 20 = 30\end{aligned}$$

(b) With tariff  $t = 10$ , domestic price is

$$P_t = P_w + t = 40$$

Quantities

$$\begin{aligned}Q_D(P_t) &= 80 - 40 = 40 \\Q_S(P_t) &= 5 + 0.5(40) = 5 + 20 = 25 \\M_t &= 40 - 25 = 15\end{aligned}$$

(c) Tariff revenue

$$TR = t \cdot M_t = 10 \cdot 15 = 150$$

## Solution 4d-g

- (d) Deadweight loss is the sum of a production-distortion triangle and a consumption-distortion triangle

Production increase

$$\Delta Q_S = 25 - 20 = 5$$

Consumption decrease

$$\Delta Q_D = 50 - 40 = 10$$

So

$$DWL = \frac{1}{2}t\Delta Q_S + \frac{1}{2}t\Delta Q_D = \frac{1}{2}(10)(5) + \frac{1}{2}(10)(10) = 25 + 50 = 75$$

- (e) Quota set to match imports under the tariff

$$M_Q = 15$$

This implies the domestic price rises to  $P_Q = 40$ , so quota rent is

$$QR = (P_Q - P_w) \cdot M_Q = (40 - 30) \cdot 15 = 150$$

- (f) If the domestic government captures quota rents, the welfare loss equals the same deadweight loss as the tariff that restricts imports to the same level

$$\text{Welfare loss} = 75$$

- (g) If foreign exporters capture the quota rents, domestic welfare loss equals deadweight loss plus the transfer of quota rents abroad

$$\text{Welfare loss} = 75 + 150 = 225$$

**Week 7: solutions**  
**ECON 1-01**

**TA:** Allegra Saggese  
**Date:** February 17, 2026

**Professor:** KC Fung  
**Topic:** Chapter 10-11

## Problem 0: Budget line

### Solution 0

(a) The budget line is

$$\begin{aligned}P_x x + P_y y &= I \\6x + 4y &= 120\end{aligned}$$

(b) Intercepts

$$\begin{aligned}y = 0 &\Rightarrow 6x = 120 \Rightarrow x = 20 \\x = 0 &\Rightarrow 4y = 120 \Rightarrow y = 30\end{aligned}$$

(c) Solve for  $y$

$$\begin{aligned}4y &= 120 - 6x \\y &= 30 - \frac{3}{2}x\end{aligned}$$

The slope is  $-\frac{P_x}{P_y} = -\frac{6}{4} = -\frac{3}{2}$ , which is the opportunity cost of  $x$  in terms of  $y$ : how many units of  $y$  must be given up to get one more unit of  $x$  while staying on the budget line. This means we forfeit two items of  $y$  to get three items of  $x$ , or we forfeit  $\frac{2}{3}$  of  $y$  to get one unit of  $x$ . Both are fair ways of describing the opportunity cost.

(d) With  $I = 180$  we update the consumer's total income. It is now *higher*.

$$6x + 4y = 180$$

The budget line shifts outward in a parallel way because prices are unchanged but income is higher, so all affordable bundles expand proportionally

(e) With  $P_x = 3$ ,  $I = 120$ ,  $P_y = 4$

$$3x + 4y = 120$$

The budget line pivots outward around the  $y$ -intercept because  $P_y$  and income are unchanged, so the maximum  $y$  stays  $y = 30$ , but the  $x$ -intercept increases to  $x = 40$

## Problem 1: Marginal utility

### Solution 1

- (a) The term  $\frac{MU_x}{P_x}$  is the marginal utility per dollar spent on good  $x$ . It measures how much additional utility the consumer gets from spending one more dollar on  $x$  at the current bundle. Marginal utility, on its own, is the utility you get from consuming one more additional unit of the good you are purchasing, given whatever is your current consumption (i.e. going from zero consumption to one unit *may have* a different marginal utility than going from consuming 100 units of a good to 101 units of a good). The **marginal utility per dollar** spent on a good or service is the additional utility gained from spending one more dollar on that good or service.
- (b) If  $\frac{MU_x}{P_x} > \frac{MU_y}{P_y}$ , then a dollar spent on  $x$  generates more additional utility than a dollar spent on  $y$ . The consumer can increase total utility without increasing income by shifting a small amount of spending away from  $y$  and toward  $x$ . This reallocation raises utility because the gain in utility from the extra spending on  $x$  is larger than the loss in utility from reducing spending on  $y$ .
- (c) A bundle where  $\frac{MU_x}{P_x} \neq \frac{MU_y}{P_y}$  cannot be optimal because there exists a feasible reallocation of spending that increases total utility while keeping total spending the same. Optimality requires that there be no way to make the consumer better off without increasing income, so the consumer must allocate spending until the marginal utility per dollar is equalized across goods.
- (d) Start from the condition

$$\frac{MU_x}{P_x} = \frac{MU_y}{P_y}$$

Cross-multiply to obtain

$$MU_x P_y = MU_y P_x$$

Divide both sides by  $MU_y P_y$

$$\frac{MU_x}{MU_y} = \frac{P_x}{P_y}$$

Since  $MRS = \frac{MU_x}{MU_y}$ , this is exactly

$$MRS = \frac{P_x}{P_y}$$

- (e) The slope of the indifference curve equals the slope of the budget line means the consumer's willingness to trade  $y$  for  $x$  at the margin equals the market's tradeoff given by relative prices. At that point, the consumer cannot increase utility by moving along the budget line, because any small increase in  $x$  requires giving up  $y$  at exactly the rate that leaves the consumer indifferent at the margin, they have no way to increase their utility.

## Problem 2: Income and substitution effect

### Solution 2

- (a) **Substitution effect:** coffee becomes relatively cheaper than tea when  $P_C$  falls from 4 to 2, so the consumer substitutes toward coffee and away from tea, holding real utility constant. Recall the substitution effect of a change in the price of a good is the change in how of the good (quantity) is consumed as the consumer *substitutes away* from that good in favor of another, relatively cheaper good. It results from the change in price effecting the quantity consumed. So at a new equilibrium, although we don't quite know this given we don't have enough information from the problem, we assume, that the consumer likely drinks more coffee relative to tea as its less expensive (as long as they are not perfect complements). This changes the *slope of the demand curves*.
- (b) **Income effect:** the price decrease raises the consumer's real purchasing power, so the consumer can afford more goods overall. This means that the change in price of a good changes the total quantity of that good that can be consumed due to a change in the consumer's purchasing power (from the price change). Since coffee is normal, the income effect actually increases coffee consumption. For tea, the income effect depends on whether tea is normal or inferior. *Remember: the income effect often reinforces the substitution effect.*
- (c) **For a normal good,** both effects increase consumption of the good whose price falls. The substitution effect increases coffee consumption because it is cheaper relative to tea - and its not a perfect complement - so the consumer buys more coffee when the **relative (and actual) price of coffee** decreases. She substitutes away from tea. Then the income effect increases coffee because the consumer is effectively richer - a drop in the price of coffee means she could consume the exact same amount of both coffee and tea and have a bit of money left over. We know she will spend that or else its inefficient, so the income effect reinforces the substitution effect.
- (d) If coffee is inferior, the substitution effect still increases coffee when its price falls, but the income effect decreases coffee because higher real income causes the consumer to shift away from the inferior good. Therefore the two effects work in opposite directions.
- (e) **Coffee is a Giffen good if it is inferior** because it takes a large share of the consumer's budget. Where the income effect is strong enough to outweigh the substitution effect, a price decrease reduces quantity demanded and a price increase raises quantity demanded.

### Problem 3: Short run costs

#### Solution 3

- (a) Total cost is just equal to the fixed cost plus variable cost:

$$TC(Q) = FC + VC(Q) = 200 + 10Q + Q^2$$

- (b) The average fixed cost is the fixed cost per unit of produced good:

$$AFC = \frac{FC}{Q} = \frac{200}{Q}$$

As  $Q$  rises, the same fixed cost is spread over more units, so  $AFC$  falls with  $Q$ . This means the more units you produce at a given fixed cost, the *lower* your average fixed cost will be.

- (c) Average variable cost is:

$$AVC = \frac{VC}{Q} = \frac{10Q + Q^2}{Q} = 10 + Q$$

Here  $AVC$  rises with  $Q$ . In general,  $AVC$  is U-shaped because initially specialization can lower cost per unit, but at higher output diminishing marginal returns raise variable cost per unit. This means with more units to produce, it becomes more unclear what the variable costs will be or they will rise, so  $AVC$  goes up.

- (d) Average total cost is just the total cost per unit of good:

$$ATC = \frac{TC}{Q} = \frac{200 + 10Q + Q^2}{Q} = \frac{200}{Q} + 10 + Q$$

Using  $ATC = AFC + AVC$ ,  $AFC$  falls with  $Q$  while  $AVC$  eventually rises with  $Q$ , so their sum is typically U-shaped.

## Problem 4: Marginal costs

### Solution 4

(a) Marginal cost is the derivative of total cost

$$MC(Q) = \frac{d}{dQ} (200 + 10Q + Q^2) = 10 + 2Q$$

(b) Average total cost is

$$ATC(Q) = \frac{200}{Q} + 10 + Q$$

Set  $MC = ATC$

$$10 + 2Q = \frac{200}{Q} + 10 + Q$$

$$2Q - Q = \frac{200}{Q}$$

$$Q = \frac{200}{Q}$$

$$Q^2 = 200$$

$$Q = \sqrt{200}$$

(c) If  $MC < ATC$ , producing an additional unit costs less than the current average, so it pulls  $ATC$  down. If  $MC > ATC$ , the next unit costs more than the current average, so it pushes  $ATC$  up. Therefore  $ATC$  is minimized exactly where  $MC = ATC$

(d) If the coefficient on  $Q$  in  $VC$  rises from 10 to 20, then

$$TC(Q) = 200 + 20Q + Q^2$$

$$MC(Q) = 20 + 2Q$$

$$ATC(Q) = \frac{200}{Q} + 20 + Q$$

Both  $MC$  and  $ATC$  shift upward because variable cost is higher at every output level

## Problem 5: DMR

### Solution 5

- (a) Marginal product of labor is

$$MP_L = \frac{dQ}{dL} = \frac{d}{dL}(20L - L^2) = 20 - 2L$$

- (b) Marginal product begins to decline immediately because

$$\frac{dMP_L}{dL} = \frac{d}{dL}(20 - 2L) = -2 < 0$$

So  $MP_L$  is decreasing for all  $L > 0$

- (c) Diminishing marginal returns means that when at least one input is fixed, adding more of the variable input eventually yields smaller and smaller additional increases in output. In layman's terms, it means that with a fixed input, lets say capital machinery (i.e. you buy a machine that seals bottle caps on bottles and it costs the same amount of money to run the machine for every bottle that has a cap sealed to it) and some variable input, lets say labor hours, you will see diminishing marginal returns when the cost of additional labor hours actually yields less output. Imagine you hire someone to work for six hours. He uses the machine to make sealed bottles of kombucha. He's good at it for six hours, and consistently produces 100 bottles. But you ask him to work twelve hours (this translates to a rise in the variable cost in our model). Now you've only got 150 bottles of kombucha. But he worked double the hours! Shouldn't you have double the bottles of kombucha as you've kept the machine running and you hired him for double the time to work? The problem here is that every additional hour your laborer works tires him out! By the time he gets to bottling in the twelfth hour, he is not very productive, so you are producing *less output* per unit of input (labor hours).
- (d) With a fixed input, diminishing marginal returns imply that each additional unit of labor adds less output, so producing one more unit of output requires more additional labor. If labor is a variable cost, needing more labor per extra unit raises the marginal cost of producing additional output, so  $MC$  rises with output.
- (e) Diminishing marginal returns occur only in the short run because they require at least one fixed input. In the long run all inputs are variable, so the firm can adjust plant size and capital as well as labor, avoiding the short-run crowding that generates diminishing marginal returns.

# Week 9: solutions

## ECON 1-01

**TA:** Allegra Saggese  
**Date:** March 2, 2026

**Professor:** KC Fung  
**Topic:** Monopoly, Oligopoly

### Problem 0: Perfect Competition

#### Solution 0

(a) Marginal cost is the derivative of total cost

$$MC(Q) = \frac{d}{dQ} (50 + 5Q + Q^2) = 5 + 2Q$$

For a perfectly competitive firm, profit maximization occurs where

$$P = MC$$

$$25 = 5 + 2Q$$

$$20 = 2Q$$

$$Q = 10$$

(b) Profit equals total revenue minus total cost

$$TR = PQ = 25(10) = 250$$

$$TC = 50 + 5(10) + (10)^2 = 50 + 50 + 100 = 200$$

$$\pi = TR - TC = 250 - 200 = 50$$

(c) In the long run, positive economic profits attract entry. As new firms enter, market supply increases, causing the market price to fall. Entry continues until economic profits are driven to zero, where price equals minimum average total cost.

## Problem 1a: What are monopolies?

### Solution 1a: What are monopolies? a-b

(a) Monopolies are industries or markets that are characterized as having **one seller**, the monopolist, in the market. Monopolists often can succeed as the only seller in a market, giving them **market power**. Market power allows firms that are monopolies to be price-setters. Monopolies are often characterized as markets where the price is slightly higher and the quantity produced is lower than the perfectly competitive market. We also know the following:

- Firms do not produce where  $MR = P$ , i.e.  $MR \neq P$  in equilibrium
- Produce until  $MR = MC$  and then they stop
- $\Pi = (P - ATC) \cdot Q_m$
- $Q_m < Q^*$  and  $P_m > P^*$ . This means the quantity is less than in perfect competition and higher prices than in perfect competition
- Total surplus is lower

(b) Barriers to entry protect monopolists by limiting the number of new entrants into a market. This allows monopolists to earn economic profits. **There are five barriers to entry** that allow monopolies to exist:

1. Control of a scarce resource or input
2. Increasing returns to scale (IRS)
3. Technological superiority
4. Government barriers and protections (patents, copyright)
5. Network effects and externalities

## Solution 1a: Cont'd 1a, c

(c) To identify monopolies, let's think of some firms that may currently be operating in violations of the normal rules of a competitive market. These violations, need to be measured. Normally we assess the following:

- **Market share:** what portion of total goods in a sector, let's say agriculture products, are sold by that one company?
- Is the firm a **price setter**? Can they change their price (up or down) and still maintain control of their market power?
- Does the firm engage in **anti-competitive or unfair strategies** (i.e. buying competitors via merger or acquisition, selling at a loss temporarily, overcharging consumers, or stifling innovation)?<sup>a</sup>
- Is there a **significant barrier to entry**? If so, is an existing player blocking others from entering?

Currently, the US has a number of ongoing litigation suits open with US companies, including Amazon and Meta - two large technology firms. They both have been accused of undertaking unfair or strategic anti-competitive moves to ensure market dominance. These cases are pending, and as thus *are not clear examples of monopolies*, although the government has accused them of being so based on evidence gathered by the US Department of Justice and the Federal Trade Commission (FTC).

While still a pending case, currently the FTC has sued three pharmaceutical benefits manager (PBMs) for what they claim is unfair pricing coordinating, and in a sense creating an *oligopoly* structure in the market.<sup>b</sup> The FTC, under its current case, has managed to reduce the cost of inhalers (medical device for asthma from \$ 500 or more to just \$35.<sup>c</sup> This is because they identified collusion between three large firms, where they agreed to inflate prices in an effort to artificially boost profits.

Now, why is this bad? Maybe from a moral - normative - standpoint, we don't like the behavior. But in economics, we look at the positive implications. Here, we might actually see a **net welfare loss** where consumers pay more than the marginal cost of the goods, and thus have less money to spend on other things - like investing in their businesses, buying assets, or buying other consumer goods.

- **Normative:** normative statements decide a preference or a moral position on how the world should be. For example, we may say that monopolies are bad because its not *fair* for one company to make all the money.
- **Positive:** positive statements describe an objective or neutral point of view of the world. Monopolies generate a net social cost due to the distortionary wedge caused by inflated prices. Monopolies therefore decrease social welfare and are inefficient in markets.

---

<sup>a</sup>see the FTC guidelines and definition of monopolization here: <https://www.justice.gov/archives/atr/monopoly-power-and-market-power-antitrust-law>. Note that there is significant evidence that needs to be provided in order to prove an individual has either become or attempted to become a monopoly.

<sup>b</sup>Caremark Rx, Zinc Health Services, et al., In the Matter of (Insulin) accessible at: <https://www.ftc.gov/legal-library/browse/cases-proceedings/221-0114-caremark-rx-zinc-health-services-et-al-matter-insulin>

<sup>c</sup><https://www.ftc.gov/news-events/news/press-releases/2025/01/ftc-releases-summary-key-accomplishments>

## Solution 1a: Cont'd 1a, d

(d) Natural monopolies: Natural monopolies exist in the somewhat rare cases where the marginal cost, that is, the cost of satisfying one more customer, is lower than the cost of servicing the previous customer. The marginal cost curve, and as such, the supply curve, is downward sloping or flat over the relevant range of production.

This is called we call a **natural monopoly** because it is economically efficient for there to only be one supplier.

Some examples of natural monopolies exist in markets in which there is a natural economy of scale: i.e. utilities and roads. Does it make sense for you - an individual - to build your own transmission line that connects to a power plant? Probably not, as the up front cost of capital is extremely high, especially for one single connection. The government allows utility companies (energy infrastructure providers) to have a natural monopoly so they may take advantage of the *economies of scale* (or increasing returns to scale) and offer a lower price for consumers.

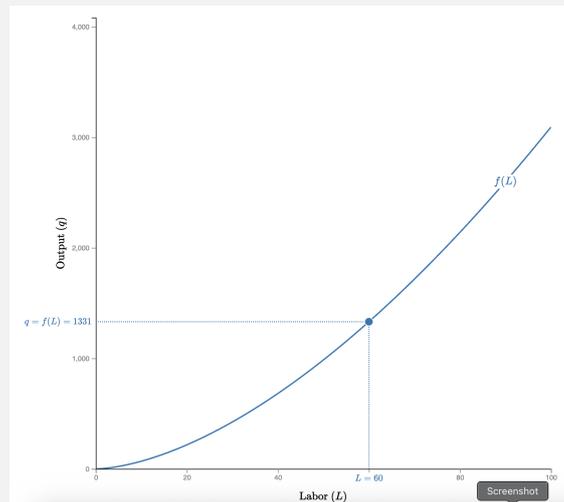


Figure 1: An example of output vs. labor where there are increasing returns to scale (IRS)

Other natural monopolies can be legally sanctioned by the government. The United States Post Office (USPS) is a legal monopoly, in that they have the sole legal authority to operate throughout the US. Yes, there are other distributors of mail, but only USPS is legally allowed to distribute first class mail.<sup>a</sup>

<sup>a</sup><https://psu.pb.unizin.org/introductiontomicroeconomics/chapter/chapter-8-monopoly/>

## Problem 1b: Monopoly

### Solution 1

(a) Total revenue is

$$TR = P \cdot Q = (60 - 2Q)Q = 60Q - 2Q^2$$

Marginal revenue is

$$MR = \frac{dTR}{dQ} = 60 - 4Q$$

Profit maximization requires

$$\begin{aligned}MR &= MC \\60 - 4Q &= 20 \\40 &= 4Q \\Q &= 10\end{aligned}$$

(b) Substitute  $Q = 10$  into demand

$$P = 60 - 2(10) = 40$$

Profit equals

$$\begin{aligned}TR &= 40(10) = 400 \\TC &= 20(10) = 200 \\ \pi &= 400 - 200 = 200\end{aligned}$$

(c) Under perfect competition, price equals marginal cost

$$\begin{aligned}60 - 2Q &= 20 \\40 &= 2Q \\Q &= 20\end{aligned}$$

Competitive price:

$$P = 20$$

The monopolist restricts output from 20 to 10 and raises price from 20 to 40. This eliminates mutually beneficial trades between  $Q = 10$  and  $Q = 20$ , creating deadweight loss.

## Problem 2: Monopolistic Competition

### Solution 2

(a) Total revenue:

$$TR = (40 - Q)Q = 40Q - Q^2$$

Marginal revenue:

$$MR = 40 - 2Q$$

Marginal cost:

$$MC = \frac{d}{dQ}(10 + 10Q) = 10$$

Set  $MR = MC$

$$40 - 2Q = 10$$

$$30 = 2Q$$

$$Q = 15$$

(b) Price:

$$P = 40 - 15 = 25$$

Profit:

$$TR = 25(15) = 375$$

$$TC = 10 + 10(15) = 160$$

$$\pi = 375 - 160 = 215$$

(c) In the long run, positive economic profits attract entry. As new firms enter, each firm's demand curve shifts left. Entry continues until economic profit equals zero. In long-run equilibrium, price equals ATC, but firms produce at an output level smaller than the minimum ATC, creating excess capacity.

## Problem 3: Oligopoly

### Solution 3

- (a) An oligopoly is a market structure with only a small number of firms, where each firm's decisions affect the profits of the others. Firms are interdependent.
- (b) Imperfect competition refers to market structures where firms have market power and can influence price. In an oligopoly, firms may compete strategically, recognizing that pricing or output decisions affect rivals. They do not take price as given.
- (c) The government may use anti-trust policy to prevent collusion or block mergers that substantially increase market concentration. This is done through the Department of Justice's anti-trust regulation, or the Federal Trade Commission (FTC). It may also regulate pricing behavior. Recall the history of oligopoly regulation; in the United States, oligopoly first became an issue during the second half of the nineteenth century, when the growth of railroads, themselves an oligopolistic industry, created a national market for many goods. Industrialists realized *profits could be higher* when price was explicitly controlled. They formed **cartels** between each other, which at the time were not illegal. These agreements were not enforced, but because all the firms agreed to it, they often followed it. The government was not able to reduce this behavior until they created a legal framework to regulate these industries.
- (d) Using game theory, firms may face a Prisoner's Dilemma. Each firm has an incentive to undercut rivals to increase its own profit, even though mutual cooperation would generate higher joint profits. Strategies such as repeated interaction or tit-for-tat may sustain tacit collusion.

## Problem 4: Overview

### Solution 4

- **Perfect competition:** A market is perfectly competitive when individual buyers and sellers are price takers—no single participant has any influence on the market price. This requires:

1. many buyers and sellers, each small relative to the market
2. identical (homogeneous, non-differentiated) products
3. full information (no asymmetries)
4. no barriers to entry, with free entry and exit

Under these conditions, firms take the market price as given and choose output to maximize profit where price equals marginal cost.

- **Monopolistic competition:** Monopolistic competition is not the same as perfect competition as monopolistically competitive firms have some market power. It's not a pure monopoly, duopoly, or oligopoly because there is still some competition. But, the potential for *collusion* no longer exists. We define this market as having a structure with:

1. Many producers
2. Differentiated products (value in variety)
3. In the long run, there is free entry and exit

- **Monopoly:**<sup>a</sup> A monopoly is a market with a sole supplier of the good, where the one firm has control over setting the price, as they determine the supply function. The demand curve in a monopoly is downward sloping.

- **Oligopoly:** Oligopoly is an industry with only a small number of producers. A producer in such an industry is known as an oligopolist. Each firm in oligopoly has some market power. If there are only two firms in the market, it is a duopoly. Two things arise in this form of market:

- There is an incentive to **collude**. This means that firms would earn more economic profit if they made decisions jointly. If firms joined up, or created a **cartel**, and behaved like a monopolist, they could increase their profits.
- There is also an incentive to **cheat**. While oligopolists can potentially benefit from colluding and working together (against the consumer), a lot of times the firms do not want to do that. They are often hungry for market power. This is because, if they undercut (i.e. oversupply against their fellow cartel members) the market, they can increase their profits without having to work with anyone. This is **non-cooperative behavior**.

We understand the dynamics of this type of market through game theory. From game theory we can understand a number of strategic behaviors firms will undertake including tit-for-tat, tacit collusion, and non-cooperative equilibrium.

---

<sup>a</sup>See 1a-b for a more complete discussion of monopoly

# Final Exam Review: Solutions

## ECON 1-01

**TA:** Allegra Saggese  
**Date:** March 9, 2026

**Professor:** KC Fung  
**Topic:** Final Exam Review

### Problem 0: Elasticity

#### Solution 0

- (a) Using the midpoint formula

$$\begin{aligned} E_d &= \frac{\frac{Q_2 - Q_1}{(Q_1 + Q_2)/2}}{\frac{P_2 - P_1}{(P_1 + P_2)/2}} \\ &= \frac{80 - 100}{\frac{12 - 10}{11}} \\ &= \frac{-20/90}{2/11} \\ &\approx -1.22 \end{aligned}$$

- (b) Since  $|E_d| > 1$ , demand is elastic. Recall we take the absolute value of demand elasticity, as we are not looking for the type of good, when it is with respect to demand. The sign of the elasticity (*i.e. whether its negative or positive*) is only relevant for cross-price elasticities.
- (c) When demand is elastic, a price increase reduces total revenue because the percentage drop in quantity demanded is larger than the percentage increase in price. Recall demand elasticity means a small change in the price ( $P$ ) will lead to a larger change in  $Q_d$ . For each percentage point change in price, the percentage point drop in demand is bigger.

## Problem 1: Cross Price Elasticity

### Solution 1

- (a) The cross-price elasticity should be positive.
- (b) If goods are substitutes, an increase in the price of one good increases demand for the other good. Therefore the cross-price elasticity is positive. If goods are complements, the cross-price elasticity is negative.
- (c) If the price of coffee increases, the demand for tea increases because consumers substitute tea for coffee.

## Problem 2: Monopoly

### Solution 2

- (a) Total revenue is

$$\begin{aligned}TR &= (80 - 2Q)Q \\ &= 80Q - 2Q^2\end{aligned}$$

Marginal revenue

$$MR = \frac{dTR}{dQ} = 80 - 4Q$$

- (b) Profit maximization

$$\begin{aligned}MR &= MC \\ 80 - 4Q &= 20 \\ 60 &= 4Q \\ Q &= 15\end{aligned}$$

- (c) Price from demand

$$\begin{aligned}P &= 80 - 2(15) \\ &= 50\end{aligned}$$

### Problem 3: Monopoly vs Competition

#### Solution 3

- (a) In perfect competition, firms must sell at the market price. Recall we have two graphs, such that the price is determined by the aggregate supply and demand. When the market sets the price, this *disciplines the producers*. If producers (sellers) want to sell at a price higher than the market price, no one will buy and their profits drop to zero. If they try to undercut the market, they will get 100% of the  $Q_d$ , but at a loss. This is not rational and they won't do it.

Looking at the perfectly competitive market, we can solve where we know the firm's marginal cost and the formula for price, such that:

$$\begin{aligned}P &= MC \\80 - 2Q &= 20 \\60 &= 2Q \\Q &= 30\end{aligned}$$

- (b) Monopoly restricts output to raise price. The monopolist, therefore, does not obey a market price. Instead, the monopolist produces where  $MR = MC$ . This is because they are **price-setters**. As a price setter, they choose to sell up until it is no longer profitable (that threshold is when marginal cost exceeds the marginal revenue, after producing a certain quantity of goods). Contrarily, competitive firms always produce where  $P = MC$ .
- (c) Deadweight loss (DWL) represents mutually beneficial trades that do not occur because monopoly restricts output below the efficient level. The DWL is therefore the consumer's loss, or lack of consumer surplus that dissolves where the price is inefficient (i.e. above the market price).

## Problem 4: Perfect Competition

### Solution 4

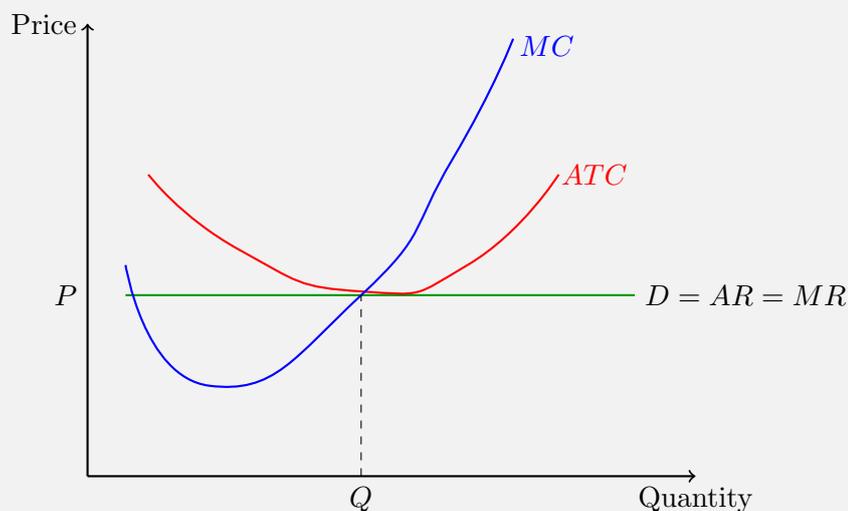
(a) Marginal cost from the first derivative is:

$$\begin{aligned} MC &= \frac{d}{dQ}(100 + 5Q + Q^2) \\ &= 5 + 2Q \end{aligned}$$

In words, the marginal cost tells us, when we are producing a certain quantity of goods,  $Q$ , how much does it cost to make that *final unit of the good*? This means if  $Q = 10$ , so the firm produces 10 goods, the marginal cost of the tenth good is  $5 + 2(Q) \equiv 5 + 2(10) = 25$ . Now, what if the firm produced 5 goods?  $5 + 2(5) = 15$ . So:

- when you produce 5 units of a good  $\Rightarrow$  the fifth unit (last unit) costs \$15 to produce
- when you produce 10 units of a good  $\Rightarrow$  the tenth unit (last unit) costs \$25 to produce

This is increasing marginal cost. This is very common and can be seen in a typical marginal cost curve graph.



(b) Profit maximizing output for a competitive firm is:

$$P = MC \rightarrow 20 = 5 + 2Q \equiv 15 = 2Q \rightarrow Q = 7.5$$

(c) Profit

$$\begin{aligned} TR &= 20(7.5) = 150 & TC &= 100 + 5(7.5) + (7.5)^2 \equiv 193.75 \\ \text{solving for profit: } & & \pi &= 150 - 193.75 = -43.75 \end{aligned}$$

## Problem 5: Oligopoly

### Solution 5

- (a) An oligopoly is a market structure with only a small number of firms, where each firm's decisions affect the profits of the others. Firms are interdependent.
- (b) Interdependence means that each firm's decisions about price and output affect the profits of rival firms.
- (c) Firms may attempt **tacit collusion** to keep prices high and avoid price competition. Tacit collusion is one form of strategic behavior, whereby firms are taking into account the effects of their actions on the future actions of other people. When firms limit output and raise prices, acting *as if* they had actually sat down and signed an enforceable agreement, we call this tacit collusion. This raises one another's profits. Even though this is not formalized, its possible to make choices based on the other few firms in the market and therefore commit tacit collusion.

## Problem 6: Game theory in imperfect competition

### Solution 6

- (a) A Nash equilibrium occurs when each player's strategy is optimal given the strategy chosen by the other player. It's also known as a noncooperative equilibrium, resulting when a player chooses to maximize their own payoff, sometimes at the cost of others. They are not interested in the effects that their choice will have on the **payoffs** of the other players.
- (b) Firms compete because the option of cheating provides higher profits regardless of what the rival does. Therefore, they could cooperate and do better than compete strictly. But the possibility of cheating makes it more profitable (in the absence of punishment). Recall that cheating in the short run may increase profits, but over time, the sellers may be putting each other out of business. They may choose to punish one another - go tit for tat - or they may try to start a price war - driving prices very low.
- (c) Repeated interaction allows strategies such as tit-for-tat to punish cheating and sustain cooperation. Recall in a tit-for-tat game players cooperate at first, then they do whatever the player did in the previous period. This strategic behavior can lead to a price war, and is often worse for the firms that engaging in cooperation.

## Problem 7: Trade

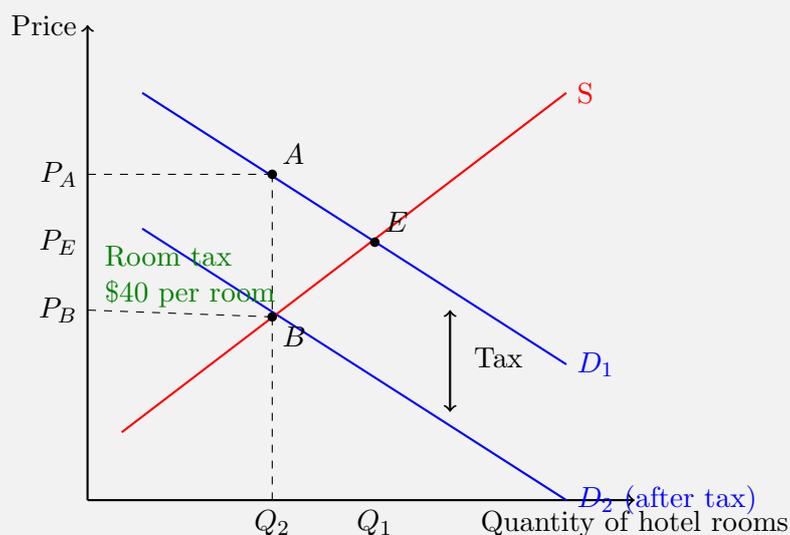
### Solution 7

- (a) A tariff is a tax on an imported good. Consumer surplus decreases because the tax causes domestic prices rise.
- (b) When a tariff is imposed, the imported price increases. Producers domestically sell at that price. Producer surplus therefore increases because domestic producers receive the higher price.
- (c) Tariffs reduce total surplus by preventing mutually beneficial trades, creating dead-weight loss (DWL).

## Problem 8: Taxes

### Solution 8

- (a) An excise tax is a tax on a sale of a good or service. A tax shifts the supply curve upward, raising the price buyers pay. The quantity demanded and supplied decreases. This is because the tax raises the cost on either the consumer or producer. The slopes of the demand and supply curve give us the incidence, or the *burden of taxation* (i.e. who foots the bill). Because of this, we know that the price faced by both the consumer and producer go up, but by how much depends on the tax incidence.



- (b) Deadweight loss is the loss of **total surplus** due to mutually beneficial trades that no longer occur because of the tax. When a tax is imposed and the demand shifts down, then less people may make purchases that would make them happier. Therefore, DWL here is equal to that loss.
- (c) When demand is elastic, quantity falls more in response to a tax, increasing the size of deadweight loss. Recall elastic means more horizontal on the graph, and therefore the DWL triangle grows as demand is more elastic. This DWL is from the tax.

## Problem 9: Externalities

### Solution 9

- (a) A negative externality occurs when a firm or individual imposes an uncompensated cost on others. Externalities can be a reason why markets break down (fail). Recall a negative externality = external cost. A key negative externality is pollution. While the producer makes a good that he sells (good for the consumer!) there is an additional cost (poor health outcomes) that are born by the public. This imposition of a cost across the public is *external*.<sup>a</sup>
- (b) Markets may produce inefficient outcomes because private decision makers ignore external costs. Simply put, if a producer does not have to pay for something - pollution - he does not factor it into his optimization problem. So if he's in a competitive market, he produces where  $MC = P$ . If he is in a monopolist market, he produces where  $MC = MR$ . The *social cost* is not the *private cost*. The market outcome is inefficient.
- (c) Policies such as emissions taxes or cap-and-trade systems can internalize the external cost and reduce pollution efficiently. Emissions taxes are Pigouvian taxes, such that the government identifies the optimal quantity of emissions, or the socially optimal amount, and then charges the producers a tax that allows the equilibrium to reach this socially optimal quantity.

---

<sup>a</sup>If you are interested in the first case of an economist thinking about how to solve the issue of negative externalities, read Ronald Coase (1962) where Coase proposes when property rights are well defined, it is easy to rectify negative externalities. Now, in the case of climate change, you can see how this theorem breaks down. Do you have a right to clean air? What about future you? Does future you have a right to a planet with limited temperature rise? These questions devolve quickly into hypothetical cases with complex consideration coming from philosophy, politics and even biology.

# Final Exam Review Worksheet

## ECON 1-01

**TA:** Allegra Saggese  
**Date:** March 17, 2026

**Professor:** KC Fung  
**Topic:** Final Exam Review

*These questions were designed with the help of AI (ChatGPT). The questions are also based on KC Fung's lecture slides and Krugman & Wells, primarily chapters 11-14.*

### Problem 0: Market structures and demand curves

#### Solution 0

- (a) The horizontal demand curve corresponds to a perfectly competitive firm because the firm is a price taker and can sell any quantity at the market price.

The slightly downward-sloping demand curve corresponds to a monopolistically competitive firm. Firms sell differentiated products and therefore have some market power, but competition from close substitutes makes demand relatively elastic.

The steeper downward-sloping demand curve corresponds to a monopolist. A monopolist is the sole seller of a good with no close substitutes and therefore faces the entire market demand curve.

- (b) The demand curve facing a perfectly competitive firm is horizontal because the firm is a very small part of the overall market. If it tried to charge a higher price than the market price, consumers would purchase from other firms. Therefore the firm takes the market price as given.
- (c) Monopolists and monopolistically competitive firms face downward-sloping demand curves because they sell differentiated products and therefore have some degree of market power. If they increase price, the quantity demanded for their product decreases.

## Problem 1: Profit maximization

### Solution 1

- (a) Firms maximize profits by producing the quantity of output where marginal revenue equals marginal cost:

$$MR = MC$$

At this point the additional revenue from producing one more unit equals the additional cost of producing it.

- (b) The main revenue and cost concepts are:

$$TR = P \times Q$$

$$TC = FC + VC$$

Total revenue ( $TR$ ) is the total amount of money the firm receives from selling its output.

Total cost ( $TC$ ) is the sum of fixed costs and variable costs.

Fixed costs ( $FC$ ) do not change with output, while variable costs ( $VC$ ) increase as production increases.

Average total cost is:

$$ATC = \frac{TC}{Q}$$

- (c) If a firm produces where  $MR = MC$  but finds that

$$P < ATC$$

then the firm is making an economic loss. The revenue per unit is less than the total cost per unit of production.

## Problem 2: Monopoly behavior

### Solution 2

- (a) Marginal revenue lies below the demand curve because when a monopolist lowers price to sell an additional unit, the lower price applies to all units sold. Therefore the extra revenue from selling one more unit is less than the price.
- (b) In perfect competition firms produce where

$$P = MC$$

In monopoly the firm produces where

$$MR = MC$$

Since  $MR < P$  for a monopolist, the monopolist produces less output and charges a higher price than a perfectly competitive market.

- (c) Deadweight loss occurs because the monopolist restricts output below the socially efficient level. Some mutually beneficial trades between buyers and sellers do not occur.

## Problem 3: Monopolistic competition in the long run

### Solution 3

- (a) When firms earn positive economic profits, new firms are attracted to the market because they want to earn similar profits.
- (b) Entry of new firms increases competition and reduces the demand faced by each existing firm. As a result the firm's demand curve shifts leftward.
- (c) In long-run equilibrium entry continues until economic profits are zero. This occurs when:

$$P = ATC$$

However the firm still has some market power because the demand curve is downward sloping. Therefore:

$$P > MC$$

## Problem 4: Excess capacity

### Solution 4

- (a) Excess capacity occurs when a firm produces less output than the level that minimizes average total cost.
- (b) Monopolistically competitive firms produce less than the efficient scale because they face downward-sloping demand curves. They choose output where  $MR = MC$ , which occurs at a quantity smaller than the minimum of the ATC curve.
- (c) Perfectly competitive firms produce at the minimum of the ATC curve in long-run equilibrium because entry and exit drive profits to zero and firms operate at the most efficient scale.

## Problem 5: Price discrimination

### Solution 5

- (a) Perfect price discrimination occurs when a monopolist charges each consumer a price equal to that consumer's willingness to pay.
- (b) Perfect price discrimination eliminates deadweight loss because the monopolist sells the good to every consumer whose willingness to pay is greater than marginal cost.
- (c) Under perfect price discrimination consumer surplus is reduced to zero and all surplus becomes producer surplus.

## Problem 6: Herfindahl–Hirschman Index

### Solution 6

- (a) The HHI is calculated by squaring the market shares and summing them:

$$\begin{aligned} HHI &= 40^2 + 30^2 + 20^2 + 10^2 \\ &= 1600 + 900 + 400 + 100 \\ &= 3000 \end{aligned}$$

- (b) The HHI measures the level of concentration in a market. Larger values indicate a more concentrated industry.
- (c) Antitrust authorities use the HHI to evaluate mergers and market power. If a merger substantially increases the HHI, regulators may investigate or block the merger.

## Problem 7: Oligopoly and strategic behavior

### Solution 7

- (a) An oligopoly is a market structure with a small number of firms. Firms are strategically interdependent because the actions of one firm affect the profits of others.
- (b) Firms may attempt tacit collusion in order to maintain higher prices and earn larger profits.
- (c) Collusion may break down because each firm has an incentive to cheat by lowering price to gain market share. This creates a prisoner's dilemma situation.

## Problem 8: Network externalities

### Solution 8

- (a) A network externality occurs when the value of a product increases as more people use it.
- (b) Network effects can create market power because consumers prefer platforms with larger user bases.
- (c) First-mover advantage occurs because an early entrant can attract many users, making it difficult for competitors to enter later.

## Problem 9: Taxes and deadweight loss

### Solution 9

- (a) An excise tax increases the price paid by consumers and reduces the price received by producers. Consumer surplus and producer surplus both decrease while the government collects tax revenue.
- (b) Deadweight loss represents the value of mutually beneficial trades that no longer occur because the tax increases the price and reduces the quantity traded.
- (c) Deadweight loss becomes larger when demand is more elastic because quantity responds more strongly to the tax.