Chapter 1

Cost and Benefit Analysis

Economics is about the study of decisions. Decisions are everywhere in our daily life. Assume that decision-makers have a single well-defined objective, the guiding principle to decisions for the maximization of such objective is the cost and benefit principle.

In this chapter, we will start with an illustration of the simple cost and benefit principle, and then many extension and applications of the principle under different scenarios. Variants of these applications will be seen repeatedly in later chapters.

1.1 Should we enlarge the class size?

Consider the choice of class size of an introductory microeconomics course. Suppose we are considering two different class sizes: a big section of 300 students or 12 sections of 25 students. If we do not consider the cost at all, most of us will prefer the class size of 25 because other things equal, a smaller class will allow better interaction among the students and professors, and therefore better learning outcomes. Of course, the costs of the two different class sizes are not the same. It is generally more costly to have smaller classes!

For the sake of illustration, let's ignore the cost of equipment and venue (i.e., assume that it is zero) and focus on the cost of hiring instructors. Suppose the cost of hiring an instructor to teach a section is \$90,000. Hiring one instructor to teach a section of 300 implies an average cost of \$300 per student. Hiring instructors to teach 12 sections of 25 students implies an average cost of \$3,600 per student. University administrators and students must consider this trade-off of choosing class sizes: For better learning outcome, we have to pay a higher cost per student.

We have to consider the trade-offs in making this decision because *resources are scarce and we have unlimited wants*, i.e. that available resource is not enough to fulfill all of our wants. In this example, the resources will be the budget of the university, and our budget for studying. If we want to have smaller classes, we must contribute more resources. If we want to save resources, we must have larger classes. In short, there is simply no free lunch.

The Scarcity Principle (also called no-free-lunch principle)

Our boundless wants cannot be satisfied with limited resources. Therefore, having more of one thing usually means having less of another.

When the amount of resources is more than enough to meet our wants, we need not give up another activity when taking on an activity. In other words, if the resources are not scarce, we can choose to do an activity at no cost. Since there is no trade-offs, there is no need to make decisions at all. Unfortunately, for most of us, resources are scarce and consequently we must make choices. Of course, one may say that some people are so rich that they are not financially constrained at all. However, we are born equal in the following sense: we all have 24 hours a day! Given this fixed amount of resources (i.e., time), every day, rich people face the similar choices as I do. "How much time should I spend on studying, how much time on sleeping and how much time on many other activities?"

Microeconomics is the study of how people make choices. We try to understand how people make choices in many different kinds of situations. With a good understanding of how people make their decisions,

1. we will be able to make better decisions ourselves.
2. we can predict other people's behavior if we foresee some of the constraints are going to change in the future.
3. we can design better policies that modify people's behaviors.

The beauty of economics is that we are able to predict and formulate policies based on a very small set of assumptions about individuals. The first assumption is rationality.

Definition. *An individual is said to be* ***rational*** *if the person has well-defined goals and thus try to fulfill them as best as possible.*

For firms, we assume that they pursue profits. For consumers, we assume that they pursue happiness or satisfaction.

The guiding principle that helps a rational agent to maximize his well-defined objectives or goals is the so called cost-benefit principle.

Definition. *The* ***Cost-Benefit Principle*** *says a rational individual (or a firm or a society) should take an action if, and only if, the extra benefits from taking the action are at least as great as the extra costs.*

Should I do activity** x**?

Define $C(x)$ = the costs of doing x; $B(x)$ = the benefits of doing x.

If $B(x) \geq C(x)$, do x; otherwise don't.

A note about the weak inequality. The weak inequality implies that if $B(x) = C(x)$, we would do activity x. When $B(x) = C(x)$, in fact, there is no benefit of doing activity x, why do x then? Note, if use strictly inequalities instead, we would say do x if $B(x) > C(x)$; do not do x (do something else) if $B(x) < C(x)$. If so, we would have no decision when $B(x) = C(x)$. To make the decision complete (i.e., either yes or no) and to avoid the undecidedness, we have chosen to use the weak inequality here.

To apply the principle, the first step is to identify the action under consideration. The second step is to estimate the cost and benefit associated with the action. Finally, the decision is made by comparing the cost and benefit.

Consider the choice of optimal class size. Suppose the current class size is 25. We consider whether to make the class size larger, say, to 300. *The action is to make the class size larger from 25 to 300.* Moving from a class size of 25 to 300, the instructor to student ratio is lowered. Consequently, the cost per student is lowered, the instruction quality will worsen.

The benefit of the action is a reduction in the cost per student. Suppose the faculty salary to teach a course is \$90,000 and the cost of equipment is negligible. Then, the cost per student is \$300 for the class size of 300 and \$3600 for the class size of 25. Thus, the benefit of the action is a saving of \$3300 $(= 3600 - 300)$ per student.

The cost of the action is the reduction in instruction quality. In order to compare the cost and benefit, we need to use the same unit of measurement. Since the benefit is in monetary units, it would be convenient to express the cost in the monetary units as well. Thus, we would like to convert the subjective feeling of reduction in instruction quality into monetary terms.

How to estimate the benefit? Let's start with a simple example. Imagine that action x is to pick up a \$10 bill. Suppose you do not have to pick up the bill in person, however. If you send someone to pick up the \$10 bill, you will have to pay someone \$$y$.

What is the benefit of this action? \$10, obviously. What is the maximum you are willing to pay someone to pick up the bill? We know that you are willing to do so as long as y is less than or equal to 10. So, the maximum you are willing to pay someone to pick up the bill is \$10, i.e., $y = 10$. Thus, the maximum you are willing to pay someone to pick up the \$10 bill can be interpreted as an estimate of your benefit from the action.

Suppose there is a parcel to pick up. You are willing to pay someone a maximum of \$$y$ to pick it up. We can infer that your benefit from picking up the parcel is \$$y$.

How to estimate the cost? Suppose the cost of picking up a check is \$10. What is the smallest check that will attract you to take this action? We know that you are willing to do so as long as the benefit is larger than or equal to \$10. Thus, the minimum benefit required to induce us to pick up the check is \$10. It is obviously, then, we can estimate the cost of action by the minimum benefit required to induce us to take action.

Back to the class size example. From the discussion above, one way to obtain an estimate is to ask the maximum amount you is willing to pay to avoid a switch from a class of 25 to a class of 300.[1] Equivalently we can obtain an estimate with the following steps.

[1] Alternatively, we can also obtain an estimate by asking the minimum amount you must receive to agree to a switch. Under some conditions, the two estimates are close to each other.

1. Start with a big z.
2. Ask the question: Are you willing to pay z dollars to avoid a switch?
3. If the answer is "no", z is lowered slightly and repeat step 2. If the answer is "yes", we stop. The last z will be the maximum amount you are willing to pay to avoid the switch.

Once we obtain estimates of both cost and benefit of the action, we are ready to make a decision. Of course, the cost differs across individuals. Consequently, given the benefit, we expect different individuals to make different choices. If their cost is lower than \$3300, they will choose to switch to the class size of 300; otherwise they will choose the class size of 25. Even without a survey, we can use our common sense to guess who are more likely to have a higher cost. Those who are less financially constrained will be willing to pay more to avoid a switch, and so are those who are less disciplined and who are more used to learning in a small class setting.

In a real world, we observe a spectrum of universities and colleges with different class sizes. The ones with smaller class sizes charge a higher tuition fee than the ones with larger class sizes, reflecting the trade-off we discussed earlier. Students sort themselves into universities and colleges of different class size according to their "cost". Those who are less financially constrained are more likely to attend universities with smaller classes.

Example. Should you turn off the alarm?

It is Saturday 7:00AM. The alarm is ringing. You are lying in your comfortable bed. You realize this is Saturday and you do not have to go to work. Normally you would have set the alarm off on Friday night but you forgot. If you do nothing, the alarm will die in 5 minutes. Should you leave your comfortable bed and turn off the alarm or to wait it out?

Here, the action being considered is "leave your comfortable bed and turn off the alarm". The benefit is removing the annoying alarm ring. The cost is to leave your comfortable bed. In order to make a decision using the cost-benefit principle, we will need to estimate the cost and benefit of the action, in the same unit of measurement. The cost, $C(x)$, can be estimated by the minimum amount it would take to get you out of your comfortable bed. For example, $C(x) = \$10$ means that if someone pays you \$10, you will be just happy to leave your comfortable bed. The benefit, $B(x)$, can be estimated by the maximum you would be willing to pay someone to turn off the alarm. For example, $B(x) = \$100$ means that if someone offers to help turn off the alarm but charges you any amount less than or equal to \$100, you will be willing to take the offer. Given $C(x) = 10$ and $B(x) = 100$, cost-benefit principle suggests that you should leave your comfortable bed and turn off the alarm yourself because $B(x) > C(x)$.

One can also understand the decision above by imagining a conversation with a third person. After obtaining $C(x)$ $(= 10)$ and $B(x)$ $(= 100)$ from you, he says he is willing to help you turn off the alarm and charge you \$100. After receiving \$100 dollar from you, he hires you to turn off the alarm and pay you \$10. This third person ends up gaining \$90 and you were just happy enough to have traded with him. Of course, that third person can be yourself and you will gain an equivalent of \$90

$(= B(x) - C(x))$ by getting out of your comfortable bed and turning off the alarm. In fact, $B(x) - C(x)$ is called the **economic surplus** of taking action x.

Definition. ***Economic Surplus*** *is the benefit of taking any action minus its cost, i.e.,* $ES(x) = B(x) - C(x)$.

Using the definition of economic surplus, the cost-benefit principle can be re-stated as "a rational individual (or a firm or a society) should take an action if, and only if, the economic surplus of taking the action is larger or equal to zero."

In the alarm example, if $C(x) = 150$ and $B(x) = 100$, we will have $B(x) - C(x) = -50$. Obviously, the third person will not be interested in the trade with you, offering to help turn off the alarm by charging you a fee of \$100 and hiring you to turn off the alarm by paying you a fee of \$150. Consequently, you will remain in bed and wait it out.

1.2 We do not use cost-benefit analysis for every decision, do we?

It is not difficult to find the use of cost-benefit analysis in various discussions of public decisions. Below are some examples.

1. "China cannot afford to ignore the energy potential of its rivers - nor the human costs of forced resettlement and the impact of exploitation of the environment and water resources. A balance between social **cost and benefit** demands transparency."[2]

2. "Sally Wong, executive director of Hong Kong Investment Funds Association, said the fund industry in principle welcomed measures to enhance transparency and let employee have a choice, but we also have to achieve balance between **cost and benefit** of any proposed changes."[3]

Nevertheless, critics argue that we do not really use cost-benefit analysis to make decisions. Nobody will compute the cost and benefit of getting out of his/her comfortable bed and turn off the alarm!

The key is not whether one uses cost-benefit analysis consciously in making decisions but that we are making decisions **as if** we were using cost-benefit analysis. The act of riding bicycle is guided by the principles of physics, so is the use of chopsticks in a Chinese cuisine. When we ride bicycle or use chopsticks, do we perform a lot of calculations according to the principles of physics? Of course not. However, we are riding bicycle as if we are using the principles of physics. Similarly, a good cook is guided by the principles of chemistry and biology. Although a good cook may never learn chemistry and biology, she is cooking as if she has learned such subjects. Nevertheless, studying the chemistry and biology principles of cooking can help improve the cooking of an ordinary cook. In short, while we may not be making cost and benefit calculations consciously, we act as if we had done such calculation for most decisions. If we fail to act according to cost-benefit principle, we will be penalized. Then, we will either learn from the experience and avoid similar mistakes in the future or become extinct very

[2] South China Morning Post EDT14 | EDT | editorial 2008-02-27, "Rush to development demands transparency"

[3] South China Morning Post EDT1 | EDT | By ENOCH YIU 2007-05-16, "Pension boss wants to give employees choice"

soon. In fact, our casual observation suggests that even beggars might have acted as if they know the cost-benefit principle.

Is rationality a realistic assumption?

Treat rationality as a working assumption and the cost-benefit analysis as a guiding principle. We should judge the assumption and the principle by its usefulness in explaining and predicting real world phenomena.[a]

[a]For further discussions, see Friedman, M. "The Methodology of Positive Economics," *Essays In Positive Economics*, Univ. of Chicago Press, Chicago, 1953.

Example. Even beggars are rational

We often see beggars at busy streets, such as those at Causeway Bay or Star Ferry but not in country parks or deserts. The major cost of begging is time. Causeway Bay has a much higher traffic of people and thus begging at Causeway Bay will get a good return, say, \$1000 per day. In stark contrast, country parks have only few passerbys, and thus begging at country parks will get only little return (say, \$10 per day), if any. Imagine that at the very beginning beggars spread out across the territories, i.e., some at Causeway Bay and some at country parks. Periodically, the beggars might review the decision of whether to switch their begging locations. Consider a beggar initially located at Causeway Bay. She considers whether to switch from Causeway Bay to a country park. Switching from Causeway Bay to a country park will lower the return by \$990 ($= 1000 - 10$). That is, the benefit is $-\$990$ ($= 10 - 1000$). The cost is zero since the same amount of time is used. Since the benefit is less than the cost, the beggar will stay at Causeway Bay. Now consider another beggar initially located at a country park. He considers whether to switch from a country park to Causeway Bay. Switching from Causeway Bay to a country park will raise the return by \$990 ($= 1000 - 10$). That is, the benefit is \$990 ($= 1000 - 10$). The cost is zero since the same amount of time is used. Since benefit is higher than cost, the beggar will move to Causeway Bay. Thus, both beggars will end up at Causeway Bay.

It is also possible that the beggar initially located at the country park does not act according to the cost-benefit principle and chooses to stay at the country park. At the end, he will fail to gather enough food and hence starve to death. That is, the penalty due to the failure to follow cost-benefit principle can be so big that the beggar at the country park goes extinct and the one at Causeway Bay thrives.

1.3 Opportunity cost

The principle of cost and benefit is easy to understand but its applications are not so simple. The difficulty lies in the estimation of cost and the estimation of benefit.

Often, there are costs and benefits we should included but most of us fail to include them. There are costs and benefits we should ignore but we include them by mistake. Needless to say, mistakes made in the estimation of costs and benefits can lead to wrong decisions.

Here we focus on the discussion of costs. Similar logic will apply to the discussion of benefits.

Example. Should you go wind-surfing today?

Stanley Main Beach Water Sports Centre is not too far away from HKU (within 45 minutes by bus). At Stanley, we can do all sorts of water sports including wind-surfing. From experience you can confidently say that a day at Stanley is worth \$500 to you. The charge for the day is \$100 (which includes bus fare and equipment). Based on this information, we will likely conclude from cost-benefit analysis that we should go wind-surfing:

$$B(x) = \$500;\ C(x) = \$100; \qquad B(x) > C(x).$$

However, in most cases, the explicit cost of \$100 (charge for the day) is not the only cost of going wind-surfing. You must also take into account the value of the most attractive alternative you will forgo by heading for Stanley.

Suppose that if you do not go wind-surfing, you will work at your new job as a research assistant for one of your professors. The job pays \$450 dollars per day, and you like it just well enough to have been willing to do it for free. "Should I go wind-surfing or stay and work as a research assistant?"

Going wind-surfing means that we have to forgo the \$450 salary from the RA job. Thus, we should add \$450 to the cost.

$$B(x) = \$500;\ C(x) = \$100 + 450 = \$550; \qquad B(x) < C(x).$$

Hence, we should not go wind-surfing.

The example shows the importance to consider the forgone alternative in making decisions. If we fail to take into account the alternative forgone, we will be making a very different decision.

Definition. ***Opportunity cost*** *of an activity is the value of the next best alternative that must be forgone in order to undertake the activity.*

Opportunity cost, though important, is often forgotten in doing cost-benefit analysis. The following example is a very good check of our understanding of the concept of opportunity cost.

Example. The opportunity cost of seeing Eason Chan

You won a free ticket to see a concert by Eason Chan, a local pop singer. You cannot resell it (say, your photo ID will be checked at entrance). Yo-Yo Ma, the world's finest cellist, is performing on the same night and is your next-best alternative activity. Tickets to see Yo-Yo Ma cost \$800 each. On any given day, you would be willing to pay up to \$1000 to see Yo-Yo Ma. Assume there are no other costs of seeing either performer. Based on this information, what is the opportunity cost of seeing Eason Chan?

(A) \$0. (B) \$200. (C) \$800. (D) \$1000.

The correct answer should be (B) \$200.

It is not surprising to see students failing to get the correct answer. Indeed, a similar version of this question was given to economists with postgraduate training in a conference. Less than 25% of the respondents got it correct, worse than having a chimpanzee randomly selecting one of the four options. The survey result shows how difficult the concept of opportunity cost could be.

To illustrate the answer, let's consider several modified examples step by step. This is our usual approach to solve a difficult problem. We try to modify/simplify the setup so that the answer will become obvious. After having a good understanding of the simpler problem, we gradually add features back towards the original problem and see how we can solve the original problem.

Let's start by considering the case when we do not have to pay to attend the concert of Yo-Yo Ma.

Example. The opportunity cost of seeing Eason Chan (special case I)

You won two free tickets to see the concerts by Eason Chan, a local pop singer, and Yo-Yo Ma, the world's finest cellist. You cannot resell the tickets (say, your photo ID will be checked at entrance). They are performing on the same night. You would be willing to pay up to $1000 to see Yo-Yo Ma. Assume there are no other costs of seeing either performer. Based on this information, what is the opportunity cost of seeing Eason Chan?

(A) $0. (B) $200. (C) $800. (D) $1000.

The answer should be obvious. To see Eason Chan, we have to give up the alternative of Yo-Yo Ma, which is worth $1000 to us. Thus, the answer should be (D) $1000.

Now let's modify this question so that we have to pay $1000 to collect a check of $1000.

Example. The opportunity cost of seeing Eason Chan (special case II)

You won a free ticket to see a concert by Eason Chan, a local pop singer. You cannot resell it (say, your photo ID will be checked at entrance). There is an opportunity for you to pick up a check of $1000 at the city hall. The ticket to enter the city hall costs $1000. Assume there are no other costs of either seeing Eason Chan or picking up the check. Based on this information, what is the opportunity cost of seeing Eason Chan?

(A) $0. (B) $200. (C) $800. (D) $1000.

Note that the check is worth $1000 but we have to pay $1000 to enter the city hall to obtain the check. What do we get by picking up the check? $0! So, the opportunity cost of seeing Eason Chan is (A) $0.

Now let's modify this question so that it looks more like the original question – we have to pay $1000 to see Yo-Yo Ma.

Example. The opportunity cost of seeing Eason Chan (special case III)

You won a free ticket to see a concert by Eason Chan, a local pop singer. You cannot resell it (say, your photo ID will be checked at entrance). Yo-Yo Ma, the world's finest cellist, is performing on the same night and is your next-best alternative activity. Tickets to see Yo-Yo Ma cost $1000. On any given day, you would be willing to pay up to $1000 to see Yo-Yo Ma. Assume there are no other costs of seeing either performer. Based on this information, what is the opportunity cost of seeing Eason Chan?

(A) $0. (B) $200. (C) $800. (D) $1000.

Seeing Yo-Yo Ma is worth $1000 to us but we can see Yo-Yo Ma only if we pay $1000. Doesn't it look like the last example of picking up a check? Yes. The opportunity cost of seeing Eason Chan is (A) $0, again.

By now, you must be getting bored. But, let's modify this question once again so that we have to pay $800 to pick up a check of $1000 at the city hall. Yes, the numbers are chosen to look like those in the original question.

Example. The opportunity cost of seeing Eason Chan (special case IV)

You won a free ticket to see a concert by Eason Chan, a local pop singer. You cannot resell it (say, your photo ID will be checked at entrance). There is an opportunity for you to pick up a check of $1000 at the city hall. The ticket to enter the city hall costs $800. Assume there are no other costs of either seeing Eason Chan or picking up the check. Based on this information, what is the opportunity cost of seeing Eason Chan?

(A) $0. (B) $200. (C) $800. (D) $1000.

Note that the check is worth $1000. We have to pay $800 to enter the city hall to obtain the check. What do we get by picking up check? $200! So, the opportunity cost of seeing Eason Chan is (B) $200.

Now the answer to the original question should be obvious. The answer should be (B) $200. To attend the Eason Chan concert, we have to give up attending the Yo-Yo Ma concert. While we are willing to pay $1000 to see Yo-Yo Ma, the cost of ticket is $800. Thus, seeing Yo-Yo Ma is worth $200 to us.

Learn this general approach of solving similar difficult problems – not just how to compute opportunity cost for one or two specific questions.

An approach to solve difficult problems

When we have difficulty in understanding a concept or solving a problem, it is always useful to construct a simpler example, of which we are sure of the answer. Then, we can gradually build on it the more complicated features in the original problem. Then, we will be able to understand the original more complicated problem.

1.3.1 Monetary expenditure or explicit cost should be counted as an opportunity cost

It is often a confusion that opportunity cost includes only cost that we do not pay explicitly. Is the thirty dollar I pay for coffee an opportunity cost?

Example. Is the thirty dollar I pay for coffee an opportunity cost?

Consider the following four scenarios:

1. We have one hour. We can do one of the following two things. (A) To see a movie which is free at Global Lounge, or (B) To work as a research assistant which pays \$50 per hour (assume zero psychic cost). What is the opportunity cost of seeing the movie? If we see the movie, we cannot use the time to do the research assistant work. So, the opportunity cost of seeing the movie is the research assistant work that we can do. Saying the opportunity cost is the research assistant work is not convenient. We would like to translate it into monetary terms. Since one hour of research assistant work pays \$50, we translate the opportunity cost as \$50.

2. We have some resources. We can use the resources to do one of the following two things. (A) To exchange for a cup of coffee at Starbucks, or (B) To exchange for a set meal at Oliver Sandwich. What is the opportunity cost of having a cup of coffee? If we drink a cup of coffee, we cannot have the set meal. So, the opportunity cost of a cup of coffee is a set meal at Oliver Sandwich. Again, we want to translate the opportunity cost into monetary terms. Suppose we are willing to pay \$40 dollars for the set meal. Then, we say the opportunity cost is \$40.

3. We have some resources. We can use the resources to do one of the following two things. (A) To exchange for a cup of coffee at Starbucks, or (B) To exchange for a set meal at Oliver Sandwich. What is the opportunity cost of having a cup of coffee? If we drink a cup of coffee, we cannot have the set meal. So, the opportunity cost of a cup of coffee is a set meal at Oliver Sandwich. Again, we want to translate the opportunity cost into monetary terms. Suppose we are not given the information how much we are willing to pay for the set meal, but we are told a set meal costs \$30. What is our best guess/estimate of the opportunity cost? The best guess/estimate is \$30.

4. We have \$30. We can use the money to buy one of the following two things. (A) a cup of coffee at Starbucks, or (B) a set meal at Oliver Sandwich. What is the opportunity cost of having a cup of coffee? If we drink a cup of coffee, we cannot have the set meal. So, the opportunity cost of a cup of coffee is a set meal at Oliver Sandwich. Again, we want to translate the opportunity cost into monetary terms. We are not given information how much we are willing to pay for the set meal. The only information we have is that the set meal costs \$30. Then, our best estimate of the opportunity cost of a cup of coffee is \$30.

Of course, there is no need to do the translation in case (4). However, the example shows clearly that the money we pay for a cup of coffee should be interpreted as the opportunity cost of a cup of coffee.

These examples clearly illustrate that estimation of opportunity cost depends on the information provided in the question. To reinforce our understanding, let's consider an additional example.

Example. What is the opportunity cost of a bottle of wine?

Consider the following four scenarios and see their equivalence:

1. We pay \$500 for a bottle of wine, and if no other information is provided, then the opportunity cost is \$500 because \$500 can be used to buy something that is of value \$500.

2. We pay \$500 for a bottle of wine, and if we could have use the same amount to buy a pair of shoes and we normally are willing to pay \$900 for the shoes, then the opportunity cost is \$900 because \$500 can be used to buy something that is of value \$900 to you.

3. We have one coupon. We can use it to exchange for a bottle of wine or a check of \$500. The opportunity cost of a bottle of wine is \$500.

4. We have one coupon. We can use it to exchange for a bottle of wine or a pair of shoes. Normally, you will be willing to pay up to \$900 for the pair of shoes. The opportunity cost of a bottle of wine is the value of a pair of shoes, or \$900.

From the example, we can easily see the equivalence of scenarios (1) and (3), and the equivalence of (2) and (4). Sometimes, we are confused. Confusion is natural in the process of learning. When confused, again, try to modify the example into something that we can conclude clearly. In the above example, we essentially treat the 500-dollar bill as a coupon (a piece of paper). A coupon allows us to exchange for check of \$500 is essentially a 500-dollar bill. Such modification may look trivial but it does allow us to see why the opportunity cost of a bottle of wine is \$500 when we are only told we pay \$500 for a bottle of wine, and why the opportunity cost of a bottle of wine is \$900 when we are only told we pay \$500 for a bottle of wine and the \$500 can be used to buy a pair of shoes that is worth \$900 to us. While we are still paying \$500 for the same bottle of wine, the additional information changes our estimation of opportunity cost.

$$\begin{tikzcd}
\boxed{\text{A pair of shoes}} & & \boxed{\text{A bottle of wine}} \\
& \boxed{\text{Coupon}} \arrow[ul] \arrow[ur] &
\end{tikzcd}$$

1.3.2 Count only the items that are affected by the decision

A common mistake students make is to count all the "cost" information provided in the question but in fact some of the cost should be excluded (ignored).

Consider the following pairs of scenarios.

1. *There is an opportunity for you to pick up a check of* \$1000 *at the city hall. The ticket to enter the city hall costs* \$800*. Should you pick up the check?*
   The answer is obviously YES. YES because the benefit of \$1000 is larger than the cost of \$800.

2. *You spend* \$300 *on meals every day. There is an opportunity for you to pick up a check of* \$1000 *at the city hall. The ticket to enter the city hall costs* \$800*. Should you pick up the check?*
   It looks like we should treat \$300 on meals as a cost. Yes, the \$300 is a cost but not a cost of the action or decision at question. If we pick up the check, we get \$1000; if we do not pick up the check, we do not get \$1000. The benefit of picking up a check is then \$1000. If we pick up the check, we have to pay \$800 to purchase the ticket to enter the city hall; if we do not pick up

the check, we do not need to enter the city hall and thus do not need to incur \$800. The \$300 on meals is not affected by our decision and thus should not be included in the analysis. Thus, our conclusion will be to pick up the check, and get an economic surplus of \$200 (= \$1000 – \$800). If we had wrongly included the cost of meals as a cost in the cost and benefit analysis, we would have ended up with a benefit (\$1000) smaller than the cost (\$800 + \$300) and thus would have concluded not to pick up the check. Making such mistake is costly – an economic surplus of \$200.

Consider another group of scenarios.

1. *There is an opportunity for you to pick up a check of \$1000 at the city hall. The ticket to enter the city hall costs \$1200. Should you pick up the check?*
   The answer is obviously NO. NO because the benefit of \$1000 is less than the cost of \$1200.

2. *There is an opportunity for you to pick up a check of \$1000 at the city hall. The ticket to enter the city hall costs \$1200. By mistake, you purchased the ticket to enter the city hall and it is FULLY REFUNDABLE. Should you pick up the check?*
   Note the additional information about the refundable ticket to enter the city hall. Some of us will feel confused. Let's carefully check which items are affected by our decision of picking up the check. If we pick up the check, we get \$1000; if we do not pick up the check, we do not get \$1000. The benefit of picking up a check is then \$1000. If we pick up the check, we do not have to pay \$1200 to purchase the ticket to enter the city hall because it is already paid; if we do not pick up the check, we can get a refund of the ticket, i.e., \$1200. Picking up the check, we lose the refund. Therefore, the cost of picking up the check is \$1200. Given the benefit (\$1000) is less than the cost (\$1200), we should not pick up the check.

3. *There is an opportunity for you to pick up a check of \$1000 at the city hall. The ticket to enter the city hall costs \$1200. By mistake, you purchased the ticket to enter the city hall and it is NONREFUNDABLE. Should you pick up the check?*
   Note the additional information about a non-refundable ticket to enter the city hall. Some of us will feel confused. Let's carefully check which items are affected by our decision of picking up the check. If we pick up the check, we get \$1000; if we do not pick up the check, we do not get \$1000. The benefit of picking up a check is then \$1000. If we pick up the check, we do not have to pay \$1200 to purchase the ticket to enter the city hall because it is already paid; if we do not pick up the check, we cannot get a refund of the ticket. Therefore, the cost of picking up the check is zero. The \$1200 appears to be a cost but is not a cost relevant to our decision. Given the benefit (\$1000) is larger than the cost (\$0), we should pick up the check.

Carefully note the impact of refundability on the cost of the decision.

The non-refundable cost is often known as sunk cost. To illustrate the concept of sunk cost, the activity of auctioning off a ten-dollar bill is sometimes done in class.[4] Here are the rules:

[4] The game originates from Martin Shubik: "The Dollar Auction Game: A Paradox in Noncooperative Behavior and Escalation," *The Journal of Conflict Resolution*, 15, 1, 1971, 109-111.

1. The auction is conducted as an English auction, with the highest bidder taking the ten-dollar bill. When submitting a bid, raise your hand and cry out the bid.

2. Each time a player bids, his or her bid is recorded. If a player bids more than once, the higher bid replaces the lower bid, so that a player always has only one outstanding bid. In fact, we keep track of the highest bid submitted by any players.

3. Initial bid should be \$1. Each bid increment should be exactly \$1. No players are allowed to submit two consecutive bids.

4. As opposed to a standard English auction however, the winning bidder is not the only bidder who pays for the dollar bill. When the auction ends, all bidders who entered a bid during the auction must pay an amount equal to their highest bid. Only the highest bidder, however, gets the dollar bill.

This activity has been played many times. The highest bids were always much more than \$10. Are the bidders rational to submit a bid higher than \$10? For illustration, consider the following bids recorded in one experiment conducted in a workshop.

n-th bid	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Agent who submitted n-th bid	A	B	C	B	D	C	D	E	C	E	C	E	C	E

Consider the 11th bid made by bidder C. Bidder C's previous bid was \$9 for a \$10 bill. Her bid was surpassed by bidder E. Now, she is raising the bid beyond \$10. She is using \$11 to exchange for a \$10 bill! Why would she do that? Surprising, isn't it? Is she rational? Remember a rational individual will take an action only if the extra benefit of doing so is larger than or equal to the extra cost. Most of us understand that it is perfectly rational for the bidder C to raise the bid beyond \$10 because the previous highest bid she made is like spilled milk. Raising the bid or not has no impact on the \$9 (her previous highest bid) she has to pay. If she does not raise the bid, she would surely lose and she will have to pay \$9 for nothing. If she raises the bid by \$2 from \$9 to \$11, she gave herself a chance of winning the \$10 bill. If she wins, she would be like using \$2 to get a \$10 bill. In making the decision of raising the bid, it is the extra cost and extra benefit of the action that count.

This experiment brings out the difference of the two concepts in our cost-benefit analysis: sunk cost versus marginal cost. The only costs that should influence a decision about whether to take an action are those that we can avoid by not taking the action. Sunk costs are costs that have already been incurred and cannot be recovered to any significant degree, and thus should not be considered. In contrast, marginal cost should be considered.

Definition. ***Sunk cost*** *is a cost that is beyond recovery at the moment a decision must be made.*

Can you think of examples that are similar to the auction described above? Two came to mind.

1. Suppose several men are pursuing a beautiful young lady. To please her, each of them has to send her flowers, buy her dinners, take her out to movies, etc. Suppose the lady picks the one who is willing to spend the most on her. The one who spends the most is like the highest bidder – the winner. The rest would have to pay for whatever highest bid they ever announced.

2. Suppose several construction companies are competing for a government project. Each company will invest in hiring experts to prepare a design plan. Suppose the quality of the design plan is directly related to the input of experts. At the current spending on experts, company A's plan is slightly better than company B's. So, if the competition stops at this point, company A will win the project. However, company B has an option to hire another expert to help modify the design. The benefit is to win the project; the relevant cost is the cost of hiring an additional expert. The cost company B had incurred previously is sunk and thus should not be taken into consideration, i.e., deciding whether to further modify the design.

The following is a very common situation facing students.

Example. Some monetary expenditures should not be counted as opportunity cost

Here are the costs of pursuing a one-year Master of Economics degree for Angela:

Item	Cost ($)
Tuition fee	50,000
Books	2,000
Housing	10,000
Food	10,000
Lost income from work	100,000

Studying and working are equally desirable in Angela's mind. Suppose that Angela could live at home at no cost to her if she works, but must live on campus if she goes to school. Food is required at school or home. What is Angela's total opportunity cost of pursuing the master degree rather than working?

Let's do a comparison of the two alternatives: study versus work.

Item	Cost of study ($)	Cost of work ($)	Benefit of work ($)
Tuition fee	50,000	0	
Books	2,000	0	
Housing	10,000	0	
Food	10,000	10,000	
Income from work			100,000

Because expenditure on food is the same under the two alternatives, it should not be considered. If she studies, she will have to incur the "additional" monetary expenditure (excluding food) of tuition fee, books, and housing, i.e., 50,000+2,000+10,000=62,000. She will not be able to work and hence have to give up the opportunity of earning 100,000. Hence, her total opportunity cost of pursuing a master degree is 162,000.

This example illustrates how sometimes "expenditure" are wrongly taken into account in making their decision but in fact, they are not really relevant for the decision concerned.

1.3.3 Psychic cost is a cost

We may feel stressful when we engage in some activity. The stress is a cost of doing such activity.

Suppose John feels stressful to attend a family gathering during the Chinese New Year. We can estimate the stress or psychic cost by asking whether he would be willing to attend the meeting if he can expect to obtain $\$x$ dollar of red pocket money in the gathering. Start from a small number of x such that John will choose not to go. Then, gradually raise x till John would be willing to go. This amount of red pocket money can be used as an estimate of the stress or psychic cost of attending the family gathering.

Example. Count the psychic cost

Mary wants to go to a concert. The price of the ticket is \$50. To go to the concert, she has to cancel a job which pays her \$200. She is willing to pay \$150 to hire someone else to do the job for her. What is the opportunity cost of going to the concert?

Let's think about it. What does Mary give up when she goes to the concert? She would have to give up \$50 for the ticket, which could have been used to buy any other thing that is worth \$50. In addition, she would have to give up the job which pays her \$200 but the job costs her \$150 of psychic cost. That is, the job she gives up is worth only \$50 to her.

Thus, for the concert, Mary gives up $\$50+\$50 = \$100$.

Why is the job worth only \$50 to Mary? The key is the psychic cost. The job pays Mary \$200 but the job costs Mary \$150 of psychic cost. That is like, someone can give Mary a check of \$200, but to get the check, Mary has to do something that will cause a damage of \$150 to her. Or, someone can give Mary a check of \$200, but to get the check, she has to pay \$150 entrance fee. Jobs of such nature are only worth \$50 to you.

1.3.4 Count only the best alternative as the opportunity cost, not the sum of all alternatives

You have one hour to spend on either of the following activities.

1. An hour of RA work, of value \$50 to you.

2. An hour at the gym, of value \$70 to you.

3. An hour of reading, of value \$40 to you.

4. An hour of sleeping, of value $\$x$ to you.

Which forgone alternative should we count in computing the cost of spending the hour sleeping? The key is to recognize that we have only one hour and can do only one of the activities. If you spend the hour sleeping, you will give up one of the remaining activities, you do not give up all of them. So, we ask if you do not spend the hour sleeping, what would you choose to do? From the data above, you should spend the hour at the gym because it yields the highest value to you (among RA, gym and reading). Thus, the cost of spending the hour sleeping is \$70, the value of an hour at the gym.

Note, I purposefully let the value of sleeping blank (denoted as $\$x$). The reason is that when we talk about the opportunity cost of sleeping, we do not need to know the value we get from sleeping, as we had illustrated in the discussion above.

Count only the best alternative as opportunity cost

Suppose if we do not do activity x, we could have done activity $A1$, yielding an benefit of $B(A1)$, or activity $A2$, yielding a benefit of $B(A2)$. The opportunity cost of doing activity x is

$$\max\{B(A1), B(A2)\}$$

Example. Count only the best alternative, not all alternatives

Larry was given offers by three different graduate schools, and must choose one. Elite U costs \$50,000 per year and did not offer Larry any financial aid. Larry values attending Elite U at \$60,000 per year. State College costs \$30,000 per year, and offered Larry an annual \$10,000 scholarship. Larry values attending State College at \$40,000 per year. NoName U costs \$20,000 per year, and offered Larry a full \$20,000 annual scholarship. Larry values attending NoName at \$15,000 per year. What is the opportunity cost of attending State U?

Item	Elite U	State U	NoName U
Costs	50,000	30,000	20,000
Financial aid		10,000	20,000
Values of attending	60,000	40,000	15,000

First, it is easy to verify that if Larry is given any of the three offers, he would be happy to take the offer because each of them will yield a benefit that is higher than the corresponding cost. Second, Larry ranks State U as the first choice (40000-30000+10000=20000), NoName U the second (15000-20000+20000=15000), and Elite U the last, (60000-50000=10000). Third, we know that the opportunity cost should include only the best alternative forgone. The best alternative of attending State U is NoName U. Thus, Larry's opportunity cost of attending State U should include the monetary cost of attending State U, i.e., 30,000-10,000=20,000 and the forgone net benefit he should have gotten from NoName U, i.e., 15,000. Thus, the total opportunity cost of Larry attending State U is 35,000 = 20,000+15,000.

1.4 The impact of having more alternatives

We choose to do activity x only if the benefit of doing x is larger than the cost of doing x . The cost of doing x often includes the benefit of doing the best alternative of x . Suppose $A1$ is the only alternative available. Then, assuming there are no other costs, the cost of doing x is simply the benefit of doing $A1$.

$$C(x) \quad = \quad B(A1)$$

Suppose we observe that John will choose to do x in such situation. We can infer that the benefit of doing x is larger than the cost of doing x (or the benefit of doing $A1$).

$$B(x) \quad \geq \quad C(x) \quad = \quad B(A1)$$

Now, suppose John is given an additional alternative, say $A2$. That is, if John does not do x , he can do either $A1$ or $A2$. The cost of doing x is no longer the benefit of doing $A1$ but, instead, the maximum of the benefit of doing $A1$ and the benefit of doing $A2$. With this additional alternative available, the cost of doing x is at least as high as the case with only one alternative $A1$.

$$C(x) \quad = \quad \max\{B(A1), B(A2)\} \quad \geq \quad B(A1)$$

Thus, it is possible that with the additional alternative, John will choose not to do activity x anymore, i.e.,

$$B(x) \quad < \quad C(x) \quad = \quad \max\{B(A1), B(A2)\}$$

> As more alternatives to activity x become available, we will either stay with activity x or switch to something else. That is, the chance of doing x will fall.

Now, we can see why students are less likely to attend lectures in recent years. In recent years, more alternatives have become available to us. Consequently, the cost of attending lecture has become higher. If the benefit of attending lectures stays the same, more people will choose not to attend lectures. As a policy, to counter such phenomenon (to encourage students to attend lectures), we will need to find a way to increase the benefit of attending lecture or increase the cost of not attending lecture. Taking attendance at lectures is one possible policy.

Our discussion here can also be used to understand why college enrollment rate tends to be high during recessions. Assume that there are three activities to be chosen by John – college, work and leisure. Should John attend college? The decision will rest on benefit and cost comparison. Suppose John originally chose not to attend college. We can infer that his benefit of attending college was lower than the cost of attending college.

$$\text{B(College)} \quad < \quad \text{C(College)}$$

The cost of attending college includes tuition fee and the benefit he could have gotten from the best alternatives (either work or leisure).

$$\text{C(College)} \quad = \quad \max\{\text{B(Work)},\text{B(Leisure)}\} + \text{others}$$

Remember, when one alternative is eliminated, the benefit he could have gotten from the best alternative will be smaller or unchanged. If smaller, it is possible that John will choose to attend college.

Now, suppose John originally chose to stay home to enjoy leisure, we must have

$$\text{B(Leisure)} \quad > \quad \text{C(Leisure)} \quad = \quad \max\{\text{B(Work)},\text{B(College)}\} + \text{others}$$

And, suppose now we are in a recession. Will John change his decision? No. Because when the alternative of Work is eliminated, we will have

$$\text{C(Leisure)} \quad = \quad \text{B(College)} \quad \leq \quad \max\{\text{B(Work)},\text{B(College)}\}$$

That is, the cost of Leisure can only become smaller than before. John will not switch from Leisure to attending College.

Suppose John originally chose to work full-time, we must have

$$\text{B(Work)} \quad > \quad \text{C(Work)} \quad = \quad \max\{\text{B(Leisure)},\text{B(College)}\} + \text{others}$$

And, suppose now we are in a recession. Will John change his decision? Possible, because when the alternative of Work is eliminated, the decision involves a comparison between the benefit of attending College and the benefit of Leisure.

$$\text{B(College)} \quad \text{v.s.} \quad \text{C(College)} \quad = \quad \text{B(Leisure)} + \text{others}$$

The simple fact that John chose to work full-time does not give us any information about the comparison of B(College) and B(Leisure). Thus, it is possible to have

$$\text{B(College)} \quad \geq \quad \text{C(College)} \quad = \quad \text{B(Leisure)} + \text{others}$$

or

$$\text{B(College)} \quad < \quad \text{C(College)} \quad = \quad \text{B(Leisure)} + \text{others}$$

In the first case, John will choose to attend College when the opportunity of working full time is eliminated. In the second case, John will not choose to attend College.

As long as we have some people with B(College)>B(Leisure), we will see an increase in college enrollment during recessions.

You see, if we are able to understand the cost-benefit analysis well, we will be able to understand and predict the college enrollment during recessions, and possibly many more important phenomena around us.

1.5 Two alternative questions, same decision

Consider the following example.

> *"Howard usually spends his Saturday afternoons at a tutoring center as a private mathematics teacher for some primary school students. This job pays him \$200, and Howard is just willing to do the job for free. This weekend, his girlfriend Elva asks him to go dating with her. Howard values dating with Elva at \$250 and he plans to buy some flowers for Elva, which costs about \$30. The opportunity cost of going dating is ______________."*

What is the opportunity cost of going dating? The opportunity cost of going dating should consist of the monetary cost of dating (i.e., the \$30 for the flowers) and the implicit cost (the opportunity of earning \$200 from the job). Thus, the opportunity cost is going dating is \$230 ($= 200 + 30$).

Why should we count the monetary cost of buying flowers (i.e., \$30) as an opportunity cost? Because the \$30 has an alternative use! For instance, a cup of coffee at the University Coffee Shop costs \$20. If no other alternative to the use of the same amount of money, the cost of \$20 will be treated as an opportunity cost because the amount of \$20 can be used to buy \$20 worth of something else.

What is the opportunity cost of doing the job? To do the job, Howard will have to give up whatever he can get from dating (his best alternative in this case). Howard gets a benefits equivalent to \$250. The cost of dating is sending flowers of \$30. Thus, the opportunity cost of doing the job is \$220 ($= 250 - 30$).

The following table summarizes the discussion above.

	Opportunity cost	Benefit	Economic Surplus	Decision
Dating	$200 + 30 = 230$	250	$250 - 230 = 20$	Dating
Working	$250 - 30 = 220$	200	$200 - 220 = -20$	Dating

Table 1.1: Different approach of asking questions, same decisions

To make a decision in this case, there are two ways to ask the question.

1. Should I go working instead of dating? In this case, we will need to know the benefit of working and compute what we give up. Since the benefit ($200) is less than the cost ($220), we should not go working. That is, we will go dating, instead.

2. Should I go dating instead of working? In this case, we will need to know the benefit of dating and compute what we give up. Since the benefit ($250) is larger than the cost ($230), we should go dating.

Thus, no matter how we consider the decision, we will arrive at the same answer.

A possible confusion:

The opportunity cost of doing the job ($220) is lower than that of dating ($230). Shouldn't we choose the alternative with the lower opportunity cost (i.e., working)?

Note that the comparison of opportunity costs for decision making is wrong. Our decision should be based on cost and benefit principles. That is, we should be comparing the cost and benefit — not just the cost of activity A and cost of activity B. Indeed, the goal of economic decision makers is to choose the activity that will generate the largest possible economic surplus.

The comparison of cost will be a useful guide only if the benefit of activity A is the same as the benefit of activity B.

1.6 Two alternative ways of computing the cost and benefit, same decision

Consider the following example.

> After an exchange at OKU in England, you were about to return to Hong Kong. You noticed that the Mr. Bean (a UK comedy television programme) complete series DVD were sold at HK$1,800 at Hong Kong stores and about HK$500 in England. You had been planning to bring back a Mr. Bean DVD set and sell it at about HK$1,300. Then Uncle Fong asked you to bring back a Mr. Bean DVD set, and promised to pay you the cost of the DVD (i.e., HK$500). You value the chance of helping Uncle Fong at $700. Will you help him? (Assume you can only bring back one Mr. Bean DVD set.)

Often, there is a disagreement in computing cost and benefit. The difference is really about the point of time we consider the problem.

1. Imagine you have not yet purchased the DVD set.
   The benefit of helping Uncle Fong? Your valuation of helping Uncle Fong = $700. The refund you get from Uncle Fong = $500. The cost of the DVD = $500. Hence, the benefit is $\$700 + \$500 - \$500 = \$700$.
   The cost of helping Uncle Fong? Helping Uncle Fong, you will lose the opportunity of bringing back the DVD and reselling it yourself. What you could have gotten by bringing back the DVD

and reselling it yourself is equal to

$$\underset{\text{DVD's sale value}}{\$1300} - \underset{\text{DVD's purchase price}}{\$500} = \$800$$

Hence the economic surplus is

$$\underset{\text{benefit}}{\$700} - \underset{\text{cost}}{\$800} = -\$100$$

Since the economic surplus is negative, you should not help Uncle Fong.

2. Imagine you are already back with the DVD set.
What you will receive from Uncle Fong is then

$$\underset{\text{valuation of helping}}{\$700} + \underset{\text{reimbursement}}{\$500} = \$1200$$

The cost of helping Uncle Fong? Helping Uncle Fong, you will lose the opportunity of reselling the DVD. Hence, the cost is $1300, what you would have gotten by selling the DVD.
Hence the economic surplus is

$$\underset{\text{benefit}}{\$1200} - \underset{\text{cost}}{\$1300} = -\$100$$

Since the economic surplus is negative, you should not help Uncle Fong.

Both approaches will yield same economic surplus and thus the same conclusion.

It is important to remember, when two consultants are doing a cost and benefit for the same situation, they may end up with a different estimation of cost and benefit. Nevertheless, if they have done the analysis carefully, they will end up with the same economic surplus and thus recommend the same decision.

1.7 More on the estimation of benefit and cost

Suppose I am considering whether I should go to a skiing trip. I would need to figure out the benefit I get from the skiing trip and the cost of the skiing trip. Let's focus on the estimation of benefit. Which of the followings are the correct way(s) of estimating benefit?

1. Suppose I am going to the skiing trip initially. Imagine someone is willing to pay me not to go to the skiing trip. The benefit of my going to the skiing trip can be estimated as "the minimum amount I will need from him/her".

2. Suppose my mom forbids me to go to the skiing trip initially. The benefit of going to the skiing trip can be estimated as "the maximum amount of money I am willing to pay (or bribe) my mom so that I will be allowed to go".

In fact, both are valid measures, but why?

Again , when we had difficulty understanding / solving the problem, try to modify it so that the answer becomes clear and obvious.

We know how to measure the distance between point A and point B, don't we?

We can start from point B and ask how far point A is from point B; we can start from point A and ask how far point B is from point A. Both ways of measuring the distance should yield the same answer.

Here is my modified version of the original question. Suppose I am considering whether I should go to pick up a check of $1000 at the city hall (a skiing trip). I would need to figure out the benefit I get from picking up the check (the skiing trip) and the cost of picking up the check (the skiing trip). Let's focus on the estimation of benefit (i.e., assuming the cost to be zero). Which of the followings are the correct way(s) of estimating benefit?

1. Suppose I am going to pick up the check (the skiing trip) initially. Imagine someone is willing to pay me not to go to pick up the check (the skiing trip). The benefit of my going to pick up the check (the skiing trip) can be estimated as "the minimum amount I will need from him/her".

2. Suppose my mom forbids me to go to pick up the check (the skiing trip) initially. The benefit of going to pick up the check (the skiing trip) can be estimated as "the maximum amount of money I am willing to pay (or bribe) my mom so that I will be allowed to go".

With the replacement of skiing trip by the activity of picking up a check, we have made very clear what the benefits are.

Now, consider the case of measuring changes in happiness (economic surplus) of skiing. First we need to measure the happiness you have with skiing (A), and the happiness you have without skiing (B). The difference in the happiness will be the benefit we derive from skiing. Similar to the measurement of physical distance, there are two different ways of measuring the difference: starting from B, or starting from A. Let $U(\text{skiing}, m)$ be a utility function that measures the happiness of skiing and other consumption expenditure (m).

1. Starting from A, we ask: Suppose you are allowed to go skiing initially. What is the minimum amount of money your mom has to pay you so that you will not go skiing. That is, what should x be so that $U(\text{skiing}, m) = U(\text{no skiing}, m + x)$.

2. Starting from B, we ask: Suppose you are not allowed to go skiing initially. What is the maximum amount of money that you are willing to use to bribe your mom to let you go skiing. That is, what should x be so that $U(\text{no skiing}, m) = U(\text{skiing}, m - x)$.

Both ways of estimating the change in happiness should yield a similar answer.

1.8 Absolute versus proportional

Many people will focus on the proportional savings or gains in making purchase decisions. Regarding the decision of purchasing the same good, a big discount is of course preferred to a small one. However, it will be wrong to compare such proportional savings across good. A good understanding of cost and benefit analysis helps us avoid such mistakes.

Consider the following two situations.

1. You are about to buy a $20 alarm clock at the campus store when a friend tells you that Fortress has the same alarm clock on sale for $10.

2. You are about to buy a $6510 laptop computer from the campus store when a friend tells you that Fortress has the same computer on sale for $6500.

Consider the first situation, the benefit ($10) is clearly given, the cost of going to and back from Fortress is not. Suppose you would decide to go to Fortress to buy the clock, will you go in the second situation? Some students will conclude that they will choose to buy the clock at Fortress but not the laptop because the percentage of saving is much higher in the case of buying a clock than that of buying a laptop. Cost and benefit analysis suggests that we should choose the same action in both situations. That is, cost and benefit analysis suggest we should focus on absolute difference instead of proportions.

For illustration purpose, let's modify the setup slightly.

Suppose the university offers students a coupon to save $10 to buy the clock, $10 on the laptop at the campus store. The university will charge students a price for the coupon, say "x". If the price of coupon (x) is $5, the benefit ($10) is higher than the cost ($5), definitely we will want to purchase the coupon and save the $10 in both cases (clock and laptop). Right?

If the price of coupon (x) is $11, the benefit ($10) is smaller than the cost ($11), definitely we will NOT want to purchase the coupon. Right?

Do we pay attention to the price of the two items? No!

Now, change the "coupon" to the "information that Fortress sells the clock at $10", and the "information that Fortress sells the computer at $6500". And, your cost of walking to Fortress and back is equivalent to the cost of a "coupon". Should we not arrive at a similar conclusion as in the discussion above? Of course, the only difference is that our decision now is whether you will walk to Fortress instead of whether you will buy the coupon.

When challenged with this conclusion, some students often argue that there is a non-zero probability of damage during transportation (say, robbery). We can certainly include this additional consideration in our discussion.

Here is an example, just to show the complexity of a model that takes into account of such additional considerations. Suppose when we purchase the good off campus, we will have to incur a transportation cost of c, and the probability of damage during transportation is π. Suppose the price of the item purchased off campus is P_A. The damage can be fixed with a cost proportional to the price of the purchase, and the cost of fixing the damage is dP_A. The expected cost of fixing the damage is then πdP_A. Thus, the cost of buying the item off campus is really $P_A + c + \pi dP_A$. Suppose the price of the item purchased on campus is P_B. Buying the item on campus, no transportation is required and the probability of damage is zero. Thus, the cost of buying the item on campus is just P_B. Should we buy the item off campus? We will buy from off campus if and only if

$$P_A + c + \pi dP_A \leq P_B$$

or

$$P_B - P_A \geq c + \pi dP_A$$

Let's check to understand this result. When both c and π are zero, the inequality becomes $P_B - P_A \geq 0$. That is, we will buy from off campus if and only if the price off campus (P_A) is lower than the price on campus (P_B).

When π is zero, the inequality becomes $P_B - P_A \geq c$. That is, we will buy from off campus if and only if the price off campus (P_A) is lower than the price on campus (P_B) by the amount of c. Whether to buy off campus depends on whether the difference of prices (gain from the saving on prices) is smaller than or equal to the cost of transportation. When the cost of transportation increases, we may switch from buying off campus to buying on campus. Conversely, when the cost of transportation reduces, we may switch from buying on campus to buying off campus.

When d is zero, regardless of the value of π, we will buy from off campus when $P_B - P_A \geq c$. Again, whether to buy off campus depends on whether the difference of prices (gain from the saving on prices) is smaller than the cost of transportation.

When c is zero but d and π are both positive, the inequality becomes $P_B - P_A \geq \pi dP_A$. That is, we will buy from off campus if and only if the price off campus (P_A) is lower than the price on campus (P_B) by the amount of πdP_A. Note, again, πdP_A is the expected cost of fixing the damage. Because the expected cost of fixing the damage depends on P_A, the decision whether to buy off campus depends on the value of the item too. A bigger value of the item (P_A), the less likely we will buy from off-campus. For example, for any given difference between the on-campus and off-campus prices, we are more likely to buy a laptop on campus than an alarm clock.

When c, d and π are all positive, we have the original inequality $P_B - P_A \geq c + \pi dP_A$. That is, we will buy from off campus if and only if the price off campus (P_A) is lower than the price on campus (P_B) by the amount of $c + \pi dP_A$. In words, we will buy off campus only if the difference of prices (gain from the saving on prices) is smaller than or equal to the cost of transportation plus the expected cost of fixing the damage.

In a country where car accidents happen every day, or robbery happens every day, the probability π is a big number and it cannot be ignored. In Hong Kong or in most industrialized countries, π is a very very small number and thus can be safely ignored. Ask ourselves how many purchases we make in the past, and how many times we had an accident on our way back home? Most of us living in Hong Kong will conclude that π is almost zero. So, we will assume π to be zero. When π is zero, the conclusion reached in the model with probability of damage is the same as that without probability of damage we discussed above.

Model Abstraction

Economic models are often abstract. We need to focus on the abstract models in order to reach some strong conclusions. The important decision is what to include in the model. When we insist on putting everything we can imagine in the model or in our analysis, we can easily have more than 10 variables to consider. Then we will be saying things like "The following will result when the variable A is larger than x, variable B is smaller than y, variable C is larger than z, etc." When so many variables are included in a model, the model often becomes intractable, the conclusion is often weak, and the implication is often unclear.

It is often useful to consider an abstract model focusing on one or two important features of a situation. Once we understand how to analyze the model and its implications, we can gradually add other features back to the model and see how these additional features will change the implications.

There is also a reason that we do not include e as some of you would in such discussion. In our class, most students have not learned how to handle uncertainty and risk yet. For the purpose of teaching and learning, we will have to assume a world of certainty for the moment. The topic about uncertainty and risk will be covered in more advanced courses.

1.9 Optimal quantity

Consider the question of how many bowls of "leung cha" (herbal tea)[5] to consume. This appears a very different decision from the one that we have discussed earlier. The decision we discussed earlier ("Should I do activity x?") is really a zero-one decision, or a no-yes decision. Can we use cost-benefit analysis to solve this optimal amount of "leung cha" problem? The answer is definitely yes – but with a twist.

We can rewrite the decision of how many bowls to consume into a sequence of zero-one decisions: "should I consume an additional bowl?"

When the decision is whether to consume an additional unit, we will have to compare the benefit due to the additional unit (marginal benefit, MB) and the cost due to the additional unit (marginal cost, MC). Let $MB(Q)$ denote the marginal benefit due to the $(Q+1)$-th unit, and $MC(Q)$ denote the marginal cost due to the $(Q+1)$-th unit. If we are told of the total benefit of consuming $(Q+1)$

[5] https://multimedia.scmp.com/news/hong-kong/article/2162156/herbal-tea/index.html

units and the total benefit of consuming Q units, the marginal benefit of the $(Q+1)$-th unit is simply the difference between the total benefits.

$$MB(Q) = TB(Q+1) - TB(Q)$$

Marginal cost due to the $(Q+1)$-th unit is related to total cost in a similar manner.

$$MC(Q) = TC(Q+1) - TC(Q)$$

Often, when we have an increment (D) that is different from 1 unit, we would like to do a standardization.

$$MB(Q) = \frac{TB(Q+D) - TB(Q)}{D}$$
$$MC(Q) = \frac{TC(Q+D) - TC(Q)}{D}$$

Then, the $MB(Q)$ will still be interpreted as the marginal benefit of an additional unit when we already have consumed Q units; similar interpretation for $MC(Q)$. Of course, whenever possible, it is easier to consider an increment of 1 unit (i.e., $D = 1$).

With this understanding of MB and MC, the sequence of zero-one decisions of <u>one unit at a time</u> would be like:

1. Currently standing to consume $Q = 0$, should I consume the first bowl? We should consume the first unit only if $MB(Q = 0) \geq MC(Q = 0)$.

2. Currently standing to consume $Q = 1$, should I consume the second bowl? We should consume the second unit only if $MB(Q = 1) \geq MC(Q = 1)$.

3. Currently standing to consume $Q = 2$, should I consume the third bowl? We should consume the second unit only if $MB(Q = 2) \geq MC(Q = 2)$.

and so on. Generally if we have already decided to consume $Q = n$ units, we should consume the $(n+1)$-th unit only if the marginal benefit due to the $(n+1)$-th unit, $MB(Q = n)$, is higher than the marginal cost due to $(n+1)$-th unit, $MC(Q = n)$.

Let's get back to the original optimal amount of "leung cha" problem. Suppose the price of an additional unit (MC) is fixed at \$10 per bowl, i.e.,

$$MC(Q) = 10$$

and the benefit of an additional bowl of leung cha in any given month is summarized by

$$MB(Q) = 89 - 10Q$$

That is, we have the following marginal benefits:

Q	$MB(n)$	Q	$MB(n)$
0	89	5	39
1	79	6	29
2	69	7	19
3	59	8	9
4	49	9	-1

Table 1.2: Marginal benefit of "Leung Cha" consumption, discrete case

Q	$MB(Q)$	$MC(Q)$	Expand?	Q	$MB(Q)$	$MC(Q)$	Expand?
0	89	10	✓	5	39	10	✓
1	79	10	✓	6	29	10	✓
2	69	10	✓	7	19	10	✓
3	59	10	✓	8	9	10	×
4	49	10	✓	9	-1	10	×

Table 1.3: Optimal quantity of "Leung Cha" consumption, discrete case

Suppose we are standing at $Q = 5$ bowls, should we consume an additional bowl of leung cha? The marginal benefit of an additional bowl of leung cha is

$$MB(Q = 5) = 89 - 10 \times 5 = 39$$

As the marginal benefit ($= 39$) is higher than the marginal cost ($= 10$), we will choose to consume an additional bowl of leung cha. That is, 5 bowls of leung cha is not our optimal choice of quantity.

By repeating the steps we describe above, we should be able to easily make the decisions of

That is, we should consume 8 bowls of "leung cha" in a month.

In the above example, we assume that the quantity "leung cha" are discrete, e.g., 1 bowl, 2 bowls, etc.

Now suppose the quantity of "leung cha" is perfectly divisible, i.e., we can have $Q = 3.14159$ bowls, say.

In this case of perfectly divisible quantity, how do we understand the meaning of MB? Because the increase in quantity can be a very tiny quantity, MB is defined as

$$MB(Q) = \frac{TB(Q + \Delta) - TB(Q)}{\Delta}$$

where Δ is assumed to be a <u>very small</u> quantity. Note, the division by Δ helps to standardize the $MB(Q)$ to mean the marginal benefit <u>per unit</u> at the quantity Q.

Suppose we continue to have

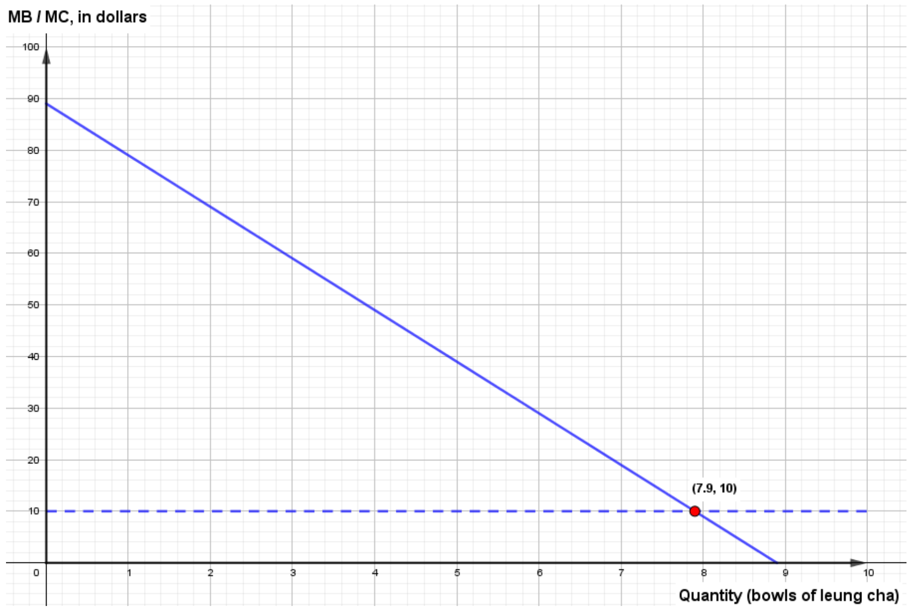

Figure 1.1: Optimal quantity of "Leung Cha" consumption, perfectly divisible case

$$MB(Q) = 89 - 10Q$$

which is shown as the downward sloping solid line in the following graph.

In the graph, we also show the MC curve as the horizontal dotted line.

How many bowls should we consume? We should continue to expand as long as marginal benefit is larger than marginal cost.

We can repeat our earlier analysis by allowing the standing quantity at a non-integer Q, say $Q = 3.14159$. If we are standing at the Q=3.14159 bowls, should we consume an additional bowl?

$$MB(Q = 3.14159) = 57.5841$$

As the marginal benefit is higher than the marginal cost, we will choose to consume an additional bowl of leung cha.

In fact, when leung cha is perfectly divisible, we do not have to increase the amount by one bowl at a time. Suppose we are asking the question whether we should increase the consumption by 0.1 bowl, the marginal benefit of this additional 0.1 bowl will be estimated as

$$57.5841 \times 0.1 = 5.75841$$

The corresponding marginal cost will be

$$10 \times 0.1 = 1$$

As the marginal benefit is higher than the marginal cost, we will choose to consume an additional 0.1 bowl of leung cha.

More generally, we can ask the question whether we should increase the consumption by Δ bowl, the marginal benefit of this additional Δ bowl will be estimated as

$$MB(Q = 3.14159) \times \Delta = 57.5841 \times \Delta$$

The corresponding marginal cost will be

$$MC(Q = 3.14159) \times \Delta = 10 \times \Delta$$

As the marginal benefit is higher than the marginal cost, we will choose to consume an additional Δ bowl of leung cha. Note, we are still comparing $MB(Q = 3.14159)$ and $MC(Q = 3.14159)$, that is the Δ does not affect our decision to expand consumption or not.

Repeating this analysis with an additional Δ bowl, we should be able to arrive at the optimal quantity of 7.9 bowls. To see why 7.9 is optimal, consider the quantity that is slightly less than the claimed optimal quantity and the the quantity that is slightly more than the claimed optimal quantity. Think about the quantity $Q = 7.9 - \Delta$. To make it concrete, let $\Delta = 0.1$, i.e., $Q = 7.8$. At this Q, the marginal benefit is

$$MB(Q = 7.8) = 11$$

and the marginal cost is

$$MC(Q = 7.8) = 10$$

As the marginal benefit is higher than the marginal cost, we should expand.

At $Q = 7.9 + \Delta$, say $\Delta = 0.1$, the marginal benefit is

$$MB(Q = 8) = 9$$

and the marginal cost is

$$MC(Q = 8) = 10$$

Should we expand? No, because the marginal benefit is less than the marginal cost. In fact, we would like to reduce the quantity.

Repeating the analysis with an arbitrary small Δ bowls appears to be a daunting job. Luckily, there is a short-cut – by simply equating MB and MC.

$$\begin{aligned} MB(Q) &= MC(Q) \\ 89 - 10Q &= 10 \\ 10Q &= 79 \\ Q &= 7.9 \end{aligned}$$

A remark. Some students would say since at $Q = 7.9$, $MB(Q) = MC(Q)$, applying the “weak inequality” of cost-and-benefit analysis we defined earlier (we should do an activity x if the benefit of

$\Delta = 0.1$			$\Delta = 0.01$			$\Delta = 0.001$			$\Delta = 0.0001$		
Q	MB	MC	Q	MB	MC	Q	MB	MC	Q	MB	MC
7.6	13	10	7.87	10.3	10.0	7.897	10.03	10.00	7.8997	10.003	10.000
7.7	12	10	7.88	10.2	10.0	7.898	10.02	10.00	7.8998	10.002	10.000
7.8	11	10	7.89	10.1	10.0	7.899	10.01	10.00	7.8999	10.001	10.000
7.9	10	10	7.90	10.0	10.0	7.900	10.00	10.00	7.9000	10.000	10.000
8.0	9	10	7.91	9.9	10.0	7.901	9.99	10.00	7.9001	9.999	10.000

Table 1.4: Optimal consumption as Δ increment approaches zero

doing x is larger or equal to the cost of doing x), we should expand, say, by $\Delta = 0.1$, to $Q = 8.0$. True, if the increment has to be $\Delta = 0.1$ at a time. However, at hand, we are assuming a perfectly divisible quantity, i.e., allowing Δ to be arbitrary close to zero. At $Q = 7.9$, $MB(Q) = MC(Q)$, using the weak inequality, we should expand by Δ. When Δ is essentially zero, $Q + \Delta$ is essentially Q.

The following tables show how we will conclude that the optimal quantity approaches $Q = 7.9$ as Δ gets arbitrary close to zero.

A remark is in order. We have been adopting the definition of MB as a change in total benefit due to an increase in quantity, i.e., MB is defined as

$$MB_A(Q) = \frac{TB(Q + \Delta) - TB(Q)}{\Delta}$$

Alternatively, we can also adopt the definition of MB as a change in total benefit due to a decrease in quantity, i.e., MB is defined as

$$MB_B(Q) = \frac{TB(Q) - TB(Q - \Delta)}{\Delta}$$

When the change Δ is very very small, we can show that the two definitions yield approximately the same estimate of MB, i.e.,

$$MB_A(Q) \approx MB_B(Q)$$

When the change Δ is very very small, we may adopt the two definitely interchangeably.

1.9.1 The assumption on MC and MB

Generally, we assume that MB is non-increasing in additional units and MC is non-decreasing in additional units. These are assumptions that need not be true in some situations. When these assumptions are true, the decision is simplified to what we discussed by the comparison of marginal benefit and cost as stated here.

1. General rule: Keep expanding as long as MB is larger than MC. Stop whenever we have $MC > MB$.

2. Rule for perfectly divisible quantities: Choose the quantity at which $MB(Q) = MC(Q)$

When it is not true, we will need to think of alternative strategies to solve the problem. Experience tells us the assumption is likely true most of the time but there are exceptions. Benefits and costs can be very subjective and thus we may not have a very scientific proof that the assumption must be true.

1.9.2 Optimal quantity at $MC = MB$

When the quantity is perfectly divisible, MB is non-increasing in additional units and MC is non-decreasing in additional units, the rule is to choose the quantity Q (call it Q^*) such that $MB(Q^*) = MC(Q^*)$. Why is this quantity optimal?

To check optimality, the usual trick is to check whether a small deviation from the quantity Q^* will yield a gain, or a loss.

To demonstrate a very sharp result, let's assume that MB is (strictly) decreasing in additional units and MC is (strictly) increasing in additional units.

1. Now, consider a quantity Q smaller than Q^* by the small amount of x, say $Q = Q^* - x$. Since MB is decreasing in Q, $MB(Q^* - x) > MB(Q^*)$. Since MC is increasing in Q, $MC(Q^* - x) < MC(Q^*)$. We have then,

$$MB(Q^* - x) > MB(Q^*) = MC(Q^*) > MC(Q^* - x)$$

Thus, if we are standing at the quantity of $Q = Q^* - x$, increasing the quantity by a small amount of x (i.e., moving toward Q^*) will yield a gain (in economic surplus) of[6]

$$[MB(Q^* - x) - MC(Q^* - x)] \times x > 0$$

Conversely, moving in the opposite direction will yield a loss. That is, if we are standing at the quantity of $Q = Q^*$, decreasing the quantity by a small amount of x (i.e., moving toward $Q^* - x$) will yield a loss (in economic surplus) of

$$[MB(Q^* - \Delta) - MC(Q^* - \Delta)] \times x > 0$$

2. Now, let's do the reverse and consider a quantity Q larger than Q^* by the small amount of x, say $Q = Q^* + x$. Since MB is decreasing in Q, $MB(Q^* + x) < MB(Q^*)$. Since MC is increasing in Q, $MC(Q^* + x) > MC(Q^*)$. We have then,

$$MB(Q^* + x) < MB(Q^*) = MC(Q^*) < MC(Q^* + x)$$

[6] Recall the definition of $MB(Q)$.

$$MB(Q) = \frac{TB(Q + \Delta) - TB(Q)}{\Delta}$$

which can be rewritten as $TB(Q + \Delta) - TB(Q) = MB(Q) \times \Delta$. Thus, an increase of the quantity from Q to $Q + x$ will cause an increase in TB approximately equal to $MB(Q) \times x$. Similarly, an increase of the quantity from Q to $Q + x$ will cause an increase in TC approximately equal to $MC(Q) \times x$.

Thus, if we are standing at the quantity $Q = Q^* + x$, decreasing the quantity by a small amount of x (i.e., moving toward Q^*) say, we lose $MB(Q^* + x) \times x$ and save $MC(Q^* + x) \times x$.[7] In total, we end up with gaining

$$[MC(Q^* + x) - MB(Q^* + x)] \times x > 0$$

Thus, when MB is (strictly) decreasing in additional units and MC is (strictly) increasing in additional units, a small deviation from Q^* (where $MB(Q^*) = MC(Q^*)$) will cause losses. Thus, Q^* must be optimal.

The above discussion assumes (strictly) decreasing MB and (strictly) increasing MC. By repeating the above steps of analysis, it is not difficult to see the conclusion remains sharp if we have (strictly) decreasing MB and non-decreasing (or weakly increasing) MC, or non-increasing (or weakly decreasing) MB and (strictly) increasing MC. When we have non-increasing (or weakly decreasing) MB and non-decreasing (or weakly increasing) MC, we may end up with some indeterminacy occasionally.

1.10 Allocation of resources

Consider allocating a team of wild blueberry gatherers to the Forest East or Forest West. Suppose the team has only one gatherer. Where should we send our gatherer if the amount of blueberries collected from the two forests are as tabled?

Forest East	Forest West
100 kgs	130 kgs

We can apply cost-benefit analysis to answer this question. To do so, we ask "should we send our gatherer to Forest West or to Forest East?" If we send our gatherer to Forecast West, the benefit is 130 kilograms of blueberries. The cost is the amount of blueberries we could have gotten if we had sent the gatherer to Forest East, i.e., 100 kgs.[8] Since benefit is larger than cost, we should send our gatherer to Forest West.

Now, suppose we have four gatherers to allocate and the <u>total</u> amount of blueberries per gatherer at the two forests are as tabled.

[7] Here, I adopt the alternative definition of

$$MB(Q) = \frac{TB(Q) - TB(Q - \Delta)}{\Delta}$$

[8] There might be other costs of gathering blueberries. However, since it is very likely that the costs are the same regardless where the gatherer is sent, such costs need not be taken into consideration.

n gatherers	Forest East	Forest West
1	100 kgs	130 kgs
2	200 kgs	240 kgs
3	300 kgs	330 kgs
4	400 kgs	400 kgs

Table 1.5: Total output when different number of gatherers are sent to the two forests

Again, the cost-benefit principle can be applied to solve this allocation problem. From section 1.9, we know that to answer the question of "how many units", we can use cost and benefit analysis repeatedly for an additional gatherer sent to Forest West. We also know that in this case, we need to know the marginals: marginal cost and marginal benefit. As we illustrated in the one-gatherer case, the benefit of sending an additional gatherer to Forest West is the output from the additional gatherer to Forest West; the cost of sending an additional gatherer to Forest West is the output from the additional gatherer to Forest East. Thus, the first thing to do is to compute the marginal output when different number of gatherers are sent to the two forests. The marginal output form the n-th gatherer sent to Forest West is the total output when a total of n gatherers are sent to Forest West minus the total output when a total of $n-1$ gatherers are sent to Forecast West, i.e.,

$$MP(n) = TP(n) - TP(n-1)$$

where $MP(n)$ is used to denote the marginal output of the n-th gatherer, and $TP(n)$ the total output from n gatherers.

From this definition, the marginal output for the n-th gatherer to each of the two forests are computed as below.

n-th gatherer	Forest East	Forest West
1	100 kgs (=100 − 0)	130 kgs (=130 − 0)
2	100 kgs (=200 − 100)	110 kgs (=240 − 130)
3	100 kgs (=300 − 200)	90 kgs (=330 − 240)
4	100 kgs (=400 − 300)	70 kgs (=400 − 330)

Table 1.6: Marginal output when different number of gatherers are sent to the two forests

Now, let's think about sending the first gatherer. To Forest East or Forest West? Imagine the standard cost-benefit question: Should I send the gatherer to Forest West or Forest East? If we send him to Forest West, we get a benefit of 130. Sending him to Forest West means we cannot send him to Forest East. Thus, the cost of sending him to Forest West is the output I could have gotten from sending the gatherer to Forest East, i.e., 100. Since marginal benefit is larger than marginal cost, I should send him to Forest West.

$$\begin{array}{ccccc} \text{B(1st gatherer to West)} & > & \text{C(1st gatherer to West)} & = & \text{B(1st gatherer to East)} \\ 130 & & & & 100 \end{array}$$

Let's keep track of how many gatherers in Forest West and how many in Forest East. After the allocation of the first gatherer, we would have 0 in Forest East and 1 in Forest West.

Should we send an additional gatherer (i.e., the second gatherer) to Forest West or Forest East? If we send him to Forest West, he will be the second gatherer in Forest West. Thus, sending him to Forest West will yield an additional benefit of 110. Sending him to Forest West means we cannot send him to Forest East. If we send him to Forest East, he will be the first gatherer in Forest East. Thus, the cost of sending him to Forest West is the output we could have gotten from the first gatherer in Forest East, i.e., 100. Since marginal benefit is larger than marginal cost, we should send him to Forest West.

$$\begin{array}{ccccc} \text{B(2nd gatherer to West)} & > & \text{C(2nd gatherer to West)} & = & \text{B(1st gatherer to East)} \\ 110 & & & & 100 \end{array}$$

Again, let's keep track of how many in Forest West and how many in Forest East. After the allocation of the second gatherer, we would have 0 in Forest East and 2 in Forest West.

Should we send an additional gatherer (i.e., the third gatherer) to Forest West or Forest East? If we send him to Forest West, he will be the third gatherer in Forest West. Thus, sending him to Forest West will yield an additional benefit of 90. Sending him to Forest West means we cannot send him to Forest East. If we send him to Forest East, he will be the first gatherer in Forest East. Thus, the cost of sending him to Forest West is the output we could have gotten from the first gatherer in Forest East, i.e., 100. Since marginal benefit is smaller than marginal cost, we should not send him to Forest West. That is, we should send him to Forest East.

$$\begin{array}{ccccc} \text{B(3rd gatherer to West)} & < & \text{C(3rd gatherer to West)} & = & \text{B(1st gatherer to East)} \\ 90 & & & & 100 \end{array}$$

Again, let's keep track of how many gatherers in Forest West and how many in Forest East. After the allocation of the third gatherer, we would have 1 in Forest East and 2 in Forest West.

Should we send an additional gatherer (i.e., the fourth gatherer) to Forest West or Forest East? If we send him to Forest West, he will be the third gatherer in Forest West. Thus, sending him to Forest West will yield an additional benefit of 90. Sending him to Forest West means we cannot send him to Forest East. If we send him to Forest East, he will be the second gatherer in Forest East. Thus, the cost of sending him to Forest West is the output we could have gotten from the second gatherer in Forest East, i.e., 100. Since marginal benefit is smaller than marginal cost, we should not send him to

Forest West. That is, we should send him to Forest East.

$$\underset{90}{\text{B(4th gatherer to West)}} \quad > \quad \text{C(4th gatherer to West)} \quad = \quad \underset{100}{\text{B(2nd gatherer to East)}}$$

Again, let's keep track of how many gatherers in Forest West and how many in Forest East. After the allocation of the fourth gatherer, we would have two gatherers in Forest East and two gatherers in Forest West.

To summarize, we have

n-th gatherer	Where to send?	Reason
1	Forest West	130 (West-1) > 100 (East-1)
2	Forest West	110 (West-2) > 100 (East-1)
3	Forest East	90 (West-3) < 100 (East-1)
4	Forest East	90 (West-3) < 100 (East-2)

Table 1.7: Summary of decisions of sending gatherers

In conclusion, we should send two gatherers to Forest East and two gatherers to Forest West. The cost-benefit principle implies a general rule of allocation for a fixed amount of resources.

> *To allocate a fixed amount of resource efficiently across different production activities, we should allocate each unit of the resource to the production activity where its marginal benefit is highest.*

Correspondingly, for perfectly divisible resources, the cost-benefit principle implies a modified rule.

> *For a resource that is perfectly divisible, and for activities for which the marginal product of the resource is not always higher in one than in the others, the rule is to allocate the resource so that its marginal benefit is the same in every activity.*

To see why this rule is optimal, consider a current allocation of resource such that activity A has a higher marginal benefit than activity B. By switching a tiny amount of resource from activity B to activity A, we lose the marginal benefit from activity B and gain the marginal benefit from activity A. Since the loss in the marginal benefit from activity B is less than the gain in the marginal benefit from activity A, the total benefit will increase.

$$MB(A) \quad > \quad MB(B) \quad \longrightarrow \quad \text{Switch resources from B to A}$$

As long as the marginal benefit from the two activities are unequal at the current allocation, we can continue to switch a tiny amount of resource among the activities and total benefit will increase. This adjustment process should stop (and total benefit maximized) only if the marginal benefit is the same in every activity.

To illustrate more clearly the adjustment mechanism, let's consider two activities (1 and 2) and the amount of time or resources allocated to the two activities are $A1$ and $A2$ respectively. Further assume that MB is decreasing with the amount of activities. That is, $MB(A1)$ is decreasing with $A1$, and $MB(A2)$ is decreasing with $A2$.

Consider the initial situation, denoted as 0. We have $A1(0)$ amount of time on activity 1. We have $A2(0)$ amount of time on activity 2. We have a fixed total amount of time (denoted as K) to allocate between the two activities, i.e.,

$$A1(0) + A2(0) = K.$$

Suppose, at this initial allocation, we have

$$MB(A1(0)) > MB(A2(0))$$

or

$$MB(A1(0)) - MB(A2(0)) > 0.$$

It is beneficial to reallocate some small amount of time from activity 2 to activity 1. That is, consider the first round of adjustment, denoted as 1, we would want to have $A1(1) > A1(0)$ and $A2(1) < A2(0)$ and, of course, we should still have

$$A1(1) + A2(1) = K.$$

Consider a switch of a tiny amount of time "Δ" from activity 2 to activity 1. We know, if we increase activity 1 by one unit, we will get

$$MB(A1(0)) = TB(A1(0) + 1) - TB(A1(0)).$$

If we increase by Δ units, we will gain

$$MB(A1(0)) \times \Delta.$$

We decrease activity 2 by one unit, we will lose "approximately"

$$MB(A2(0)) = TB(A2(0) + 1) - TB(A2(0)).$$

If we decrease by Δ units, we will lose

$$MB(A2(0)) \times \Delta.$$

Since

$$MB(A1(0)) - MB(A2(0)) > 0$$

we must have

$$\Delta \times [MB(A1(0)) - MB(A2(0))] > 0.$$

What we have established here is a gain by switching a tiny amount of time "Δ" from activity 2 to activity 1.

When we do the switch, we know, because MB is decreasing with the amount of activities, we must have

$$MB(A1(1)) < MB(A1(0))$$

and

$$MB(A2(1)) > MB(A2(0)).$$

If the adjustment of the amount of activity is very small, it is possible that we continue to have

$$MB(A1(1)) - MB(A2(1)) > 0,$$

and if so, we must have

$$MB(A1(1)) - MB(A2(1))$$

closer to zero.

We can consider similar small adjustments for many rounds. Say, after n rounds, we will then have

$$MB(A1(n)) - MB(A2(n))$$

essentially equal to zero.

It is possible that we over-adjust such that

$$MB(A1(1)) - MB(A2(1)) < 0.$$

In that case, using similar logic as above, we reverse the direction of adjustment. And, eventually, we will reach

$$MB(A1(n)) - MB(A2(n))$$

essentially equal to zero.

We must remark on the two conditions:

1. The resource is perfectly divisible. Perfect divisibility means that we can consider to re-allocate any arbitrary amount of resource across activities, often denoted as Δ.

2. The marginal product of the resource is not always higher in one activity than in the others. If we have marginal product of the resource always higher in one activity than in the other, we will allocate all resources to the activity with a higher marginal product and do not want to allocate any resource to the activity that always has a lower marginal product.

Example. Allocation of a perfectly divisible resources I

After finishing homework assignments, David's father gave him an hour (or 60 minutes) to allocate between the two activities: web-surfing and newspaper reading. David's marginal benefits from the two activities are described by the two functions:

$$\begin{aligned} MB_w &= 140 - w \\ MB_n &= 200 - 2n \end{aligned}$$

where w and n are the time (in minutes) spent on the two activities respectively. Thus, $n + w = 60$. By substituting $w = 60 - n$, we have

$$MB_w = 140 - (60 - n) = 80 + n$$

Using the optimal allocation rule, we must have

$$\begin{aligned} MB_n &= MB_w \\ 200 - 2n &= 80 + n \\ 3n &= 120 \\ n &= 40 \end{aligned}$$

and

$$w = 60 - 40 = 20$$

That is, David should spend 20 minutes surfing the web and 40 minutes reading newspaper.

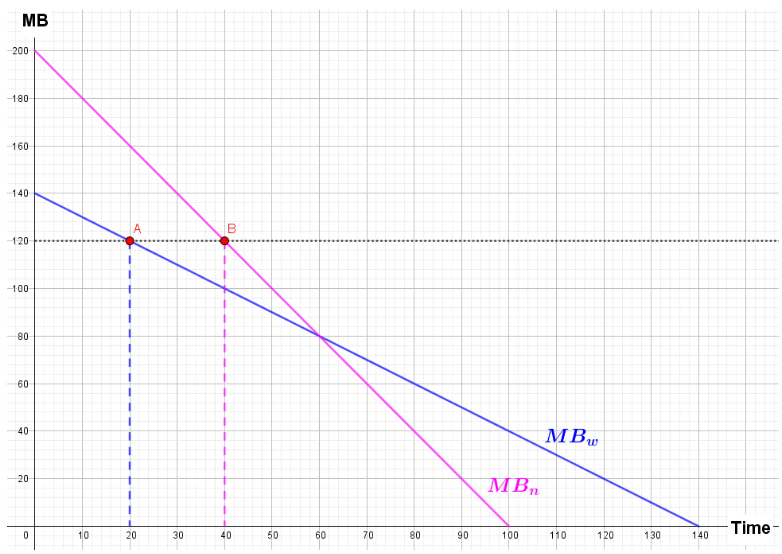

Figure 1.1: Time allocation (interior solution)

To see the importance of the second condition "the marginal product of the resource is not always higher in one activity than in the others" to the rule for allocating fixed amount of resource, we consider an example in which this second condition is violated.

Example. Allocation of a perfectly divisible resources II

After finishing homework assignments, David's father gave him an hour (or 60 minutes) to allocate between the two activities: web-surfing and newspaper reading. David's marginal benefits from the two activities are described by the two functions:

$$\begin{aligned} MB_w &= 20 - w \\ MB_n &= 200 - 2n \end{aligned}$$

where w and n are the time (in minutes) spent on the two activities respectively. Thus, $n + w = 60$. By substituting $w = 60 - n$, we have

$$MB_w = 20 - (60 - n) = -40 + n$$

Using the optimal allocation rule, we must have

$$\begin{aligned} MB_n &= MB_w \\ 200 - 2n &= -40 + n \\ 3n &= 240 \\ n &= 80 \end{aligned}$$

and

$$w = 60 - 80 = -20$$

The rule "equal marginal benefits" suggests that David wants to spend 80 minutes reading newspaper and and -20 minutes surfing the web . Of course, n cannot be larger than 60 and w cannot be negative. David can pursue the next best solution, i.e., $n = 60$ and $w = 0$. We can compute

$$\begin{aligned} MB_w(w = 0) &= 20 - 0 = 20 \\ MB_n(n = 60) &= 200 - 2 \times 60 = 80 \end{aligned}$$

That is, when David allocates all his 60 minutes on reading newspaper, he still have $MB_n > MB_w$. When $MB_n > MB_w$, he would want to re-allocate his time from web surfing to newspaper reading, but he cannot do that. In this case, because the second condition is violated, the rule of "equal marginal benefits" cannot be relied on.

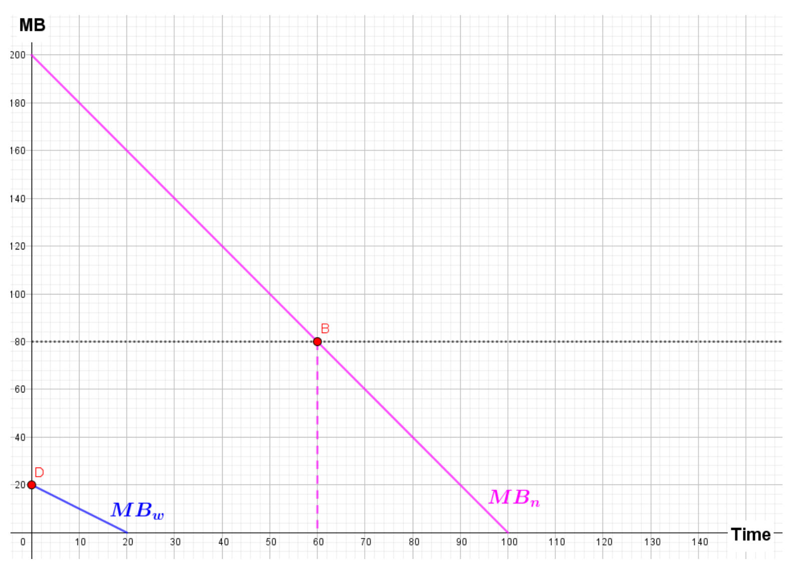

Figure 1.2: Time allocation (corner solution)

Example. Allocation of resources when the assumption of non-increasing MB is violated.

A fitness company hires 4 helpers to distribute promotional leaflets in Wan Chai (WC) and Causeway Bay (CB). The company would like to maximize the number of leaflets distributed. The following table shows the number of leaflets in a district as a function of the number of helpers deployed. For instance, when 2 helpers are sent to Wan Chai, a total of 58 leaflets will be distributed.

Number of helpers	Wan Chai	Causeway Bay
1	30	20
2	58	48
3	83	79
4	102	106
5	113	128

As a rule, we would like to compute the marginal number of leaflets distributed. It is shown below.

Number of helpers	Wan Chai	Causeway Bay
1	30	20
2	28	28
3	25	31
4	19	27
5	11	22

If we had used the allocation rule mechanically (allocate the additional unit of resources to the activity that yields a higher marginal benefit), we will conclude it is optimal to send three helpers to Wan Chai and one to Causeway Bay.

However, we can see that the marginal number of leaflets distributed is increasing in the case of Causeway Bay. As the crucial assumption for this allocation rule is violated, the allocation rule may not work. We have to consider the different combinations and compute the total leaflets distributed.

No. helpers to WC	No. of helpers CB	Total number of leaflets
0	4	106
1	3	109
2	2	106
3	1	103
4	0	102

From this table, we can see that we should send one helper to Wan Chai and three to Causeway Bay.

1.11 The difference in prices between two countries

We can use the cost-benefit principle to understand the existence of price difference across countries, with the inclusion of "shipping" cost. Consider a good (computer if you want to) sold in HK and the US. For simplicity the price of the good is quoted in US dollars. The good in the US sells at USD900. The good in HK sells at USD1000.

For a person in HK to take advantage of the cheaper price in the US, she will need to order the good and have it shipped to HK. Suppose the cost of shipping and the psychological cost of placing and following the order is x. Then, she should buy the good from the US only if $1000 - (900 + x) > 0$.

If x is larger than 100, she will not buy the good from the US. If we were the computer company selling the same computer in HK and the US and we wanted to sell the computer at different prices according to the market conditions of these two places. What price should we set in HK and in the US?

To answer this question, it would be helpful to rewrite the numbers in the question in notations instead.

Let the good in the US sells at the price of z, in US dollars. The good in HK sells at the price of w, in US dollars.

For a person in HK to take advantage of the cheaper price in the US, she will need to order the good and have it shipped to HK. Suppose the cost of shipping and the psychological cost of placing and following the order is x. Then, she should buy the good from the US only if $w - (z + x) > 0$ or $w - z > x$.

For a person in the US to take advantage of the cheaper price in HK, he will need to order the good and have it shipped to US. Suppose the cost of shipping and the psychological cost of placing and following the order is x (yes, assumed to be the same x). Then, she should buy the good from HK only if $z - (w + x) > 0$ or $z - w > x$.

Thus, the cost of shipping and the psychological cost (and probably the time cost as well) x will limit the allowable price difference in the two places.

At the extreme case of $x = 0$, we will then have $z = w$. When $x = 0$, the prices are expressed in the same currency must be the same across countries. This is in fact known as the "Law of One Price".

1.12 Inference, prediction and policy

As the basis of people's decision is cost and benefit analysis, observations of people's choice will allow us to **uncover** or **infer**, at least partially, the cost and benefit facing the decision-maker.

Suppose on his way to school, John saw a one-dollar coin on the road. He chose to ignore it. Since the benefit is clearly one dollar, his decision to ignore the coin suggests that his cost of picking up the coin is more than one dollar.

$$\begin{array}{ccccc} \text{B(pick up)} & < & \text{C(pick up)} & \Rightarrow & \text{Not pick up} \\ \$1 & & \$x & & \end{array}$$

That is, $x > 1$.

Suppose next day, on his way to school, John saw a five-dollar coin on the road. He chose to pick it up. Since the benefit is clearly five dollars, his decision to pick up the coin suggests that his cost of picking up the coin is less than or equal to five dollars.

$$\begin{array}{ccccc} \text{B(pick up)} & \geq & \text{C(pick up)} & \Rightarrow & \text{Pick up} \\ \$5 & & \$x & & \end{array}$$

That is, $x \leq 5$.

Given these two observations, we will conclude that for John, the cost of picking up a coin on the road is more than one dollar and less than or equal to five dollars, i.e., $1 < x \leq 5$.

Once we have such information about John's cost, we can **predict**, at least partially, what John will do when he sees a coin on the road. We predict that because his cost of picking up a coin is more than \$1, if he sees a fifty-cents coin on the road, he will not pick it up. Because his cost of picking up a coin is less than or equal to \$5, if he sees a ten-dollar coin, he will pick it up. What if he sees a two-dollar coin? Will he pick it up? We do not know, because we only know his cost of picking up the coin to lie between one and five dollars. The information is not enough for us to predict what he will do in this case.

$$\text{B(pick up)=\$}y \qquad \text{C(pick up)=\$}x,\ 1 < x \leq 5$$

$$\begin{array}{ccc} y \geq 5 & \Rightarrow & \text{Pick up} \\ y < 1 & \Rightarrow & \text{Not pick up} \\ 1 < y < 5 & \Rightarrow & \text{No prediction} \end{array}$$

Suppose on his way to school, John sees a plastic bottle on the ground. Will he pick it up for recycling? Suppose John does not particularly care about the environment. As his cost of picking up something on the road is between one dollar and five dollars, he will not pick it up. How to **formulate a policy** so that John will pick it up for recycling? If we make the plastic bottle to look like something more worthy than five dollars to John, he will do it. The government can do so by giving John more than five dollars whenever he picks up the plastic bottle and deposits it into a nearby bottle collection machine.

The alternative is to educate John so that some will see the benefit of recycling a bottle to be more than five dollars.

The society consists a lot of people, each with a different cost of picking up the plastic bottle. If the government pays \$5 per bottle, a lot of people will pick up bottles on the road. If the government pays \$1 per bottle, John will not do it, but somebody with a lower cost would. To keep the road free of bottles, we do not need everyone picking up the bottles, we only need some people to respond to this incentive.

1.13 Policy operates on the marginal individuals

Based on his experience, John is willing to pay $\$x$ to see a drama. The price of the ticket is $\$y$. Will he go to see the drama? The answer depends on the relative values of x and y. According to the cost benefit principle, John will go to see the drama if and only if x is larger than or equal to y or the economic surplus $(x - y)$ is larger than or equal to zero.

Suppose we lower the price of the ticket by Δ (i.e., from y to $y - \Delta$), will John change his mind? It depends on the original value of $(x - y)$.

1. Suppose $(x - y) \geq 0$. John will go to see the drama at the original benefit and cost. A lower price $(y - \Delta)$ means that John will have $(x - y + \Delta) > 0$, and hence John will continue to go. There is no change in his decision.

2. Suppose $(x-y) < 0$. John will not go to see the drama at the original benefit and cost. Depending on $(x - y)$, a lower price (y) <u>may</u> cause $(x - y + \Delta) \geq 0$, and hence John will continue to go. Let $(x - y) = w$. The new economic surplus would become $(x - y + \Delta) = w + \Delta$. It is easy to compute

$$\begin{aligned} w + \Delta &\geq 0 \\ \Delta &\geq -w \\ \Delta &\geq \mid w \mid \end{aligned}$$

   and show that there is a change in decision from "not going" to "going" only if Δ is bigger or equal to $\mid w \mid$. That is, for a given Δ, only those people with a small negative w will change their mind.

As an illustration, consider initially the price of a ticket (y) is 250 and there are several individuals with the following willingness to pay.

$y = 250$

x	100	150	200	250	300	350	400
Decision	No	No	No	Yes	Yes	Yes	Yes

If we lower the price by less than 50 dollars, say 49 dollars, there will be no impact on the decisions.

$y = 201$

x	100	150	200	250	300	350	400
Decision	No	No	No	Yes	Yes	Yes	Yes

If we lower the price by 51 dollars, there is an impact on the decisions, but only on the person with a valuation of 200.

$y = 199$							
x	100	150	200	250	300	350	400
Decision	No	No	Yes	Yes	Yes	Yes	Yes

If we want all the individuals to see the drama, we will have to lower the price by at least 150, say 151.

$y = 99$							
x	100	150	200	250	300	350	400
Decision	Yes	Yes	Yes	Yes	Yes	Yes	Yes

From this numerical example, we can see that a policy (a change in the price) generally has impact only on the decisions of individuals with a marginal valuation close to the price. If we want to induce everyone to change their decisions, we need a bigger policy (i.e., a bigger change in the price).

Note that a policy need not be a change in cost of the activity. It can also be a change in the benefit. For instance, we can advertise so that people are willing to pay more to see the drama. An effective policy will be a policy that operates relatively directly on either the cost or the benefit, or both. As an illustration of an relatively ineffective policy to encourage people to see the drama, consider giving people cash of \$100. First, such cash payment does not affect the cost of seeing the drama at all. Second, such cash payment need not have any direct impact on the benefit. The impact on the decision will be minimal, if any.

1.14 Incentives matter

In human history, it is not uncommon to relocate convicted criminals, or other persons regarded as undesirable, to a distant place – so called penal transportation.[9] The crimes committed by the criminals were not serious enough for a death penalty. Locking them up in a local prison or relocating them to a distant place appeared a good option. Perhaps partly because of its possession of many colonies around the world, England had done much of this in history. In the 1600s, it started to transport its convicts and political prisoners, as well as prisoners of war from Scotland and Ireland, to its overseas colonies in the Americas till 1776, when American Revolution broke out.

Penal transportation resumed in 1787, relocating the criminals to Australia. The British government hired sea captains to do the shipping. The captain was paid by the number criminals boarding the ship in England for Australia. While the criminals did not deserve a death penalty, the voyage ended up killing many of them. The death rate during the trip was high. On one voyage, more than one third of the men died and the rest arrived beaten, starved, and sick. The high death rate was of course not intended.

[9]For slightly more details, see https://en.wikipedia.org/wiki/Penal_transportation.

The big question is what we can do to reduce the death rate? The natural response of some administrators would be to hire someone to oversee the penal transportation operation through out the trip. The supervision on the ship is not easy. To begin with, the captain should have held such role of supervising his crew members.

To economists, the outcome of the high death rate is a result of some decisions, and decisions are results of cost and benefit analysis. In contemplation of a policy to reduce the death rate, we should start with a good understanding of the decisions facing the captain and its crew.

To decide on how many criminals to keep alive, we need to rephrase the question into marginals: Should the captain raise the number of surviving criminals on arrival by one person? The answer would be "yes" only if the benefit of doing so is higher than the cost of doing so.

Recall that the captain was paid by the number criminals boarding the ship in England for Australia. It is easy to see the benefit of raising the number of surviving criminals on arrival by one person is zero. The cost of keeping a criminal alive would involve feeding and treating the criminal well. As the benefit is lower than the cost, the captain would not attempt to do so.

Seeing such benefit and cost, we would conclude that an increase of benefit would induce the captain to raise the survival rate. A simple change in the payment will do the job: Pay the ship captains by the number of living convicts on arrival. The benefit of keeping one additional convict alive is raised. Thus, the captains will likely keep more criminals alive.

The impact of such policy switch is amazing. After the ship captains were paid per living convict on arrival, the death rate fell from over 33% to less than 1%.[10]

By changing the structure of cost and benefit, the captain and his crew will have the incentive to do what we intend them to do. This seemingly simple and effective policy looks trivial to students with a good exposure to cost and benefit analysis, but it in fact took many years for people to discover and convince the government to adopt.

When we have a policy that provides correct incentives, we do not need to do too much supervision. Instead of close supervision, the government officials can use their time to do something else.

An institution consists of a set of rules and incentive mechanisms. With the right incentive mechanism, individuals will choose to do things as designed by the mechanism. The government officials would not need to micro-manage the behavior of individuals.

1.15 Misunderstanding about the study of Economics

There are several common misunderstandings about the study of Economics.

1.15.1 Economics is useless because its assumption of rationality is not realistic.

We assume decision-makers are rational. That is, they have a well-defined goal and they do the best to achieve the goal. The cost and benefit analysis is a guiding principle. We should view the assumption of rationality as a working assumption. Some people may not be rational, but over the years, this working

[10]For more details, see Ekelund, Robert B. Jr., and Edward O. Price III: *The Economics of Edwin Chadwick: Incentives Matter*, Edward Elgar Publishing, Inc

assumption seems helpful in explaining the behavior of most decision-makers in most situations. In recent years, there are branches of Economics that deviates from this rationality assumption. They had some success in explaining the behavior of some decision-makers in some situations. In our course of studying Economics, we consider it important to start with the rationality assumption and study it well before moving on the other branches, such as Behavioral Economics.

1.15.2 Economics cares only about money.

True, in economic analysis, we talk about money all the time. But, more precisely, we are using money as a numeraire or a common measurement. For instance, in conducting cost and benefit analysis, if we say the cost of an action is three apples and the corresponding benefit is two oranges, we would not be able to compare the cost and benefit and reach a decision. We need to have the same unit of measurement! If the cost of an action is three apples, the corresponding benefit is five apples, we would conclude that a rational decision-maker will take the action. If we are given that the price of apples is \$2 per apple, we can then convert the unit of measurement to dollar: the cost is \$6 and the benefit is \$10. The conclusion "a rational decision-maker will take the action" remains unchanged.

We do not need to use money to measure costs and benefits but we definitely have to adopt the same unit of measurement for the costs and benefits in any given question.

1.15.3 Economics is bad because it teaches people to become selfish.

The decisions of rational individuals will be guided by the cost and benefit facing them. That gives people the impression that people are assumed selfish.

First, please understand that selfishness needs not be bad. When people are allowed to pursue their self-interest, via the market, the whole society can benefit. It is exactly because the apple growers wants profit, we are able to get our apples. It was because Mr. WONG Wai Kay, Ricky of the City Telecom wanted profit, he engineered the call-back service in Hong Kong and hence a lower rate of international calls benefiting all of us.[11] The whole society benefited not because these people love us – it is because of their pursuance of self-interest. Adam smith had discovered this, termed the ***invisible hand***, centuries ago.

> "It is not from the benevolence of the butcher, the brewer, or the baker that we expect our dinner, but from their regard to their own interest."
> – Adam Smith, *The Wealth of Nations*

Many students see only Adam Smith's *The Wealth of Nations* but ignore his other important book *The Theory of Moral Sentiments.* In *The Theory of Moral Sentiments*, Adam Smith emphasized sympathy for others.

We certainly understand that in certain situations, the pursuance of self-interest can cause mutual destruction. An example would be the well-known prisoner's dilemma game in which all players will choose the strategy of cheating (more later). One reason of such mutual destruction is the lack of

[11] For more details, see https://en.wikipedia.org/wiki/Ricky_Wong_(Hong_Kong_businessman).

trust and commitments. Such commitment problems may not be solved by altering the relevant material incentives, but it may nonetheless be possible to solve them by altering people's psychological incentives. That is, through education, we learn to be sympathetic, care about others, and have a guilty feeling when we deviate from the social norm. In essence, education changes our benefit and cost of doing things, via a change of our psychology.

Second, please understand that we do not teach people to become selfish. We teach people to become more mindful of their decision-making.

Cost and benefit can be complicated objects although we do not include such complication in most of our discussions. While the cost and benefit of a profit-maximizing firm can often be relatively objectively measured, the cost and benefit of a person depends on a lot of factors, such as taste or preference. Taste or preference reflects our genes and an accumulation of education and our upbringing.

Suppose I am concerned about the environment. In deciding whether to buy a plastic bottle of water, I would take into consideration the impact of my purchase decision on the environment. Such consideration will influence the cost or benefit, and hence my purchase decision.

For someone who is considerate about his voice on other passengers in the MTR coach, in deciding whether to speak loudly, his cost and benefit of speaking loudly will include the impact on other passengers in the MTR.

In fact, Economics does not teach us to be selfish. Indeed, it is not difficult to find some economists doing volunteer work!

Often ignored, Economics also teaches us to accept and recognize our differences. By studying Economics, we should be able to understand why different people make different decisions in seemingly the same situation. Even if we see the same five-dollar coin on the road, some will pick it up, some will not. The difference in decision is a result of different costs of picking up the coin across individuals.

Taking the same course of Introductory Microeconomics, some will choose to study hard and some will not. The difference in decision is a result of different benefits and costs of studying across individuals. These difference in benefits and costs are due to various factors facing the individuals, often unknown and difficult to quantify to an observer.

Please keep in mind that all decisions are due to some underlying benefits and costs that are simply reflection of taste and constraints. Given different tastes and constraints, it is normal for people behave differently from us.

1.16 Interpretation of survey results

In surveys, we are often asked simple questions like "Do you want an apple?" To economists, such survey results have little information content and should be interpreted carefully.

Suppose everyone of the 100 persons surveyed answers "yes" to the question. Assuming that everybody can at most buy an apple, as an apple seller, how many apples do you expect to sell if you charge \$5 per apple? It will be likely less than 100. The reason is that when people answer such questions, they will implicitly assume a zero cost for the apple. All would answer "yes" because their benefit from an apple is larger or equal to zero. But, when the price/cost is positive, many of them with a low benefit will not buy. Do we know how many will buy when the price is $5 per apple? We do not have enough information to conclude.

For the purpose of estimating how many people will buy an apple at the price of x, when economists do a similar survey, they will ask “How much are you willing to pay for an apple?”

Suppose everyone of the 100 persons surveyed said “3 dollars”. As an apple seller, we would expect to sell zero apples if we charge $5 per apple.

Suppose the 100 persons surveyed said “0.1 dollar” to “10 dollars”, uniformly distributed. As an apple seller, we would expect to sell 50 apples if we charge $5 per apple.

When we are told that $y\%$ of people surveyed said they like to have A, interpret the statement as $y\%$ of people surveyed said they like to have A when the cost of A is zero. When people realize that the cost of A is much higher than zero, the percentage of people who would like to have A will drop substantially – much less than $y\%$.

Keep this in mind when reading survey results.

1.17 Positive versus normative statements

When we use an economic tool to predict what people will do, we are making a positive statement. When we use an economic tool to tell what people should do, we are making a normative statement. The same economic tool of course can be used to make both positive and normative statements. For instance, we can use the cost and benefit analysis to predict whether an increase in a tax on cigarettes will reduce consumption of cigarettes.

We can also use the cost and benefit analysis to suggest to the government whether we should build an additional cross-harbour tunnel.

The worst thing to happen is, we make a judgment without any supporting argument based on logical reasoning of cost-benefit analysis.