Lecture 3:
Scarcity, Work and Choice

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Goal

- Labor and production function
  - diminishing average product of labor
  - diminishing marginal product of labor
- Preferences and utility
  - Indifference curves
  - Relative price
- Opportunity Cost
- Budget Constraint
- Decision Making and Scarcity
- Income and Substitution Effect

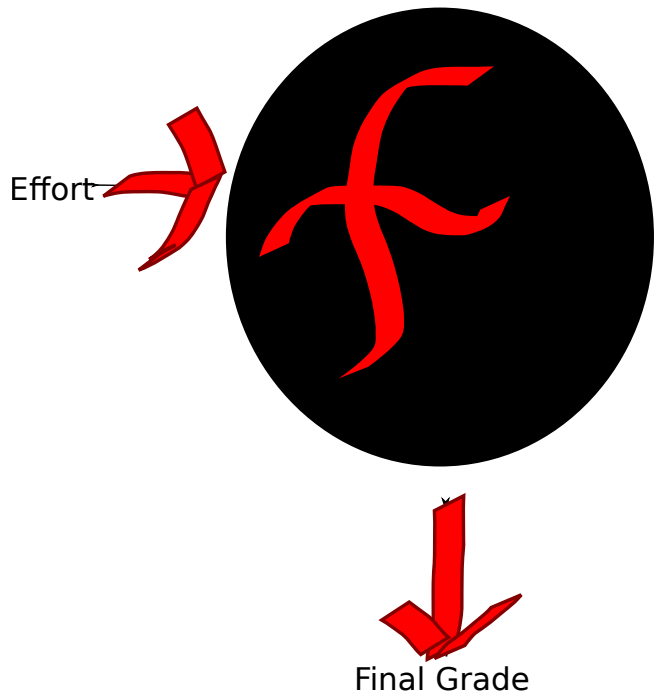
Part 1. Labor and Production Function

- As mentioned in Lecture 2, labor is an input that goes into the production function. In words, labor can be explained as work done
  - eg. fixing up a car, doing your homework, welding
- Student as a labor. You, as a student, put in a lot of work as well. You come to class, do your homework, take exams – these are different forms of labor. One choice a student needs to make is – how many hours to study (effort)?
  - This can be determined by two factors: 1) How much do you want to learn (or the grade you want to receive); and 2) the returns that you receive after you put in an additional hour of work in.
- So, lets try and come up with a simple model to see how many hours to study, under an assumption that more effort you put in better the final grade will be. Let's take Maya as an example.

Maya's Production Function

- Maya's production function maps her effort to the final grade.

Figure 1: A figurative portrayal of a production function



Effort or hours worked is an input. It goes into the production function as defined by f and gives the output (final grade).

Maya's Production Function

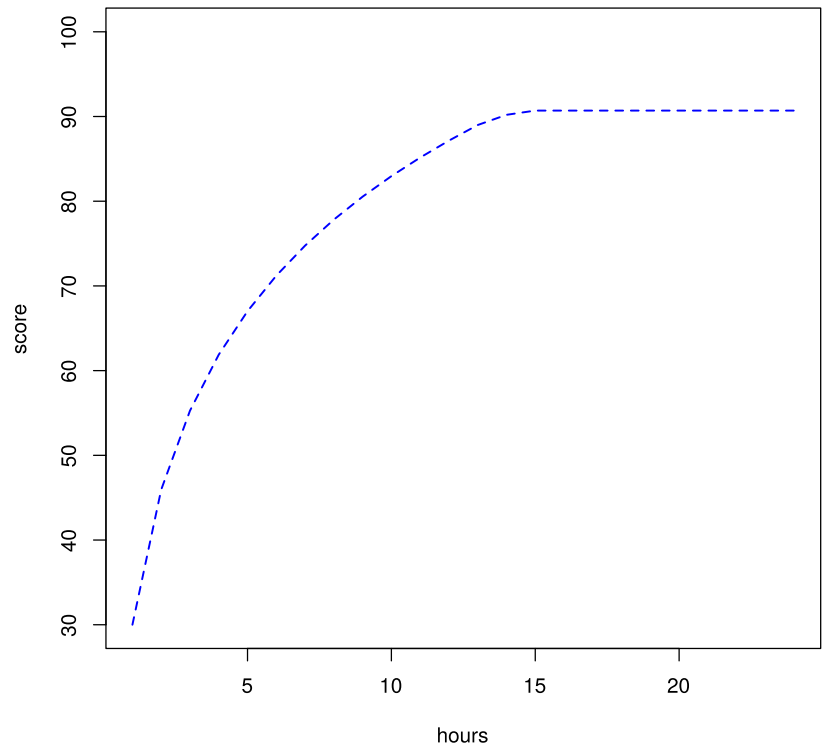
hours	score
1	30
2	46
3	55
4	62
5	67
6	71
7	75
8	77
9	81
10	83
11	85
12	87
13	89
14	90

hours	score
15	90
16	90

Starting from the 15^{th} hour,her score remains the same.

Plotting Maya's Production Function

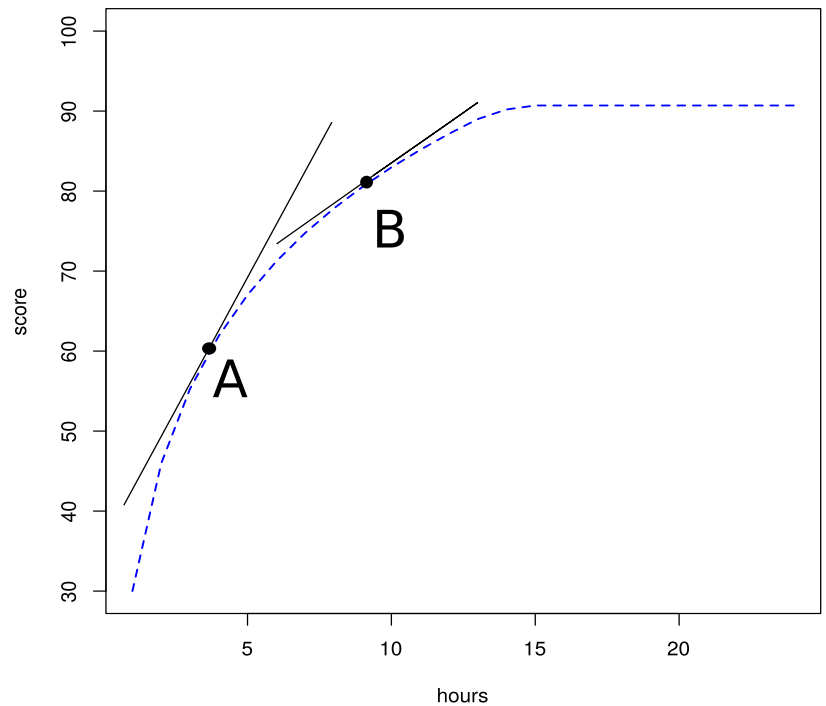
Figure 2: Production Function of Final Grade



The relationship between Maya's hours spent studying and score from the previous slide is plotted. Note that curve is bowed outside. In mathematics, we say this is a concave curve. We observe that the curve that shows the relationship between X number of hours spent studying and final score is steeper at first. As the number of hours spent studying keeps increasing, the curve then gets flatter and flatter. In mathematical sense, the slope of the curve at a given point is ever changing (not constant) and it decreases as hours spent studying increases.

Plotting Maya's Production Function

Figure 3: Production Function of Final Grade



The concept of slope is further explained by this figure. The slope of the curve at points A and B are given by the tangential lines that goes across points A and B, respectively. A tangent in relation to a given point in the curve is defined as a line such that the line only touches that given point of the curve. Here, slope of the tangential line A is steeper than tangential line B. This has very important implication in economics. What it says is that an increase in score from studying an addtional hour is higher at point A compared to point B. This is termed as the marginal product of studying. The marginal product of studying an additional hour at point A is 5 points, whereas the marginal product at point B is 2 points.

Marginal Product

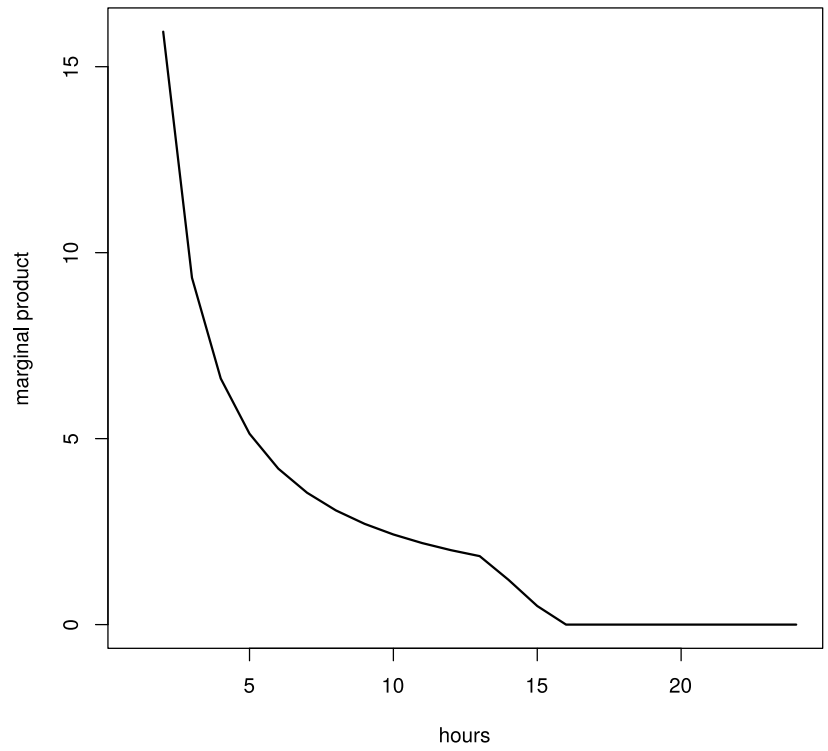
- Marginal Product: refers to increase in score from an additional hour spent studying
- Note that the marginal product is decreasing as hours stuyding increases
- Diminishing Marginal Product: The concept of reduction in marginal product as hours studying increases. Let's calculate this using a sample of the production chart.

hours	score	marginal product	Average product
1	30		$\frac{30}{1} = 30$
2	46	46-30=16	$\frac{46}{2} = 23$
3	55	55-46=9	$\frac{55}{3} = 18.33$
4	62	62-55=7	$\frac{62}{4} = 15.5$

If you keep calculating the marginal product for other hours, you will find that the marginal product after the 15^{th} hour is zero. You should also see that the average product $\frac{score}{hours}$ is decreasing. There is a relationship between the marginal product and average product. As the marginal product is decreasing, average product is also decreasing. What would happen if the marginal product was increasing?

Maya's Marginal Production of Studying

Figure 4: Marginal Product



Using the production function chart, please verify that Maya's marginal product of studying looks like the figure above.

Practice Question 1: Convex Production Function

1. Draw a graph to show a production function that, unlike Maya's, becomes steeper as the input increases.
2. Can you think of an example of a production process that might have this shape? Why would the slope get steeper?
3. What can you say about the marginal and average products in this case?

Practice Question 2.

- Say Maya gets a score of 0 is she does not spend any time studying. Based on this information and her production function chart, which of the following is true.

1. The marginal product is greater than the average product for the first hour.
2. The marginal product is zero but the average product keeps decreasing beyond the 15^{th} hour.
3. Slope of the production function is never equal to zero.
4. The average cost can rise even if the marginal cost falls.

Part 2. Preferences

- How many hours Maya spends studying depends on her preferences of how much she values getting a good score vs. something she lets go of while spending time studying.
  - This is a good time to introduce opportunity cost.
  - Note that if Maya only cared about grades, she would be studying 15 hours a day. However, Maya also cares about having free time for herself.
- Opportunity cost: Say, Maya values getting a good score and free time. In order to get a good score, she needs to study, but if she spends more time studying her free time will be diminished. Hence, she faces a trade-off. So in economic term, there is an opportunity cost of studying. For example, if she spends an additional hour studying, then she will have one less hour of free time.
  - Can you think of other examples of opportunity cost. What are some opportunity cost of going to a four year college?
  - I will provide more detailed discussion regarding opportunity cost in the next section.
- Now, getting back to preferences, what we need is a combination of score and free time that Maya would want to have, such that Maya is indifferent to any one of those combinations. We call this a set of preferences.

Preferences

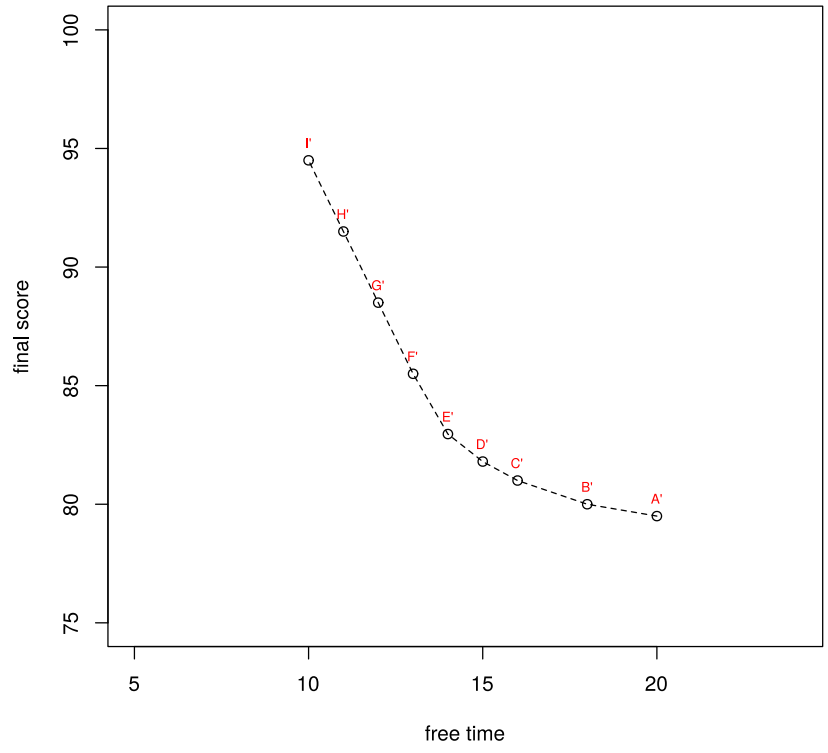
- Maya's preference set can be given by the table below:

Final Score	79.5	80	81	81.8	83	85.5	88.5	91.5	94.5
Free Time	20	18	16	15	14	13	12	11	10
Combination	A'	B'	C'	D'	E'	F'	G'	H'	I'

- Note that every one of these preference points are different and it is strictly from Maya's perspective, i.e, what she would like to have. However, not all of the points that she would like to have are feasible or practical.
- Moreover, a point to note here is that any point in her preference set will make her equally happy. Does not matter if she has {79.5 score, and 20 hours of free time} or {94.5 score, 10 hours of free time}, she would be equally happy.
  - In otherwords, Maya is indifferent about the points as highlighted in her preference set.
- Next, we plot the points in the preference set to obtain an indifference curve.

Indifference Curve

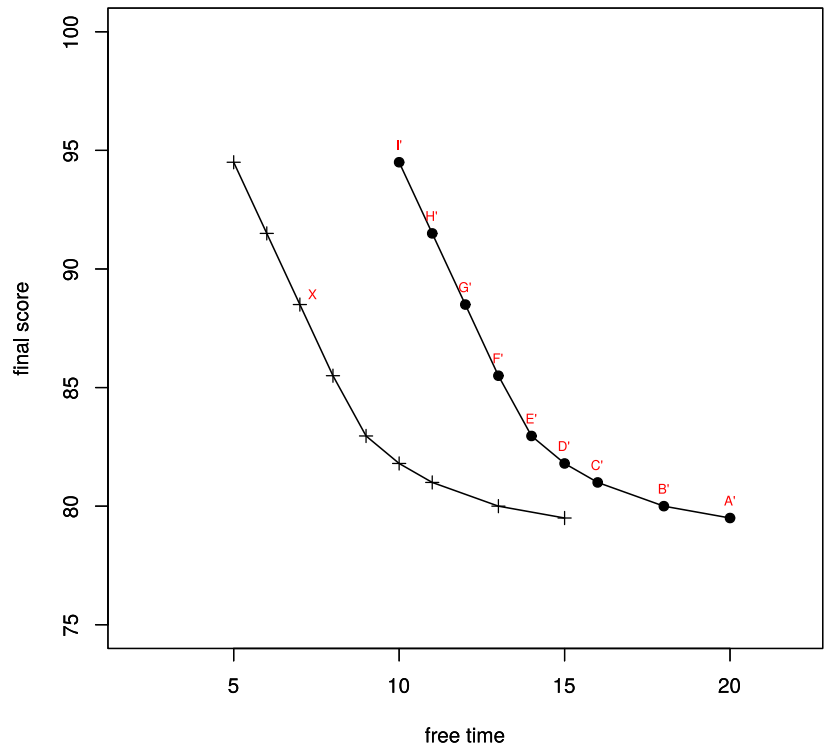
Figure 5: Indifference curve based on Maya's preference set



The figure above shows plots Maya's preference set, such that Maya is indifferent of any point on the curve. Hence, this curve is also know as the indifference curve. Any point on the curve gets Maya the same level of happiness or satisfaction. An economic term for happiness is **utility**.

Comparing two Indifference Curves

Figure 6: Indifference curve based on Maya's preference set



Here, we are comparing two sets of preference sets or indifference curves. One on the right is the same as depicted in Figure 5, and I have generated the indifference curve on the left. It can be seen that at any two adjacent points on the curves, Maya would prefer to be at the right most indifference curve compared to the one on the left. Let's compare two adjacent points X and G'. Here, being at G' yields higher level of free time for the same score.
Note that the basics indifference curve is still relevant – any point on a given curve yields the same utility. Hence, according to this argument, the indifference curves on the right, precisely the northeast direction, yields higher utility.

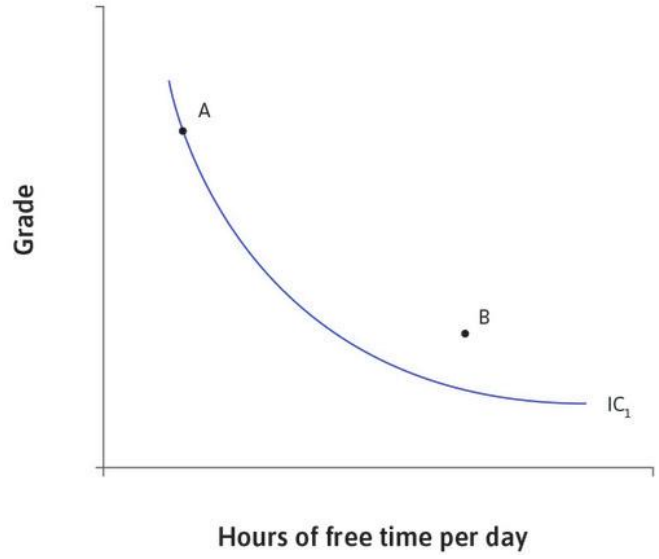
Some important traits of an indifference curve

1. Any point on the curve yields the same level of utility.
2. Is always sloped downwards due to trade off.
   - For example, to increase free time, Maya needs to sacrifice her score.
3. Are continuous in nature.
   - smooth
4. The slope of the indifference curve changes over the curve.
   - For example, as you move towards the right of the curve it becomes flatter. What does this mean?
5. An difference curve towards the right or northeast direction is always the better one.
   - This follows from comparison between two indifference curves as shown in Figure 6.

Marginal Rate of Substitution and IC

- To understand point 4 from the previous slide, we need to know what the marginal rate of substitution (MRS) implies.
- MRS: This is just how much of final score does Maya need to give up to gain an additional hour of free time. It basically is a way to track the rate of substitution between her final score and free time.
- Note that in Figure 5 at point I', Maya is willing to give 3 points of her final score to gain one additional hour of free time. However, at point B', when her free time is already high, she is only willing to give 0.25 (0.5 for 2 hours, so 0.25 for an hour) for an additional hour of free time.
- Hence, rate of substitution (how much of score is she willing to give away for an additional hour of free time) varies over the curve. It is based on quite elementary concept – if you have very high score that means you would have relatively few hours of free time (due to trade off). Hence, you would easily give away some of your scores for sake of free time. But if you are at a point where your score is low, you would be hesitant to give away that equal amount of score for the same gain in free time – you would want more free time for the same loss in score.

Practice Problem 3.1



Consider the following indifference curve. Asnwer the following questions.

1. Does combination B give higher or lower utility than combination A? How do you know?
2. Draw a sketch of the diagram, and add another indifference curve, IC2, that goes through B and crosses IC1. Label the point at which they cross as C.
3. Combinations B and C are both on IC2. What does that imply about their levels of utility?
4. Combinations C and A are both on IC1. What does that imply about their levels of utility?
5. According to your answers to (3) and (4), how do the levels of utility at combinations A and B compare?
6. Now compare your answers to (1) and (5), and explain how you know that indifference curves can never cross.

Practice Problem 3.2 Your MRS

- You are offered a job at the end of your university course with a salary per hour (after taxes) of £12.50. Your future employer then says that you will work for 40 hours per week leaving you with 128 hours of free time per week. You tell a friend: 'at that wage, 40 hours is exactly what I would like.

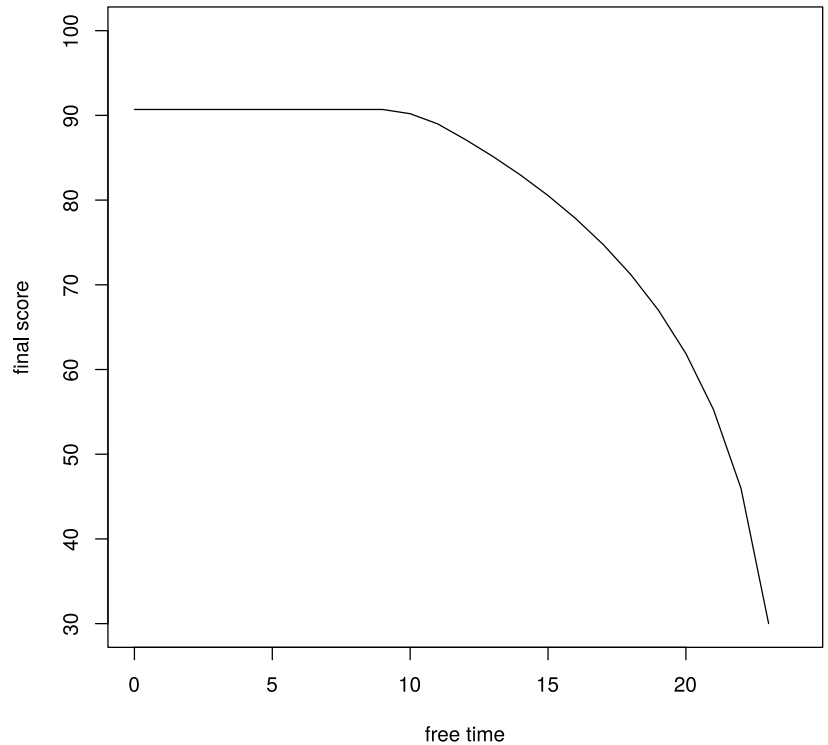
1. Draw a diagram with free time on the horizontal axis and weekly pay on the vertical axis, and plot the combination of hours and the wage corresponding to your job offer, calling it A. Assume you need about 10 hours a day for sleeping and eating, so you may want to draw the horizontal axis with 70 hours at the origin.
2. Now draw an indifference curve so that A represents the hours you would have chosen yourself.
3. Now imagine you were offered another job requiring 45 hours of work per week. Use the indifference curve you have drawn to estimate the level of weekly pay that would make you indifferent between this and the original offer.
4. Do the same for another job requiring 35 hours of work per week. What level of weekly pay would make you indifferent between this and the original offer?
5. Use your diagram (Figure 2) to estimate your marginal rate of substitution between pay and free time at A.

Part 3. Feasible Set

- Note that just because Maya has her set preferences as given by the preference chart (portrayed in Figure 5) does not mean that she will be able to obtain all of the points on her preference set.
- The points that are feasible or attainable depends on her production function. Note that her production function is given in the production function chart and presented in Figure 2.
  - The production function graph in Figure 2 has input (hours studying) on the x-axis and output (score) on the y-axis.
- What we want to do is plot feasible score and feasible free time for Maya.
  - In order to calculate feasible free time, you just do
    free time $=$ 24-hours spent studying.
- Next, we plot Maya's feasible free time (on x-axis) and scores (on y-axis).

Plotting Feasible Set

Figure 7: Indifference curve based on Maya's preference set



Here, we plot score on the y-axis and available free time on the axis. This gives a frontier that we call the production possibility frontier (ppf). Any point on or to the left of the frontier is attainable or feasible. However, points to the right of the frontier are unattainable. Maya is using her resources efficiently if she is on the frontier. The frontier is a constraint on Maya, as she cannot choose points to the right of the frontier.

PPF and Opportunity Cost

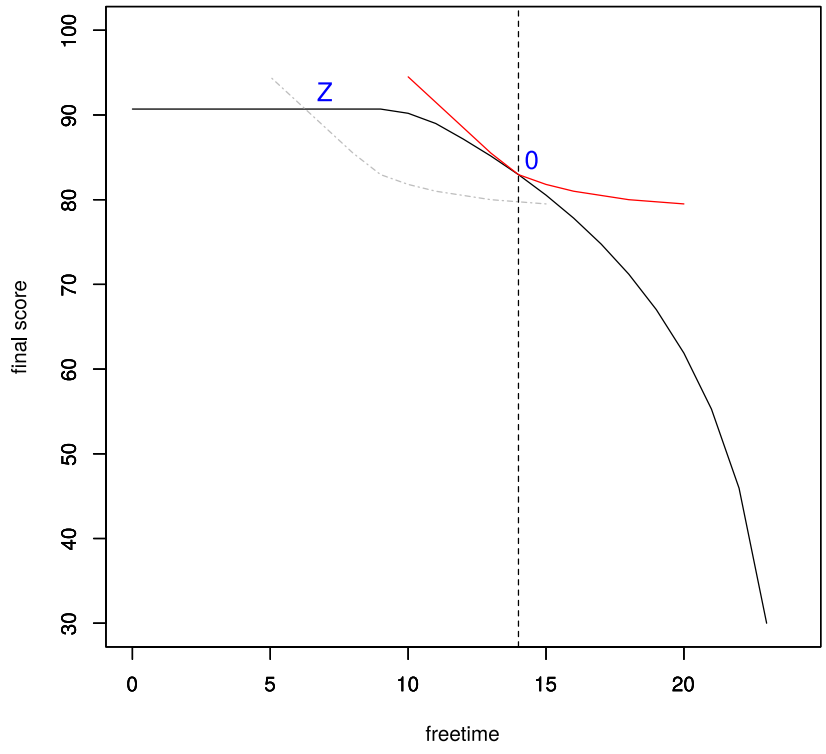
- The PPF further explains the concept of opportunity cost. Past the 10^{th} hour, in order to get an additional hour of free time, she needs to let go of some score points.
- Also, the opportunity cost of gaining an additional hour of free time increases as you have more and more of free time. This can be seen as the slope of the curve getting steeper as you move towards the right.
- The points outside of the ppf are not attainable with the current process of production.
- Points inside the ppf can be attained if resources are not being used to the maximum capacity.

Part 4. The optimal decision and scarcity

- Let's revert to the question: How many hours should Maya spend studying?
- We almost have the answer now. It depends on *i*) her feasible set of final score and free time given by the production possibility frontier (ppf), and *ii*) preference set, given by the indifference curve.
- What we have here is a constrained choice problem, where the constrain is the ppf.
  - The optimal decision is when
    MRS (marginal rate of substitution)=MRT (marginal rate of trasformation)
  - Note that we know MRS is the slope of the indifference curve. Now, MRT is the slope of the ppf, which measures the trade-off due to the constraint.
- Lets look at this graphically. We put Maya's ppf and her indifference curve together on a graph in Figure 8 (next slide).
- The ppf is given by the black curve and the IC is the red curve. The indifference curve is tangential with the ppf at point O' – this is the point where Maya's preference meets her production capacity. As you should note that other points on her IC are outside of her ppf, and are hence unattainable.

Optimal Points

Figure 8: Optimal Decision



As it can be seen, the lower IC (the grey one) also intersects Maya's ppf at point Z. Why is Z not optimal for Maya? hint: think about the positioning of the grey indifference curve in relation to the red one.

Conclusion I

- We have seen a simple but practical way of modeling one's decision under scarcity
- We looked at indifference curve and ppf and how these are graphically put together
- The optimal point lies where MRS=MRT.