CM3: THE PRODUCTION POSSIBILITIES CURVE (3/24/21)

MOST, BUT NOT ALL OF, WHAT YOU SHOULD KNOW

1. What is the difference between a diagram and a picture?

2. Why does Sleemania only produce two goods or services?

3. When choosing the two goods or services what must be true of our classification?

4. How are A2 and A3 related to scarcity?

5. What, in our toy model, is meant by efficient production?

6. Is the US economy operating at full employment and full capacity in April 2017?

7. If A2 and A3 hold why can we only produce more of one good or service if we are willing to sacrifice some of the other good or service?

8. What is a Production Possibilities Curve (Frontier)?

9. Why does the PPC slope down to the right (has a negative slope)?

10. How is opportunity cost illustrated by the PPC?

11. Why is the PPC not a straight line?

12. What assumption does the PPC make about the marginal costs of both goods?

13. Why are Zimbabwe and Venezuela likely to be producing inside of their PPCs?

14. What would cause Germany to produce within its PPC?

15. What things cause the PPC to shift to the right and what would cause it to shift to the left?

This Commentary is straight textbook economics. There is a lot of material on the web, especially on YouTube if you need more help. It illustrates the ideas in CM1 with the aid of a very simplified diagram.

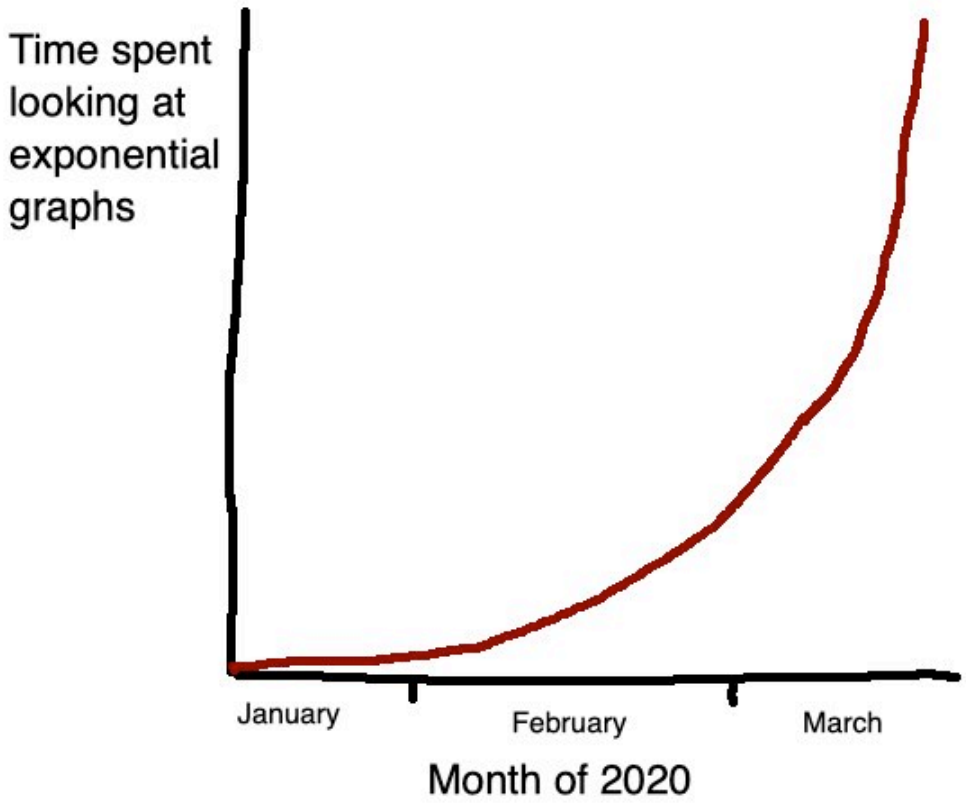
1. DIAGRAMS

1. Starting with CM3 we will begin to use a lot of diagrams. The diagrams are designed to help you understand the theory; therefore, they usually don't have numbers on the axes, and if there are numbers then they have been made up to illustrate the point being made.

Although some of you are "diagram shy" you have to get used to diagrams because they are the way economists have explained what they do to non-economists for the last one hundred and fifty years. You will find them easier than algebra and calculus.[1] Many of you would like to do everything using numerical examples, but they take far too much time.

2. *A diagram is a visual representation of a table of numbers.* As I wrote in CM1 a diagram is ***not*** a picture. *A diagram is a visual calculating device*; it tells you where you are on one axis, when you know where you are on the other axis. The diagram converts a table into a visual form where the relationship between the variables may be clearer; our eyes and brains are good at recognizing patterns. This chart from the Chart Porn site is easy to read. It would require a very large table to convey the same information in numerical form.

[1] If you are competent with algebra and calculus then try translating the arguments into mathematical form. If you are really interested then have a look at the ECON 208 Manual that is posted on the website.



3. Most economic variables take only non-negative (positive or zero) values and so my graphs will not usually have axes with negative sections.[2]

4. Diagrams live in two-dimensional surfaces (a sheet of paper or a white board) and so, because we rely on diagrams at the ECON 206 level, we will concentrate on situations in which there are only two variables. Professional economists deal with systems with *very* large numbers of variables but that requires the use of math.[3]

[2] Technically the variables are represented by real numbers (if you know what that means) and so X and Y can take values such as 1.41421356237… dollars and 2π million cans. We want to avoid holes on the axes. We are implicitly assuming that all goods and services are infinitely divisible and that economic agents are infinitely discriminating. Real numbers allow economists to use calculus, which makes the math we do much easier for us.

[3] In general, if you can prove a mathematical theorem for the case three variables then you can usually generalize the result to an arbitrary number of variables. But if you can only prove your

5. When using diagrams beware of *special cases* that may have properties that not be true in general. For example, we all have a tendency to draw curves with the same absolute slopes, usually at about 45^0, and to shift curves by the same absolute amounts, but that can be misleading and is almost certainly not representative of real economies. (This will make more sense when we move on to discuss the supply and demand model.)

2. THE PRODUCTION POSSIBILITIES CURVE (PPC)[4]

1. The PPC diagram represents an *extremely* stylized economy – the benign Tyranny of Sleemania. The purpose of the diagram is to illustrate some of the concepts that we discussed in CM1 and so it is ***not*** meant to be a realistic representation of a real-world economy such as the US economy – it is what economists call a "toy model".

This quarter you cannot see me draw the diagrams. You must get into the habit of drawing the diagrams yourselves. Plot the horizontal axis and label it. Plot the vertical axis, label it, and mark the origin – where both X and Y are zero. Plot one curve and think about why it has the slope that I gave to it (positive or negative). Usually curvature is not very important at the level at which we are operating, but in the case of the PPC the curvature/shape results from one of our assumptions (A6). Plot the other curve if there is one.

2.1 ASSUMPTIONS:

(A1) *There are **only two goods***: (This is because we are drawing our diagrams on a two-dimensional surface: see footnote 3.) Conventionally the horizontal axis is labeled X and represents the independent variable – the one doing the causing, and the vertical axis is labeled Y and it is often assumed that Y is caused by X. (But the variables on the X and Y axes in the PPC diagram are interchangeable. When we discuss supply and demand I will write more about how to think about the relationship between the variables on the two axes.) The goods and services can be anything that you choose *so long as they represent everything that is produced by the economy*: agricultural goods and services versus non-agricultural goods and services; privately produced goods and services (cars) versus publicly produced goods and services (roads); guns versus butter; goods

result for the two-variable case then there is no reason to suppose that the result holds for three or more variables, although it may do so.

[4] The Production Possibilities curve is also called the Production Possibilities Frontier (PPF).

versus services[5]; industrial output versus non-industrial output; traded goods and services versus non-traded goods and services; etc. The benign Tyranny of Sleemania ***only*** produces X-rated videos and yoyos. (You can choose to think in terms of Xylophones Zithers if you find my humor too broad for you.)

We plot X-rated videos on the horizontal axis, labeled X, and yoyos on the vertical axis, labeled Y. (In this diagram the X variable does not cause the Y variable, or vice versa.)

The point where the two axes meet, where X = 0 *and* Y = 0 (where Sleemania is not producing any X-rated videos nor any yoyos) is called the origin. (I am not going to bother about the scales and so while I will talk about producing an extra X or Y this might mean 1, 100, 1000, or a million units.) (See Figure 1.)

(A2) *There is a* ***fixed quantity of inputs*** – land, labor, capital, and entrepreneurship – and so the analysis applies to a short period of time, a year. Remember that capital means *physical* capital not financial capital. In the long run, say longer than a year this assumption becomes less and less realistic.

(A3) *There is* ***a given technology*** (again the short-run). In the long run, say longer than a year this assumption becomes less and less realistic.

(A4) ***Production is efficient*** (we produce the maximum value of output for a given cost of inputs, or minimize the costs of inputs to produce a given value of output). Economies like the US, Canada, Western Europe, Japan, the east coast of China, the western parts of Russia, South Korea, Hong Kong, Singapore are what we call advanced industrialized economies (AICs). We would expect them to utilize their scarce resources efficiently. But centrally planned economies (N. Korea, Cuba) and many members of the old Soviet bloc, and less developed countries (LDCs) in general – Africa, central and south America, south-east Asia – do not use their resources efficiently.

[5] You are probably becoming aware of how important the service sector is for US employment. About 85% of the labor force is in service industries, which do not make something physical: education, retailing, medical, entertainment, exercise, etc.

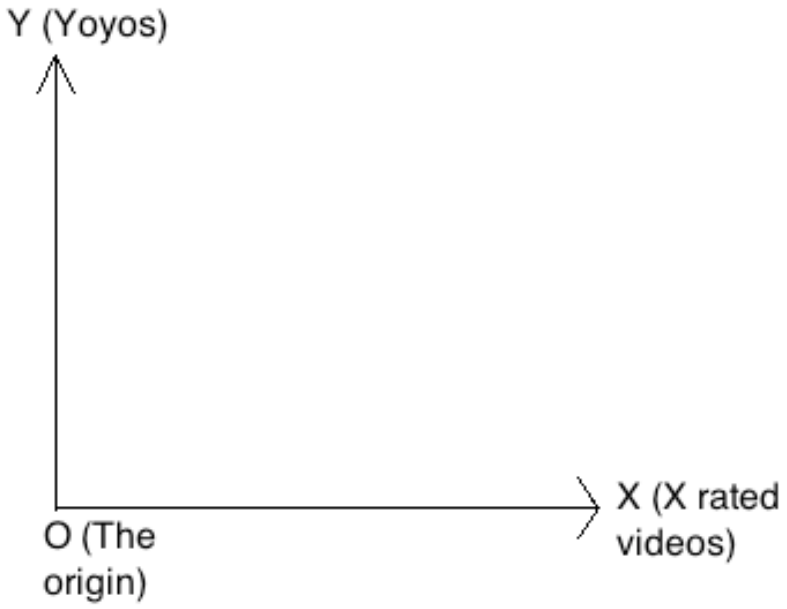


Figure 1

(A5) *There is* ***full utilization of the inputs*** – full employment of labor and no spare capacity (no unused capital equipment) – a questionable assumption even in 2019, and because of the virus totally unrealistic in early 2021 when I am revising this Commentary.

(A6) ***Differential productivity*** – some units of the inputs are better at producing X-rated videos and others are better at producing yoyos; inputs that are good at producing X-rated videos are assumed to be poor at producing yoyos and vice versa.

3. At the origin there is zero production of both commodities: X=0 and Y=0. If we now decide to produce X-rated videos then we will move rightwards along the X-axis until we reach a point of maximum output, which we label X_{max}. Because A2 and A3 are binding constraints on what we can produce – Sleemania suffers from scarce resources and has a fixed technology – we can only produce a finite amount of X. Alternatively if we decide to produce only yoyos then we move up the Y-axis to a maximum point Y_{max}, where there is no X-rated video production. (See Figure 2)

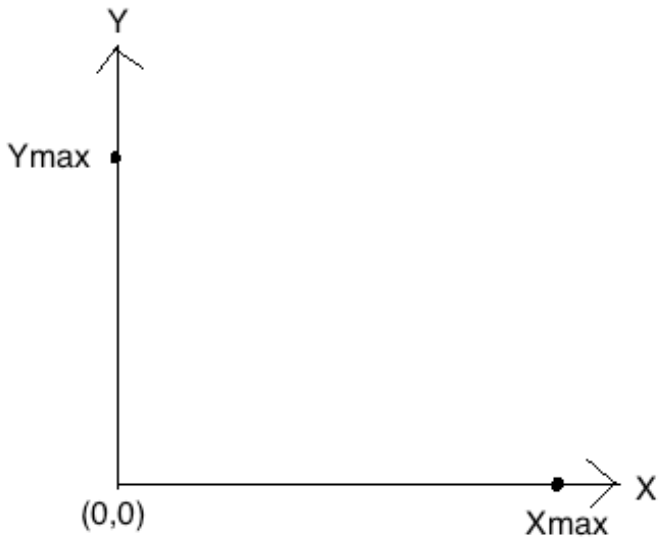


Figure 2

4. It is a basic assumption of economic theory, which seems to be consistent with what we observe in real economies, that *people prefer combinations of goods and services (of X-rated videos and yoyos) to just one good or service*. It is therefore very unlikely that if we start at Y_{max} we will want to stay there, after a while we will get tired of playing with ourselves. But we cannot move horizontally to the right or anywhere to the northeast because of A2 and A3. If we want some X-rated videos then we will have to give up some yoyos – we have to trade-off yoyos to get some X-rated videos. The PPC slopes downward as we increase the output of X-rated videos, i.e. (that is), move to the right along the X-axis; *the PPC slopes downward to the right*. This negative slope is the consequence of the scarcity of inputs.

Initially we lose very few yoyos as we switch production to X-rated videos but as we continue to do so the curve gets steeper and steeper until we reach the X-axis at X_{max} where the curve is close to vertical. (*The curvature is a consequence of A6* – see below.*)* If the line joining Y_{max} to X_{max} was a straight line then we would have constant (opportunity) costs of production, which is ruled out by A6.

Say you are taking only ECON 206 and PSY 301. You only have z hours to study (the university still makes the quaint assumption that you study two hours for every hour in class, which means that if you take 15 credits then you should spend 45 hours a week on you university courses). But an hour is an hour, whether you spend it on ECON 206 or PSY 301. The rate at which you can

substitute (trade-off) hours of studying is 1 to 1. This means that your studying PPC is a straight line with a negative 45^0 slope.

5. The curve joining Y_{max} to X_{max} is called the Production Possibilities Curve [PPC] or the Production Possibilities Frontier [PPF]. *The PPC shows us the maximum amount of one good or service that can be produced given the output of the other good or service, assuming that all resources are fully and efficiently utilized.*

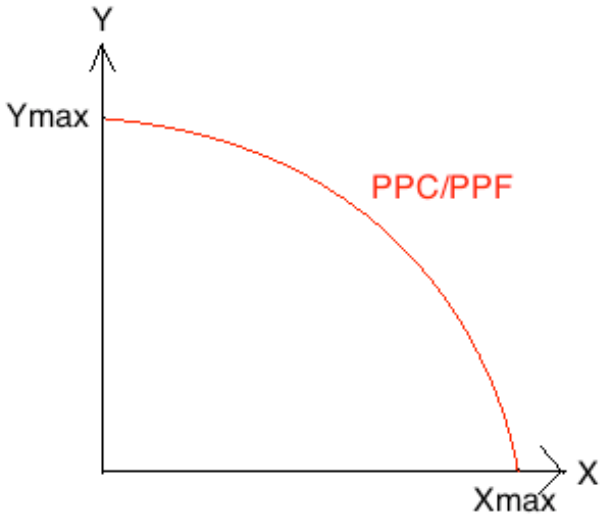


Figure 3

6. *The PPC represents* ***maximum combinations*** *of X-rated videos and yoyos given our current endowment of resources (land, labor, capital, and entrepreneurship)* and our *given technology.* ***The PPC shows the maximum quantity of yoyos we can produce given the production of X-rated videos, or the maximum production of X-rated videos given the production of yoyos.*** Only points on the PPC, on the axes, and inside the area delimited by the PPC and the axes, are *attainable* – because of A2 and A3. Combinations of X-rated videos and yoyos that lie above (or to the right of) the PPC are *unattainable* with our present endowment of inputs and our current state of technology (see Figure 4) – Sleemania suffers from scarcity of goods and services because its inputs and technology are limited. Because of scarcity the PPC is a finite

distance from the origin; *the Sleemanian economy cannot produce unlimited numbers of goods and services.*

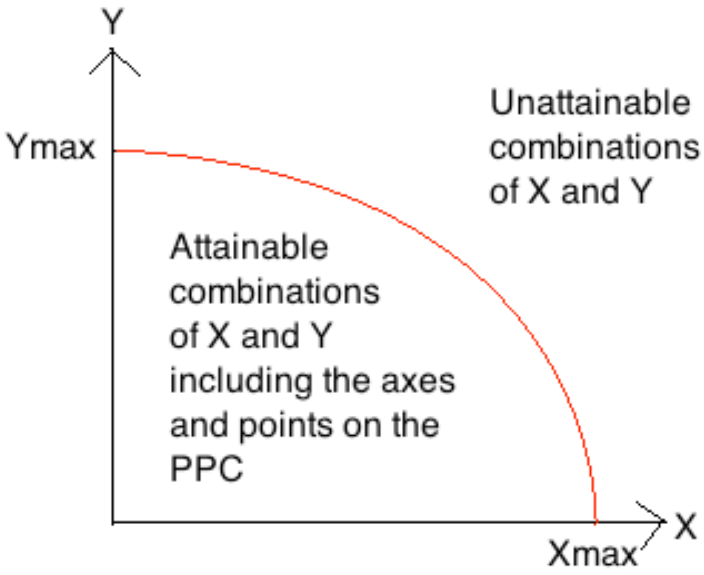


Figure 4

3. PROPERTIES OF THE PPC.

1. ***The PPC slopes down to the right*** – there is an *inverse* relation between the amount of one good we can produce and the amount of the other good we can produce. In a world of scarcity, we must *trade-off* some of one good to be able to produce more of the other good.

2. ***The slope of the PPC is a measure of the opportunity cost of X-rated videos in terms of yoyos***; how many yoyos we have to give up in order to get another X-rated video. If we draw a tangent to any point on the PPC then at the point of tangency the slope of the tangent and the slope of the PPC are equal. If we measure the slope of the tangent as the vertical change in the tangent line (the change in Y) over the horizontal change of the tangent line (the change in X) – what engineers call rise over run – then we get a negative number because the vertical change is negative (we give up yoyos to get more X-rated videos – we trade-off yoyos for X-rated videos). (See Figure 5)

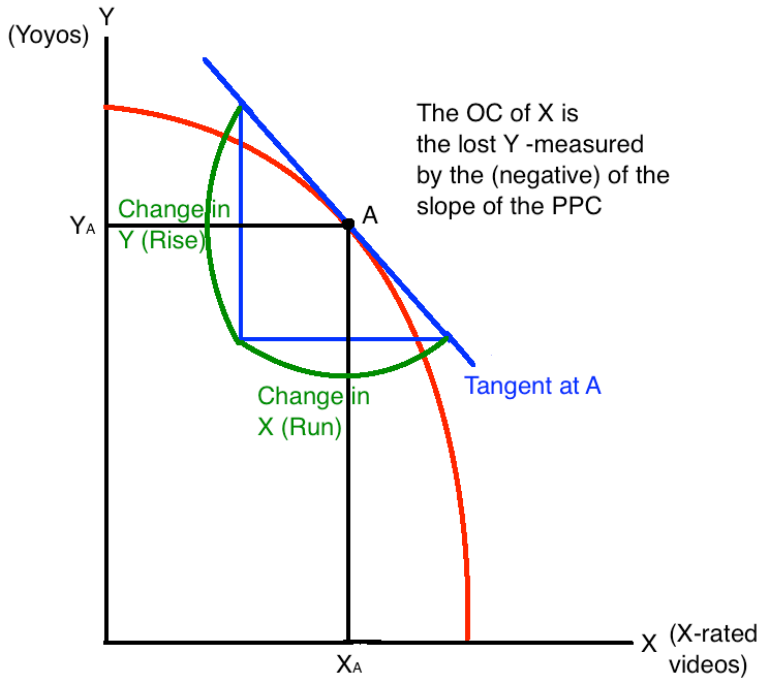


Figure 5

3. ***The PPC is bow shaped,***[6] that is, the PPC gets steeper and steeper as we move from Y_{max} along the PPC to X_{max}. (*A movement along the PPC means that we are moving resources between the two industries.*) The increase in slope[7] means is that the opportunity cost of X-rated videos in terms of sacrificed yoyos gets larger and larger as we switch more and more resources to the X-rated video industry.

This means that *both* industries are subject to increasing opportunity cost; that is both industries show strictly increasing marginal cost (MC). If the last sentence puzzles you take a thin piece of paper and draw your PPC. Convince yourself that as you move to the right along the X-axis the PPC becomes steeper and steeper. Now turn your piece of paper over and pivot it around until the Y-axis is

[6] A mathematician would say that it is concave with respect to the origin.

[7] My apologies to the mathematically astute student who will note that the negative slope is actually getting larger as we move to the right (-1/2 is bigger that -2000).

now the horizontal axis. You will see that as you move to the right along the new horizontal axis that you have to give up more and more X to get an extra Y; the PPC looked at this way gets steeper and steeper as we move rightward.

Increasing MC is a consequence of assumption A6. We are assuming that the benevolent Tyrant – blessed be his bald head! – can determine the productivity of each unit of labor in producing X-rated videos and yoyos, and lays out the given labor force side by side forming a labor line, with the most efficient (in terms of producing X) person on the left at the start of the queue. (Assume that that person is the least efficient at producing Y.) Therefore, the first unit of labor on the labor line is the one that is best at producing X-rated videos and the least good at producing yoyos, and the last unit is the one that is worst at producing X-rated videos and the best at producing yoyos.

Say that we are at Y_{max} so that we are not producing any X-rated videos and all labor is in the yoyo industry. If we want to produce some X-rated videos then we will have to move labor out of the yoyo industry. The sensible – that is the optimal or economically efficient – way to do this is to use the first unit of labor in our labor line. If we switch the first unit of labor to the X-rated video industry then we will be able to produce a large number of X-rated videos (because that unit is very good at producing X-rated videos) and we will not give up many yoyos (because that first unit is, by assumption, very poor at producing yoyos). Therefore, initially the opportunity cost (the marginal cost) of producing X-rated videos is very small – we get a lot of X-rated videos per unit of yoyos sacrificed. But as we switch more and more units of labor out of the yoyo industry and into the X-rated video industry, we will start to get increasing marginal cost because we will be moving units out of the yoyo industry that are less and less good at producing X-rated videos and better and better at producing yoyos. Therefore, we will be gaining fewer and fewer X-rated videos and giving up more and more yoyos. The marginal cost of X-rated videos will be highest (at X_{max}) when we switch the last unit of labor out of the yoyo industry and into the X-rated video industry – the unit of labor with the lowest productivity in the X-rated video industry and the highest productivity in the yoyo industry.

Clearly the argument works in both directions and so if we start at X_{max} and start to switch labor to the yoyo industry (moving *vertically*) the opportunity cost of the first yoyos will initially be low, but it will get higher and higher as we move along the PPC towards Y_{max}. (We will now be choosing labor from the right end of our labor line and will move leftwards as we switch labor between the

industries.) Marginal cost is rising in both industries (see Figure 6) although not necessarily at the same rate.

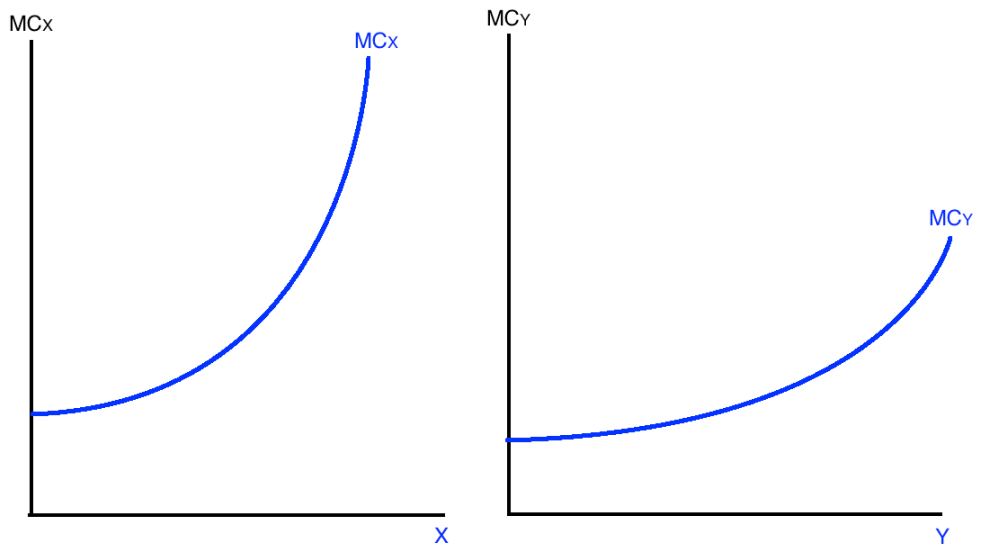


Figure 6

4. POINTS INSIDE THE ATTAINABLE AREA.

At this point in the Commentary pay careful attention because I am going to explain how to answer a possible exam question. Year after year, quarter after quarter, class after class I discover that the students who do poorly get that question wrong. Why do you think that is?

1. Economies grow and change continuously. Some industries expand and some contract and new products and processes are being introduced all of the time. There are inefficient firms but economists assume that competitive forces will replace them by more efficient ones in the long run. Labor and capital have to continuously adapt to change, moving from a declining industry to a growing one where there is better pay and more profit. This takes time. We would not expect everyone to have a job – matching workers and jobs takes time and *sometimes*, e.g. during the Great Recession (the 2010s) and even more in the Great Depression (the 1930s), the *aggregate demand for goods and services is insufficient to generate full employment*. All of this is ignored in standard micro-

principles courses where the economy is usually assumed to be operating at full employment and with full capacity utilization, that is it is assumed to be somewhere **on** its PPC. Micro models are all static and always in equilibrium, an issue that we will return to later in the course.

2. *The PPC represents "potential" output – what would be produced given that A2 and A3 and A4 and A5 hold.* Is it possible that Sleemania could be producing inside the *attainable* region, that is, producing below and to the left of the PPC? *We cannot violate assumptions A2 and A3* – the position (and negative slope) of the PPC is determined by those assumptions. That leaves three possibilities that would cause the economy to operate within its PPC: we are violating A4 (we are producing inefficiently), we are violating A5 (we have unemployed labor and underutilized capital equipment), or, we are violating both A4 and A5. In practice we would not expect an economy to always operate at full employment or full capacity (utilizing its whole capital stock) nor would we expect that it would always be fully efficient.

3. Although textbooks tend to emphasize inefficiency, violation of A4, as the reason that a country is operating inside its PPC the question that you really need to ask is: *what sort of economy are you considering?* The US and other *industrialized countries have highly efficient economic systems* and so if they are operating inside their PPCs, as they were in January 2021, then that is almost certainly because *A5 is violated* – there is unemployment and underutilization of the capital stock, because there has been a fall in aggregate demand associated with the pandemic. The Great Recession of 2010 was the result of a collapse of aggregate demand. *If an* ***advanced industrialized economy*** *is operating inside its PPC it is probably because there is insufficient aggregate demand to fully employ the labor force (there is unemployment) or to fully utilize the capital stock (there are underutilized machines)* – **A5 does not hold**.

On the other hand, as economists love to say, ***wholly or partially centrally planned economies*** (the old Soviet Union, many East European ex-Soviet countries, Cuba, North Korea, Maoist China, and ***most LDCs*** before the 21st century and even part of the UK economy from1945-1950) are notoriously inefficient although they technically had no unemployment (think of the contrast between North and South Korea or the old East- and West-German economies). Therefore, if you are asking why ***these sorts of economies*** are operating inside their PPCs then the obvious culprit is ***A4****; these countries are producing inefficiently.*

Economists assume that we prefer more goods and services to less – an apparently innocuous assumption – and so we will be on the PPC unless we violate A4 and A5. (Note how easy it is to read the first part of the sentence as admonishing us to always maximize GDP! But economists will vehemently deny advocating any such thing.)

Therefore, ***if I ask you a question about points inside the PPC***, *then the correct answer will depend on which type of economy I am asking about*: is it an industrialized/developed country like France, or is it a developing economy like Botswana or ex-command economy like Belarus? In the former case the economy would be operating inside its PPC because A5 is violated (there is unemployment) and in the latter case it would be because A4 is violated (production is inefficient, see Figure 7). I will assume that as university students you have some idea about which countries in the world are advanced industrialized economies, which are Less Developed Countries (LDCs, also called emerging economies), and which are subject to central planning.

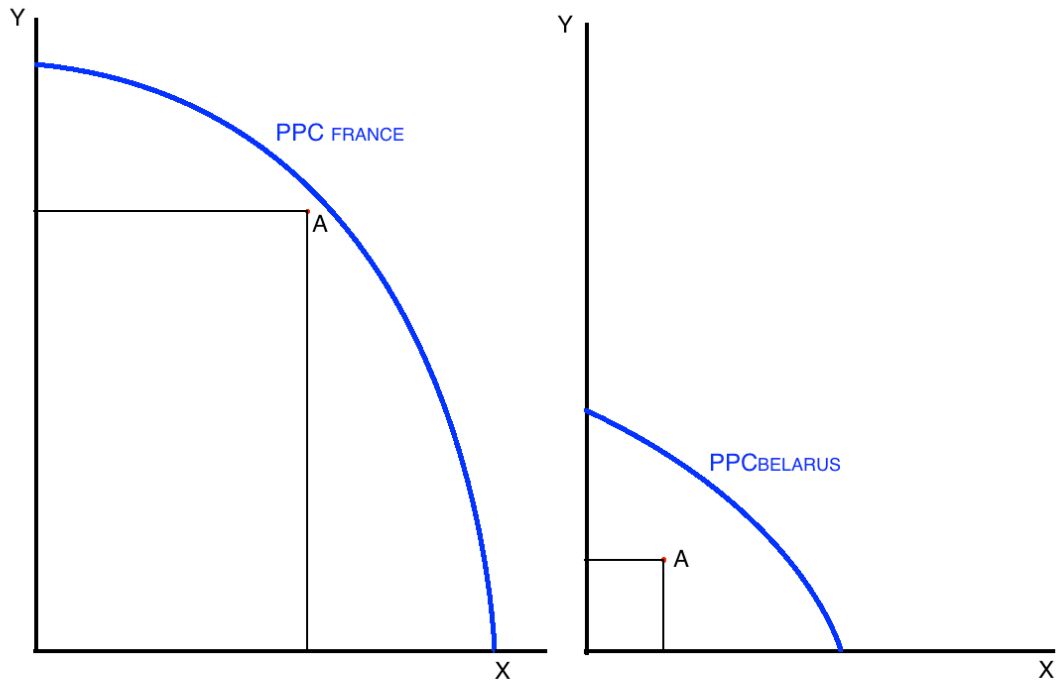


Figure 7

5. WHAT CAUSES THE PPC TO SHIFT?

1. Historically the US PPC has been expanding away from the origin as the economy grows as a result of: (1) *technological change* (violation of A3), and (2) as *the labor force increases* (and its productivity improves because of improvements in human capital and health), and (3) as *the capital stock becomes larger because of net investment* ((2) and (3) violate A2). Any combination of (1)-(3) causes the whole PPC to shift *outwards and to the right*, but not necessarily parallel.

2. *The PPC will shift back to the left* if the capital stock is destroyed (WW2), and if the labor force becomes smaller (the European labor force fell drastically because of the "Black Death" - Bubonic plague - which reduced the population of Western Europe from about 80m to 55m between 1347 and 1351). The PPC will also move to the left if technological knowledge is lost – the so called "Dark Ages" when much of the scientific knowledge available to the classical world was kept alive only in the great Arab civilizations.

3. The coronavirus pandemic has not caused the PPC to shift to the left – yet! The "Black Death" wiped out about 30% of the population of Western Europe. The current pandemic may reduce the world's population by 2% or about 150 million. In the US because the Administration failed to take timely action, we face a worst-case scenario of 6.5 million dead, although current predictions are more like 500,000 to 600,000 dead. If the deaths are disproportionately among those over 60-years-of-age then the drop in GDP – the shift in the PPC – may be relatively small. Everything depends on how quickly the US situation can be brought under control and the economy adjust – but the economic impacts will also depend on how quickly the rest of the world returns to "normal".

6. THE PPC IS ABOUT PRODUCTION NOT CONSUMPTION.

Note that the knowing the PPC is not sufficient to tell us which combination of goods and services will be produced. The PPC has nothing to say about *preferences* between X-rated videos and Yoyos. The PPC is a supply side model, it has no demand side. (4,286)