Econ 354

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Notes on Allen W. Johnson and Timothy Earle, "The Evolution of Human Societies"

Chapter 1

This is a long and complicated book, but you should find that it gives you an interesting perspective on the highly diverse kinds of human societies that have existed over time. It should also give you some ideas about why societies became larger and more complex.

I will have two jobs in my lecture notes on this book. First, I want to discuss the theory JE use to explain the evolution of human societies. This theory is presented in chapter 1 and they return to it from time to time in the rest of the book. When thinking about these theoretical issues, remember that the authors are an archaeologist and an anthropologist. I am an economist. As a result, there are some differences in how the authors think and how I think. I'll clarify these differences as we go along.

Second, you will find that much of the book consists of case studies of specific societies. For each case, JE discuss things like the natural environment, the production technology, and the social organization of the society. Using some fairly simple graphs and algebra, I will try to convince you that a little bit of economic theory can be useful in understanding why people are doing what they are doing in these societies.

I want to emphasize that my notes are not a substitute for reading the book or vice versa. If you only read my notes, you will miss most of what JE say about individual societies. On the other hand, if you only read the book you will miss all of the economic concepts I explain in my notes. To do well on the exam, you will need to be familiar with both, and be able to explain the connections between the two.

Let's get started on chapter 1. There are three fundamental concepts in thinking about the evolution of human society: the environment, individuals, and culture.

The environment consists of various opportunities and constraints provided by nature (for example, natural resources that can be converted into things humans want or need).

JE assume individual humans are generally rational, in the sense that they have consistent goals and are concerned with their own needs as well as those of their families.

Culture is a broad concept with many definitions, but most social scientists would define it something like this: "culture consists of shared knowledge and beliefs in a society that are passed down from one generation to the next through learning".

Anthropologists would include things like technology, institutions, social organization, norms, religious beliefs, etc. Economists often find it useful to separate out technology and institutions, and then define whatever is left over as 'culture'.

There are three main processes of social evolution JE want to explain.

Subsistence intensification. This means an increasing use of inputs like labor and capital in order to produce more food from a fixed amount of land of given quality.

Political integration. This means the process of bringing larger numbers of people and larger geographic territories under unified political control.

Social stratification. This means an increasing inequality of social status, wealth, and/or standards of living over time. It implies the creation of hierarchical societies.

You will see as we go through the book that JE start with small simple societies in Part I and then move on to larger and more complex societies in Parts II and III. In order to say how human societies evolved in this way, they often refer to the three processes above.

One basic question is: what are the underlying forces that drive these processes forward? Before I tackle this, I need to explain the difference between exogenous and endogenous variables. This distinction is fundamental to the ways economists think about cause and effect relationships.

Consider any economic model. An *exogenous* variable is something that is important to the model, but not determined within the model. An *endogenous* variable is determined within the model and it is often something the model was designed to explain.

We define *comparative statics* to be a theoretical analysis where we change the value of some exogenous variable to see what this does to the values of the endogenous variables. We usually think about changes in the exogenous variables as 'causes' and changes in the endogenous variables as 'effects'.

Here is an example.

I will assume everyone is familiar with the standard graph of supply and demand curves. Think about the total output of some good on the horizontal axis and the price of the good on the vertical axis. The demand curve slopes down and the supply curve slopes up. The intersection point for the two curves determines the equilibrium price and quantity.

The endogenous variables in this model are price and quantity. They are both determined within the model and they are the things the model is designed to explain.

The exogenous variables in the model are the factors that determine the locations of the demand and supply curves. For the demand curve, this includes consumer preferences, consumer incomes, the prices of other goods, and so on. For the supply curve, this includes the production technology, the prices of inputs like labor, and so on.

A comparative static exercise with the supply and demand model could involve things like (a) changing the price of a substitute, looking at how this shifts the demand curve (keeping the supply curve fixed), and studying the effects on the equilibrium price and quantity, or (b) seeing how a technological innovation shifts the supply curve (keeping the demand curve fixed), and again studying the effects on price and quantity.

Now go back to JE. Their endogenous variables are subsistence intensification, political integration, and social stratification. They are trying to explain how these things change over time. The question for an economist would be: what are their exogenous variables?

Based on chapter 1 in JE, you might argue that their exogenous variables are the natural environment, technological innovation, and population growth. There is no real problem with thinking about nature as exogenous. However, technology and population are more difficult because according to JE, they influence each other.

In fact, JE believe that there is a positive feedback loop between them: better technology leads to population growth, and increased population leads to technological innovation. I think their view is that this population/technology feedback loop drives everything else in the system, including intensification, integration, and stratification.

One ambiguity in their story involves the standard of living. An economist would expect that if technology improves more rapidly than the population grows, the average standard of living (income per person) will rise. But if the population increases more rapidly than technology improves, income per person will fall.

Depending on which of these is true, we could have two scenarios:

<u>Optimistic scenario</u>. In this view, technological change is the main driving force behind social evolution. People adopt innovations when these are beneficial in some way, and this will allow the society to support a larger population with the same natural resources. Population growth may partially offset technological gains, but it lags behind technology and is caused by it (so population is at least partly endogenous, and technology is the big exogenous variable). On average, things tend to get better over time.

<u>Pessimistic scenario</u>. In this view, population is the main driving force behind social evolution. Population growth puts increasing pressure on natural resources, leading to gradually declining resources per person, and the resulting problems motivate people to search for technological solutions. These solutions could partially offset the population pressure, but technology lags behind population and is caused by it (so technology is at least partly endogenous, and population is the big exogenous variable). On average, things tend to get worse over time.

In the modern world, most people are used to the idea that the productivity growth rate from technological innovation exceeds the population growth rate, so income per person tends to grow over time (although not always; sometimes it falls due to a financial crisis or a pandemic). Therefore, modern people tend to think about the optimistic scenario.

In general, JE lean more toward the pessimistic scenario: frequently in the book they tend to talk as if population growth causes problems that technology has trouble solving. This may not be unreasonable for the kinds of societies they consider. Most economists would probably agree that before the Industrial Revolution (about two centuries ago), population growth tended to keep the average standard of living roughly constant at a relatively low level. Most of the gains from better technology went into supporting larger populations, not improving the quality of life per person.

I want to say a few words here about what has happened to the standard of living in the very long run. Because we live in a world where income per person has been rising for the last century or so, we tend to extrapolate back in time and assume that the same must have been true over thousands of years, so the people living 15,000 years ago must have been completely miserable and always on the edge of starvation. However, the evidence from archaeology and anthropology indicates that this is NOT true.

Up until about 10,000 - 12,000 years ago, almost everyone lived in small foraging bands that hunted wild animals and gathered wild plants. These bands typically moved around a lot to follow the natural resources. Depending on the natural environment, such people might have had reasonable food intakes with modest inputs of labor per day or per week.

Around 10,000 - 12,000 years ago, people in some parts of the world began a transition to agriculture. This occurred in southwest Asia and spread from there to Europe and India. Other independent centers of agriculture included China, Africa, and the Americas. This transition involved reliance on domesticated plants and animals, a more sedentary life in villages, and eventually inequality, warfare over land, urbanization, and the emergence of the state. Commoners (who were most of the population) appear to have been worse off than their hunter-gatherer ancestors, based on archaeological evidence about diet, health, life expectancy, and similar indicators.

Since about 1750 - 1800, starting in Western Europe and then spreading to the rest of the world, the industrial revolution eventually led to rising living standards for most people. So at least for the majority, living standards over the last 15,000 years have followed a U-shaped curve: not bad for early hunter-gatherers, then worse in agricultural societies, and finally improving over the last century or two due to industrialization.

When I was a student, most people thought agriculture was a technological innovation that made people better off. Some genius discovered that plants could be cultivated in an artificial way, this raised productivity and increased the security of the food supply, other people saw how great this was, and people imitated the new technology. In this story the spread of agriculture was due to its obvious superiority over hunting and gathering.

Archaeologists today do not believe this story. First, people in hunter-gatherer societies know that if they plant seeds in the ground, something will grow. Agriculture was not a 'discovery'. People already knew how to do it, but they were choosing not to. Second, there are many examples of hunter-gatherer societies living near agricultural societies and able to copy what the farmers are doing, but again choosing not to. Third, as I mentioned above, early farmers usually had worse diets, poorer health, and shorter lives than hunter-gatherers, which makes it hard to say that agriculture was a great technological leap.

For an economist, this is a puzzle: why would people adopt a new technology if it makes them worse off? I think the answer is that agriculture was frequently adopted in response to climate changes that made hunting and gathering less attractive than it had been in the past. Or to put it another way: agriculture was a known backstop technology that could be used when the natural environment deteriorated, and it turned out to be the least bad choice from among a set of bad options. Eventually due to the increasing productivity of domesticated plants and animals, population growth, and destruction of natural habitats for wild plants and animals, this choice become irreversible: people could not go back to hunting and gathering. I won't go into the details, but I think this view is consistent with the archaeological evidence.

Now let's get back to the JE book. They discuss three ways of thinking about economic behavior:

Evolutionary biology. In this view, human beings, like other animals, are genetically programmed to seek reproductive success, and to survive until they have a chance to reproduce, and to have offspring who survive to become adults. As a result they have basic biological needs that they pursue, like food, health, sex, safety, and so on. Note, though, that this does not simply mean that people have as many kids as possible. It is also important that kids survive long enough to become adults, and it may be better to have a small number of kids who each have a high probability of survival, rather than a large number who each have a low probability of survival. Also, human beings may be programmed for complex things like logical thinking or seeking social approval if these are helpful for biological success.

Economics (what anthropologists call 'formal economics', which just means the kind of thing that most modern economists do). The idea here is that people have preferences (which economists often represent using utility functions), and they try to achieve their most preferred outcome subject to external constraints on their feasible choices. People are rational in the sense that they have consistent preferences and think logically (they understand the connections between means and ends, or causes and effects). Economists don't have much to say about where preferences come from. Some probably reflect our underlying biological needs, but people may want things that are dangerous or frivolous, they may behave selfishly at the expense of their kids, they may not have kids at all if it would be too expensive, and so on. Economists normally use the word 'want' rather than 'need' when they refer to preferences.

Culture (what anthropologists call 'substantivism' or 'structuralism'). In this view, the economic behavior of people in a society is determined largely by the culture or social institutions of that society. For instance, if you are brought up to believe that status or prestige is very important, and the best way to get prestige is to give away most of your goods, or die in combat, that is what you do. Anthropologists committed to this point of view generally do not like formal economic models where people make rational choices, or pursue their self-interest, or care a lot about material goods.

JE don't want to start from culture or social institutions in attempting to explain economic behavior. This approach has problems: for example, where does culture come from? Is it just some totally random, unexplainable thing? How do we explain the observation that similar types of societies tend to have similar cultures, or similar economic behaviors?

JE tend to believe that people's 'basic needs' come from biology, and that people pursue these material interests in ways that an economist would regard as rational. They believe culture (in the broad sense, including technology, political and social institutions, norms, beliefs, etc.) evolves over time through experimentation, and tends to stabilize around a set of practices and beliefs that 'work' in the sense of meeting basic needs. However, JE would also accept the idea that cultural inertia can make it difficult for a society to adapt quickly in response to new problems.

Another important distinction JE make in chapter 1 is between the 'subsistence economy' and the 'political economy'. The first idea is straightforward. The *subsistence economy* includes all of the economic activities taking place within households. They think of the household as a relatively self-sufficient family unit, although there are interactions with other households because people need to find mates, trade, gather information, and work together on occasional group projects. In the societies described by JE, there is usually a division of labor based upon age and gender. They picture the subsistence economy as a place where people try to meet their basic needs (such as food) in a way that minimizes cost, where costs may be measured in units of time or effort. Assuming no changes in a society's natural environment, technology, or population, the subsistence economy tends to be stable over time.

The *political economy* is a subtler concept. JE define it as the set of institutions and rules above the level of the individual household. The institutions and rules may have benefits that exceed the costs to a household, so such households would want to participate in the political economy, but for some households it could go the other way and therefore they would not want to participate (doing so would make them worse off).

What JE have in mind is that there are sometimes problems an individual household will find difficult or impossible to solve by itself. Examples include risk management, group defense, a need for investments in large public works projects, or long-distance trade. In larger-scale societies, these problems are often solved by specialists who do not produce any food and are supported by the people who do produce food.

This can lead to a class division between elites and commoners, where the people in the subsistence economy are oppressed by people in the political economy but cannot easily escape from it. It is important to remember that the societies discussed in this book are not modern political democracies and commoners do not have much influence over elite behavior. Some things the elite does could be useful for commoners (risk management, road construction, etc.), but some of it could just be predatory (conquering neighboring territories, extracting more food surplus from the commoners, etc.). We will come back to these issues in chapters 9-13.

JE picture the political economy as having a goal of maximum income for the ruling elite. Revenue from income-producing projects is often plowed back into investment in further projects, leading to a dynamic of expansion. But the political economy eventually hits some limits due to social or environmental constraints. For example, valuable resources might be located too far away, distant populations might be spread too thinly to be worth conquering, there might be hostile rulers nearby, if you squeeze the peasants excessively they might rebel or support your political rivals within the elite, and so on. The political economy could encounter such limits, collapse, and then start growing again. In general, JE think of it as unstable.

Now we are ready for an overview of JE's theory about social evolution. Take a look at Figure 3 on p. 31. At the bottom you will see a box called 'primary engine', which has both population growth and technological development included. Remember that these variables generate a positive feedback loop as discussed earlier, so both population and technology tend to expand over time. As indicated in the box, this process is subject to constraints from the natural environment (the resources that happen to be available).

JE think the primary engine leads to subsistence intensification, where people try to get more food from a fixed supply of land. This is possible because there is more labor as the population rises, and perhaps also more capital invested by the political economy. Improvements in technology could also yield more food per unit of land area.

As intensification proceeds over time, JE think it creates a series of problems. In their Figure 3 they identify four problems: production risks, raiding and warfare, inefficient resource use, and resource deficiencies. You should read their discussion to get the full story, but the general idea is that intensification causes more risk of food shortages, more competition and conflict over valuable land, more pressure to use available resources in an efficient way, and more depletion of certain resources in the local area. The solutions are strategies like food storage, defensive alliances, new technologies, and long-distance trade.

All of these potential solutions create opportunities for people in the political economy to increase their control over the society. The two main results are political integration and social stratification.

We get unified political control over larger areas because this is one way to handle risk (if things are bad in one place, they may be good in another, so having a large territory tends to average out the risks); because conflict over scarce land tends to create larger political units through aggression or defensive alliances; because technological ways of improving efficiency may require large investments in roads, canals, storage systems, and so on; and because long-distance trade is safer and cheaper when political units are larger.

We get social stratification because the elite controls central food storage systems and decides who gets access to them; because elite military power tends to create unequal property rights over land and other natural resources; because the elite manages large infrastructure projects and the tax system used to pay for these projects; and because the elite could gain monopolistic control over long-distance trade. The members of the elite often use their authority to siphon off benefits for themselves and their families, leading to political, economic, and social inequality.

I hope this explanation makes some sense. Keep in mind that this is only JE's theory and their theory might not be correct in every way. One thing you should ask yourself as you read the case studies is whether the information from these cases supports the theoretical framework they are proposing.

The rest of the book is built around a classification of societies based on their scale of social organization. Part I is about family-level groups, Part II is about local groups (consisting of several family groups with common interests in storage, defense, etc.), and Part III is about regional polities (incorporating numerous local groups, with leadership by specialists, where it is hard for individual households to withdraw their consent and refuse to participate in the political economy).

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Notes on Allen W. Johnson and Timothy Earle,
"The Evolution of Human Societies" (second edition, 2000)

Part I (chapters 2-4)

This part of the book discusses family-level groups. Chapter 2 provides some general information. There are two case studies of foraging groups in chapter 3 (the Shoshone and the !Kung), and two case studies of groups with domesticated plants or animals in chapter 4 (the Machiguenga and the Ngansan).

I will make a few comments on the individual societies, but mainly I want to develop four models that can be used to understand the nature of the economic problems such societies face, and the ways in which they solve these problems.

The specific models involve (i) cost minimization, (ii) risk management, (iii) food storage, and (iv) local resource depletion.

All of our ancestors lived in foraging societies until around 12,000 years ago. Foragers gather wild plants and hunt wild animals for food. Thus, the word 'foraging' means the same thing as 'hunting and gathering'. People who live near rivers, lakes, oceans, etc., may also use fishing. Foragers do <u>not</u> engage in agriculture (cultivating domesticated plants) or pastoralism (herding domesticated animals). The Shoshone and the !Kung in chapter 3 are foragers. The Machiguenga and Nganasan cases in chapter 4 are not pure foragers because they rely on domesticated plants or animals for a part of their diet, but they obtain other foods through hunting and gathering.

What standard of living do foraging societies have? This depends on the environment, technology, and population, but on average, life may not have been too bad. Studies of recent foraging societies, such as Australian aborigines, the !Kung of southwest Africa, and others indicate that it may only be necessary to spend a few hours per day (no more than 8 and often less) to obtain and process food.

However, these are averages. We need to consider seasonal or periodic famines due to unusual drought, heat, cold, and so on, as well as factors like disease and life expectancy. My impression from anthropological evidence is that rates of infant and child mortality in foraging societies are very high relative to modern society, but when foragers do survive to adulthood, they have reasonable life expectancies (something like 40-60 years, with a few people living even longer than that).

Foraging societies require low population densities relative to natural resources. So what limits population growth, if it is not constant starvation? Female fertility tends to be low due to occasional food shortages, the exercise associated with frequent mobility, and long periods of nursing small children. Also, some foraging societies practice infanticide, and large numbers of people may die once in a while due to natural disasters.

Technology in foraging societies is typically small scale, personal, and portable. This includes digging tools, bows and arrows, knives, baskets, bags, canteens, etc. Everyone in the society knows how to make such equipment and the required materials are readily available from nature.

Foraging groups generally move frequently to follow natural resources, especially food and water. It is common for people to disperse in small family groups at certain seasons of the year when resources are scattered, and then come together in large groups at other seasons when local food resources are rich enough to allow a larger group to assemble.

Foraging societies tend to have loose territorial boundaries, which are not defended in a systematic way. People don't 'own' land, although a particular family group may have a home range or territory that it normally uses. Sometimes a group might ask permission to use another group's home range, and permission is usually granted. Because people tend to have relatives (siblings, cousins, etc.) in other groups, it is usually easy for individuals to leave one group and join another group.

I should mention that in the Johnson and Earle book, societies are often described in the form they had shortly after contact with the outside world, when they were observed by Western anthropologists. For this reason, the case studies in the book are often based on anthropological research from early in the 20th century or the middle of that century.

In certain cases, archaeological research is needed in order to determine whether the characteristics of a society observed by Western anthropologists actually existed pre-contact, or whether these characteristics resulted from disease, conquest, colonialism, new technology, or new trading relationships. You cannot always assume that the cases in the book are accurate descriptions of what these societies looked like before contact.

Furthermore, the descriptions given by Johnson and Earle could be very different from the ways in which modern members of these societies live today. Some of the people who are described in the book might have great-grandchildren who live in large cities, use laptops, and go to universities.

Having said that, let's move on to a series of economic models of family-level groups.

Cost minimization. All foraging societies, including the ones in chapter 3, have to make choices about what foods to gather and how much time to spend on each food source. In these societies, the natural way to think about cost is to measure it in hours or other units of time. We will assume that people need some fixed number of calories for biological reasons, and that people minimize the work time needed to get those calories. Any time left over can be spent on more enjoyable things, like singing songs around the campfire.

Suppose calories can be obtained from two sources: aardvarks (obtained by hunting) and blueberries (obtained by gathering). The calories obtained from aardvarks are q_a and the calories obtained from blueberries are q_b. The total time devoted to hunting aardvarks is $C_a(q_a)$ and the total time devoted to gathering blueberries is $C_b(q_b)$. The calories from the two sources must add up to a given total q^0, which we assume is determined biologically. We can write out the optimization problem facing a forager as:

Choose q_a and q_b to minimize $C_a(q_a) + C_b(q_b)$ subject to the constraint $q_a + q_b = q^0$.

Before we can make progress in solving this problem, we need more information about the shapes of the cost curves. Think first about $C_a(q_a)$. If you don't get any calories from aardvarks, then you don't need to spend any time hunting them, so we have $C_a(0) = 0$. If you only want a few calories from aardvarks, you will probably go after the ones that live nearby, so it won't take too long to get these calories. But as you increase the number of calories you want from this source, you have to catch aardvarks that are harder to find or live further away, so your costs will rise. In fact, your costs will rise at an increasing rate (non-linearly) because it takes more and more time to catch each additional aardvark. As a result, you face a convex cost curve like the one shown in the upper left graph of Figure 1 (see the end of these notes).

The same logic applies to $C_b(q_b)$. If you don't want any calories from blueberries, then it costs you nothing in terms of time, so we start from the origin in the upper right graph of Figure 1. If you only want a few calories, you harvest the easiest and closest blueberries, which doesn't take much time. But as you keep increasing q_b it becomes necessary to go longer distances to find more blueberry bushes, and your time cost rises non-linearly as you have to go further and further to find a given number of blueberries. Thus again you face a convex cost curve. Of course, the curves for C_a and C_b will not be identical due to differences in the nature and distribution of the two food sources.

Now we need to introduce a new concept: *marginal cost* (MC). The definition of MC is that it is the slope of the total cost curve at a given number of calories. Suppose we fix a level of q_a. Then the marginal cost for aardvarks at this value of q_a is the slope

$MC_a = \Delta C_a/\Delta q_a$ for a given q_a on the horizontal axis.

Whenever we discuss marginal cost, we assume the changes ΔC and Δq are small, so MC describes the rate of change in total cost for small changes in q. This idea is shown in the lower left graph of Figure 1, where we have q_a on the horizontal axis and the *slope* of the total cost curve on the vertical axis. Because the total cost $C_a(q_a)$ has a *convex curvature*

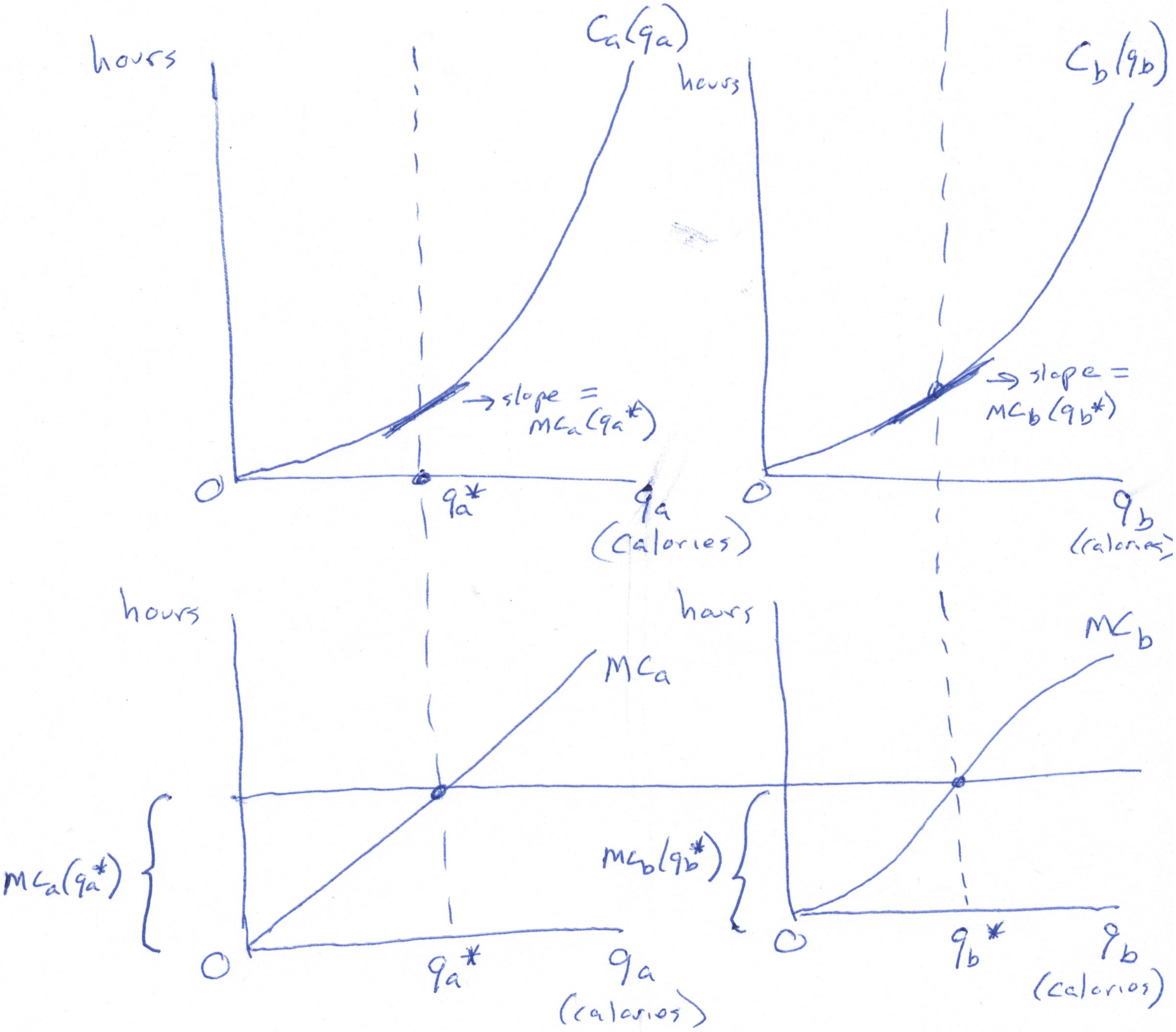

Figure 1

Cost Minimization

in the upper left graph, meaning that the slope of the total cost curve becomes steeper as q_a increases, the corresponding marginal cost curve MC_a is *rising* in the lower left graph.

The same reasoning applies to blueberries. We define the marginal cost

$$MC_b = \Delta C_b/\Delta q_b \qquad \text{for a given } q_b \text{ on the horizontal axis.}$$

This yields a similar relationship between total cost for blueberries in the top right graph and the marginal cost for blueberries in the bottom right graph, where again MC rises as the number of calories obtained from this source increases.

Here is the key economic idea. In order for the calorie choices (q_a*, q_b*) to solve the cost minimization problem, we require $MC_a = MC_b$ so that the marginal cost of calories from aardvarks is the same as the marginal cost of calories from blueberries. To put it another way, at (q_a*, q_b*) the *slopes* of the total cost curves must be equal. Why is this true?

Suppose the marginal costs are not equal. For example, suppose we have $MC_a = 5 > 3 = MC_b$ so under our current plan, the slope of the cost curve $C_a(q_a)$ is steeper than the slope of the cost curve $C_b(q_b)$. Suppose time is measured in minutes and we consider small changes in the calories obtained from each source. If we obtain one less calorie from aardvarks, we can save 5 minutes. If we obtain one more calorie from blueberries, we have to spend 3 more minutes. Doing both of these things will leave the total number of calories $q_a + q_b$ unchanged (one less calorie from one source and one more from the other source), so if we were previously satisfying the constraint $q_a + q_b = q^0$ then we are still satisfying it. However, total work time drops by 5 - 3 = 2 minutes. This shows that we were not previously solving the problem (we were not minimizing the total time cost of getting our required calories).

The same reasoning applies in reverse if $MC_a < MC_b$. In that case we should be getting more of our calories from the food with the lower marginal cost, which is aardvarks. It follows that if (q_a*, q_b*) does solve the cost minimization problem, we must have $MC_a = MC_b$. This is shown by the horizontal line in the lower two graphs in Figure 1, where q_a* and q_b* yield the same level of MC.

Notice that q_a* and q_b* could be quite different (one could be large and the other could be small) because the MC curves in the two graphs do not have to be identical. All we need is for the *levels of the MC curves* to be equal to each other.

What if the marginal costs are equal but we are not currently satisfying the constraint $q_a^* + q_b^* = q^0$? Imagine that we shift up the horizontal line shown in the lower part of Figure 1. This increases both q_a* and q_b* in a way that maintains $MC_a = MC_b$ (we have higher levels of marginal cost for both food sources). Similarly if we shift down the horizontal line, this decreases both q_a* and q_b* (we have lower marginal cost for both foods).

In order to satisfy the constraint, we raise or lower the horizontal line in the bottom part of Figure 1. This raises or lowers $q_a^* + q_b^*$. When the sum is exactly q^0, we are done.

Mathematically, you can think about this procedure as follows. We are trying to solve for two unknowns: q_a and q_b. There are two necessary conditions: the marginal costs must be equal, and the constraint on total calories must be satisfied. So we have two equations for two unknowns. If we knew the precise algebraic form of the marginal cost curves, we could solve these equations for q_a* and q_b*. Unfortunately we don't have that information, but we can still say some general things about the nature of the solution.

Economically, it is useful to think about this situation using the concepts of exogenous and endogenous variables. The endogenous variables (the things determined within the model) are q_a and q_b because these are chosen optimally by the forager. You could also say that the resulting amounts of time $C_a(q_a*)$ and $C_b(q_b*)$ spent chasing aardvarks and picking berries are endogenous (they are determined by the forager's choices).

The exogenous variables are whatever factors determine the shape and location of the cost curves, such as the climate, local ecosystems, and so on, which will determine the abundance of aardvarks and blueberries and how they are distributed over the landscape. Other exogenous variables include the technologies that are available for collecting each type of food, and how many other people are looking for these foods (if more people are hunting and gathering in the same area, this will make aardvarks and blueberries scarcer, so it will take longer for you to find enough food to obtain a given number of calories). The biologically required number of calories q^0 is also exogenous.

Now let's do some comparative statics. This involves changing an exogenous variable and looking at the effects on the endogenous variables. You should refer to Figure 1 as you run through this thought experiment. First, suppose a disease reduces the aardvark population but has no effect on blueberries. Graphically, this increases the total cost C_a for each level of q_a (it shifts up the total cost curve in the upper left graph) because now aardvarks are harder to find. It will probably also shift up the marginal cost curve MC_a in the lower left graph because the *slope* of the total cost curve is likely to increase at each level of q_a.

If we remain at the previous combination (q_a*, q_b*), we are no longer solving the cost minimization problem, because now we will have $MC_a > MC_b$ (the marginal cost curve in the lower left graph shifted up but the MC curve in the lower right graph did not change). To get back to a situation where the marginal costs are equal, we will have to reduce q_a* (which will reduce MC_a because we slide down along the new MC_a curve) while raising q_b* by an equal amount to satisfy the constraint (which will raise MC_b because we slide up along the old MC_b curve). If we continue in this way, eventually we will have $MC_a = MC_b$ so we will solve the new minimization problem. This reasoning implies that the increased scarcity of aardvarks causes foragers to obtain fewer calories from aardvarks and more from blueberries, which makes perfect economic sense. An economist would call this a *substitution effect*.

Let's try one more comparative static experiment. Instead of a disease that only affects one food source, suppose the local population density increases so there are more people looking for both types of food. From the standpoint of an individual forager, this makes *both* types of food scarcer and shifts up *both* of the total cost curves in the upper graphs of Figure 1. It will probably also shift up both of the marginal cost curves in the lower graphs of Figure 1.

Because both curves shift simultaneously, we can't say whether people substitute toward more aardvarks or more blueberries. But we can be sure about one thing: an individual forager will have to spend more time looking for food in order to satisfy the constraint $q_a + q_b = q^0$. I won't go through all the details here, but intuitively this should make sense (it would be very strange for total work hours go down when both foods are harder to find). Therefore we can predict that when population density is higher, everyone spends more of their time working, there is less leisure for singing songs around the campfire, and in this sense the standard of living falls for each individual forager.

Risk management. All small-scale societies have to deal with problems of risk. Hunters don't always catch the animals they seek, and gatherers don't always find abundant plant foods in the places they expect. Weather can be hot or cold, and wet or dry, and variation of this sort is not always predictable. People can also have illnesses or injuries that make it difficult or impossible to collect food for a while. Economists have thought a lot about risk management in modern societies, and I will develop some basic ideas here. In order to have a concrete example, I will focus on the Shoshone case from chapter 3 but similar ideas apply to the other three cases in Part I of the book.

Suppose we have an individual forager (it could also be a family) who uses pine nuts for food. The forager dislikes risk and prefers to have a constant amount of pine nuts rather than a variable amount with the same average level (I'll say more about this later).

An economist would normally assume that the forager maximizes expected utility, not expected income or expected consumption. To see how this works, look at Figure 2 at the end of these notes. We have pine nuts (x) on the horizontal axis and utility U(x) on the vertical axis. In a loose way, you can think of utility as the amount of 'happiness' or 'satisfaction' the forager gets from a given number of pine nuts. Naturally utility rises as x rises. However, the utility curve has a *concave* shape so the *slope decreases* as x rises. This has a common-sense interpretation: the first few pine nuts provide a big increase in utility (without them, you would be very hungry). However, if you already have a lot of pine nuts, getting a few more is nice but doesn't raise utility very much (you are already feeling quite full).

Mathematical note: I will not give a specific algebraic form for the utility function U(x) because this is not important for the arguments I want to make here. Any function with a strictly concave shape would work. This includes a square root function, a log function, or other possibilities.

Now suppose there is uncertainty about the number of pine nuts you will find, where the outcome depends on the weather. If the weather is bad, you will only get 5 pine nuts, but if the weather is good, you will get 25 (see Figure 2). We will assume for simplicity that bad weather and good weather are equally likely (they both have the probability 0.5). So on average, you get 15 pine nuts.

More formally, define the *expected value* (EV) to be the average number of pine nuts:

$$EV = p_1x_1 + p_2x_2$$

where p_1 is the probability of bad weather, x_1 is the number of pine nuts you get when the weather is bad, p_2 is the probability of good weather, and x_2 is the number of pine nuts you get when the weather is good. Plugging in the numbers given above, we have EV = 15. Notice that EV is on the horizontal axis in Figure 2 because it is measured in units of pine nuts. In this example it is half way between 5 and 25 because good and bad weather have equal probability. If good weather had a probability of 0.9, the EV would be closer to 25.

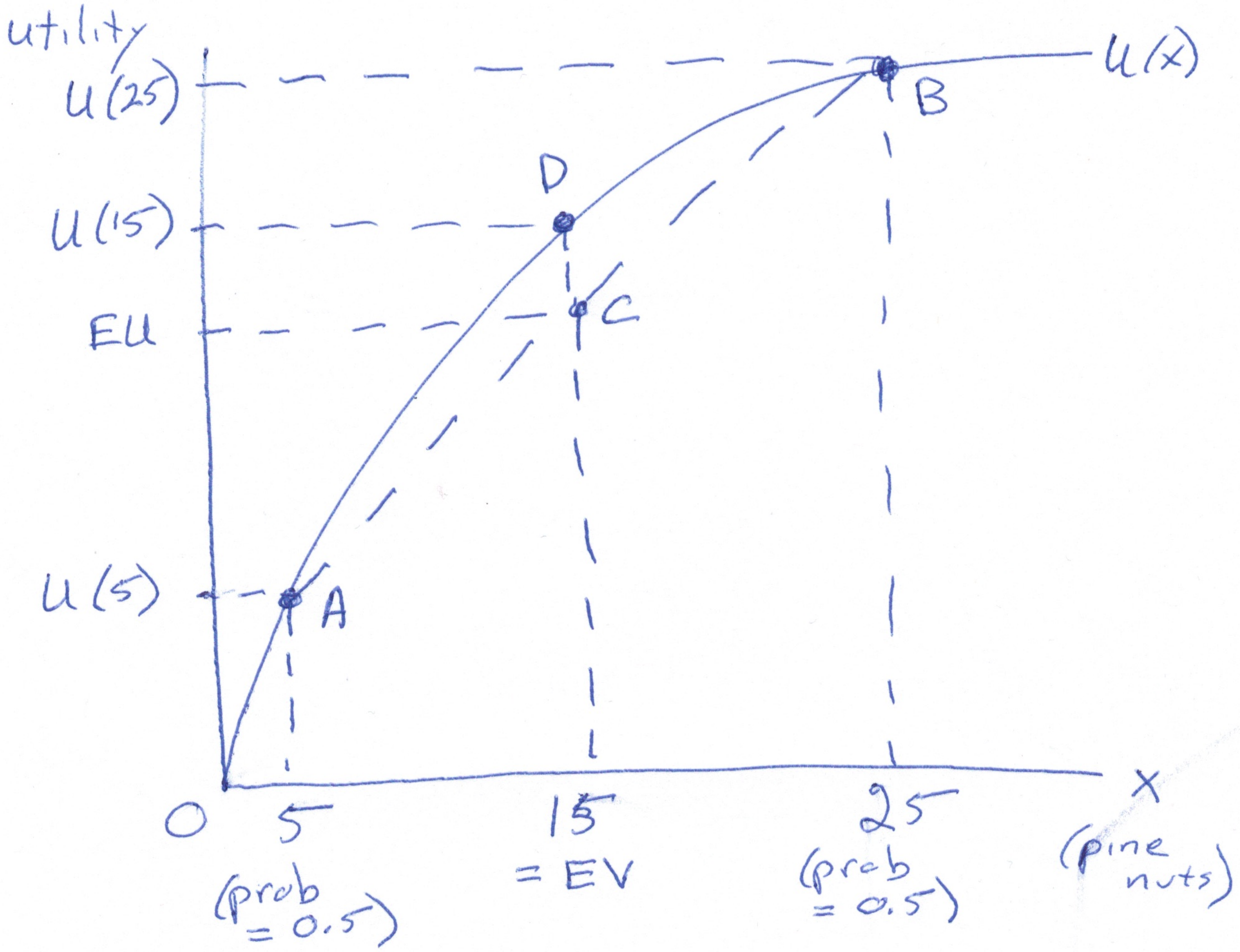

Figure 2
Risk Aversion

Now think about *expected utility* (EU). This is the average amount of *utility* (not pine nuts) the forager receives. The formal definition is

$$EU = p_1U(x_1) + p_2U(x_2)$$

where $U(x_1)$ is the utility obtained from $x_1 = 5$ pine nuts, and $U(x_2)$ is the utility obtained from $x_2 = 25$ pine nuts. The probabilities are the same as before. EU is shown on the *vertical* axis because it is measured in utility units, not physical units of pine nuts.

In Figure 2, observe that we obtain $U(x_1)$ by starting with $x_1 = 5$ on the horizontal axis, going up to the utility function U(x) at point A, and then going over to the vertical axis to find $U(x_1)$. Similarly, we get $U(x_2)$ by starting with $x_2 = 25$ on the horizontal axis, going up to the utility function U(x) at point B, and going over to the vertical axis to find $U(x_2)$.

The expected utility EU is located on the vertical axis half way between U(5) and U(25), because $p_1 = p_2 = 0.5$ so the two utility levels are equally likely. If we had $p_1 = 0.1$ and $p_2 = 0.9$, the EU would be closer to U(25).

Here comes the key economic idea. Suppose we draw the dashed line segment in Figure 2 between points A and B. It can be shown that point C, which has EV as its horizontal coordinate and EU as its vertical coordinate, is located on this line segment. Don't worry about the proof of this, but algebraically it is always true.

Notice that point C must be located below the utility function U(x) due to the concave shape of this function. In particular, point C must be below point D, which gives the utility of getting 15 pine nuts for sure (no uncertainty). Therefore it must be true that $U(15) > EU = p_1U(5) + p_2U(25)$.

Now suppose we give the forager a choice. She can either have a lottery where there are equal probabilities of getting 5 or 25; or she can have 15 pine nuts for sure. Which will she prefer? The answer must be that it is better to get 15 for sure, because the resulting utility is U(15), which exceeds the EU from the lottery. Since she maximizes expected utility, she chooses 15 for sure.

An economist defines *risk aversion* as follows: a person is risk averse if, whenever they can choose between a lottery and getting the expected value (EV) of the same lottery for sure, they prefer the expected value for sure. This will always be true if the person has a utility function with a concave shape.

Note: there is no 'd' in the word 'averse'. The term is 'risk aversion', not 'risk adversion'.

Intuitively, risk aversion means that a person dislikes risk and attempts to avoid it. In the modern world, this is why we have insurance companies. Many people are willing to pay a regular premium to an insurance company in exchange for a legal promise that they will receive some compensation if their house burns down, their possessions are stolen, or they die prematurely and can no longer support their families. In general people who are less risk averse sell insurance to people who are more risk averse, at some price that both sides find acceptable.

Note: if the utility function U(x) in Figure 2 had been a straight line instead of concave, we would have *risk neutrality* rather than *risk aversion*. In this case, the person would be indifferent between a lottery and getting the EV of the same lottery for sure. If U(x) had a convex shape, we would have *risk-seeking* behavior, where people enjoy opportunities to bear risk (they prefer a lottery rather than the EV of the lottery for sure). Such people are willing to pay money in order to bear risk (you can find them at casinos).

People in foraging societies almost always act in a risk averse way. However, there are no insurance companies, so people have to find other ways to reduce risk. The main way of doing this is by sharing food, either with the other members of your own group or with other groups. Thus, for example, if you break your leg and can't forage for a while, other people will share food with you in order to make sure you continue to get enough to eat.

Here is a numerical example where food sharing is useful. Suppose family 1 has 25 pine nuts if the weather is dry but only 5 if the weather is wet. Family 2 has the opposite case: it only has 5 pine nuts if the weather is dry but 25 if the weather is wet. Assume that the probabilities of dry and wet weather are equal (both are 1/2).

If the families do not share any food, each family is in exactly the same position as shown in Figure 2. Each family is risk averse, but each must bear some risk.

Now suppose instead that the families always split their total food equally regardless of the weather. If the weather is dry, total food is 25 + 5 = 30. Due to equal sharing, each family gets 15 pine nuts. If the weather is wet, total food is 5 + 25 = 30, and with equal sharing, each family again gets 15 pine nuts. Thus, sharing food completely eliminates risk! Each family gets 15 for sure, no matter what happens with the weather. In Figure 2, this makes each family better off (each family goes from point C to point D).

Note: when everyone becomes better off simultaneously, an economist calls this a *Pareto improvement*. We will often come back to this idea later in the course.

This example should make it clear why food sharing could be economically desirable for risk averse people. However, there are two problems.

First, this is an extreme example because I assumed the total amount of food was always equal to a constant (30). This implies that if there is no sharing, then whenever the pine nuts for one family go up, the pine nuts for the other family always go down by an equal amount. Or to put it more technically, there is a *perfect negative correlation* between the incomes of the two families (for those who know about statistics, the correlation is -1.0).

In reality, this is unlikely to be true. We expect something close to a zero correlation for risks involving physical injuries (my probability of breaking a leg is independent of your probability of breaking a leg). We might expect a positive correlation for risks involving weather (if I have bad weather and you live nearby, it is likely that you will also have bad weather). The same is true for infectious diseases (if I get sick, you are also likely to get sick). But the main point is that as long as we do not have a *perfect positive correlation* (which would be a correlation of +1.0) there is some benefit from food sharing: this still reduces risk, even though it does not make risks disappear completely.

Note: suppose we do have a perfect positive correlation. This means that in any situation where I get some additional pine nuts, you also get exactly the same number of additional pine nuts. Food sharing cannot reduce anyone's risk in this case.

Another note: in the modern world, financial advisors recommend that people invest their wealth in more than one company (hold a diversified portfolio). Although there is often a positive correlation among the profits of different firms, these correlations are usually not perfect, so if one firm does badly, it is still possible that another will do well. This lowers the risk level for the investor's overall portfolio. The same idea is expressed in the saying "don't put all of your eggs in one basket".

The second problem with my example is that I assumed people would always share their food equally. In reality, someone might promise to do this, but then break their promise after they find out how much food they actually have. Specifically, once someone finds out that they have 25 and the other family only has 5, maybe they will refuse to share. In a foraging society there are no contracts, lawyers, or courts, so methods of this kind can't be used to force people to keep their promises.

There are several potential solutions to this problem. First, if people are closely related, they may share food because they care about their relatives. This is often true within or across family-level groups. Second, individuals or groups often interact repeatedly, so they have to think about the future (if you need help today but I refuse to help, then you may not help me tomorrow when I need it). We will come back to ideas about repeated interaction and reciprocity later in the course. Third, sometimes the cost of giving help is quite small (you might be willing to let another family group forage in your home range because this does not reduce your own food supply very much). In cases of this kind, a small amount of altruism may be enough.

JE believe that the benefits of risk management sometimes create an incentive for larger-scale societies. (Remember from p. 31 that they mention 'production risks' as one of the problems arising from subsistence intensification.) From an economic standpoint, there are two primary ways in which larger scale could be useful in reducing the risks faced by individual members of a society. First, when we have larger numbers of people, we can average across many independent risks, which reduces the variance in total food. This is the same principle of risk-spreading insurance companies use when they average over the independent risks facing a large number of customers (injuries, houses burning down, and so on). Second, when a society has a larger geographic territory, it usually has a wider variety of ecological zones and is less vulnerable to local natural disasters (if things go badly in one area, they could still go well somewhere else).

These types of risk management generally require some political organization beyond the level of the family. As you go through the case studies in Parts II and III of the book, be on the lookout for cases where JE mention risk as one of the reasons for the formation of larger-scale societies.

Storage and saving. Another issue that frequently arises for small-scale societies (either based on foraging or agriculture) is how to store food for future use, and how much to store. If you read the case studies in chapters 3-4 carefully, you will see that three of the four societies have to make decisions of this kind. The Shoshone store pine nuts for use in the winter when other foods are not available, the Machiguenga store food under the ground in the form of edible roots that can be eaten later, and the Nganasan store meat in the form of frozen reindeer carcasses or live reindeer that can be eaten in an emergency. Only the !Kung do not appear to store food in a systematic way, probably because they have a variety of wild foods available at all seasons of the year.

Here I present a simple model having two time periods: 1 and 2. You can think of these periods as today and tomorrow, fall and winter, this year and next year, etc., depending on the context. We assume that there is a source of food in period 1, it is possible to store some or all of this food for later consumption, and the only food that will be available in period 2 is the food stored in period 1.

As in the previous model, we will use a utility function U(c) where c is the consumption of food. Again we assume the utility function has a concave shape (see the upper graphs in Figure 3 at the end of these notes), although here we are not concerned with risk (there is no uncertainty about anything). Let c_1 be the food consumption in period 1 and let c_2 be the food consumption in period 2. Also, let the total amount of food available at the start of period 1 be W (which stands for wealth).

The optimization problem facing an individual or family is:

Choose c_1 and c_2 to maximize $U(c_1) + U(c_2)$ subject to the constraint $c_1 + c_2 = W$

We assume the individual or family cares about the total utility from the two periods. The same utility function U(c) is used in each period. Notice that utility in the future is just as important as utility in the present (there is no 'discounting' of future consumption).

We start with a simple storage technology where any unit of food not consumed in period 1 is available in period 2. We can rewrite the constraint as $c_1 = W - s$ and $c_2 = s$ where s stands for 'saving' or 'storage'. Later I will discuss what happens with more complicated storage technologies.

To see how this problem is solved, we define *marginal utility* to be the *slope of the total utility curve* at a particular consumption level c. Mathematically we have

$$\text{Marginal utility} = MU = \Delta U/\Delta c \qquad \text{at a given level of } c$$

where the changes ΔU and Δc are small. To express this another way: marginal utility is the rate at which total utility increases as consumption increases. This idea is similar to the idea of marginal cost that was discussed in the cost minimization problem.

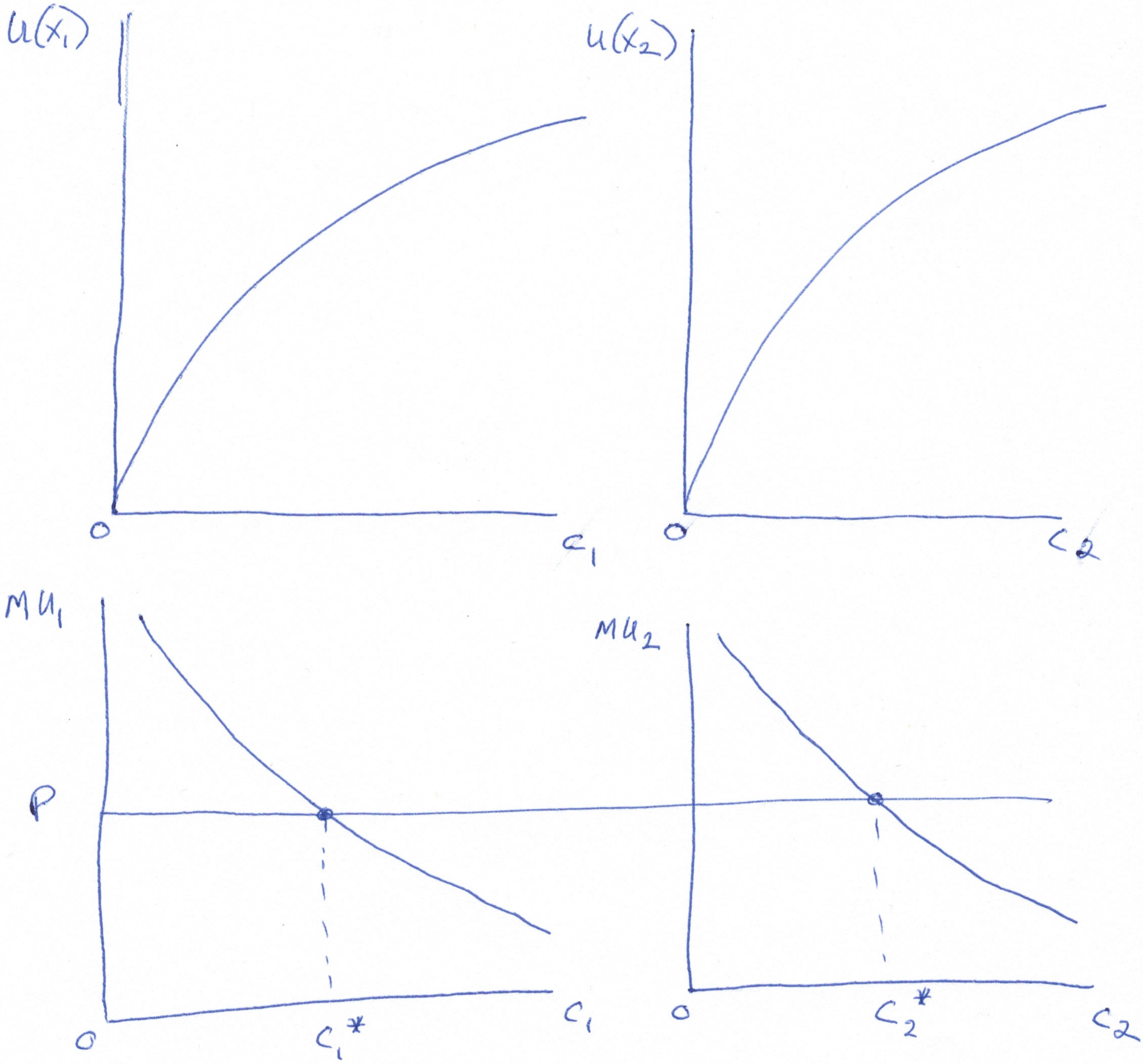

Figure 3
Total and Marginal Utilities

Because the utility function is concave as in the upper two graphs in Figure 3, the slope of the total utility curve falls as consumption (c) increases, so marginal utility decreases as c increases. The lower two graphs of Figure 3 show the marginal utility curve for each period. MU_1 falls as c_1 rises and likewise MU_2 falls as c_2 rises. Because we are using the same total utility function for periods 1 and 2, the curves for MU_1 and MU_2 are identical.

The key economic idea in this model is that in order to solve the optimization problem, it is necessary to choose c_1 and c_2 so that $MU_1 = MU_2$. To see why, suppose we have some pair (c_1, c_2) satisfying $c_1 + c_2 = W$, so it is feasible, but we have $MU_1 > MU_2$. In this case we could save one less unit of food and eat it today instead. This will decrease the total utility by MU_2 but increase it by MU_1, which is larger, so overall the total utility $U(c_1) + U(c_2)$ must increase. Therefore, we were not maximizing total utility and not solving the optimization problem. The same argument works in reverse if we have $MU_1 < MU_2$. It follows that whenever we have a solution, $MU_1 = MU_2$ must hold. But we can say more: because the MU_1 and MU_2 curves are identical, the only way to get equal marginal utility is to have $c_1^* = c_2^*$, where the stars indicate the levels when the problem is solved. This is illustrated in the lower two graphs in Figure 3.

There is one more issue: what about the constraint $c_1 + c_2 = W$? If we choose an arbitrary level of marginal utility like p in Figure 3, it could be true that $c_1^* + c_2^*$ adds up to a total less than W. In this case we can reduce p, which increases both c_1^* and c_2^*, and keep on doing this until the sum is W. On the other hand, if p is initially too low, we might get a sum $c_1^* + c_2^*$ greater than W. In this case, we can raise p, which decreases both c_1^* and c_2^* until the constraint is satisfied.

Here is a shortcut: we already said that we must have $c_1^* = c_2^*$, and from the constraint we need $c_1^* + c_2^* = W$. The only way both things can be true is when $c_1^* = c_2^* = W/2$.

You should be able to see a lot of similarity between this model and the model of cost minimization earlier in these notes. In the previous case we were trying to minimize total cost and now we are trying to maximize total utility. In both cases, we needed to look at the marginal costs or marginal utilities, and these needed to be equalized. Once we have the relevant marginal quantities equal, we can manipulate their levels in order to satisfy the constraint.

The main difference between the two models is that in the cost minimization problem, we had different cost functions for aardvarks and blueberries, so there was no reason for the marginal cost curves to be the same, and therefore no reason why we would want to have equal calories from the two sources. But here we assumed the utility function is identical for the two periods, and only the sum of the consumption levels matters in the constraint. As a result, the solution has equal levels of food consumption in the two periods.

Next I provide another graphical way of thinking about this problem. Consider Figure 4 at the end of these notes, where c_1 is on the horizontal axis and c_2 is on the vertical axis. Define an *indifference curve* to be a set of points that are equally good for the individual or family, in the sense that they all yield the same level of total utility $U(c_1) + U(c_2)$.

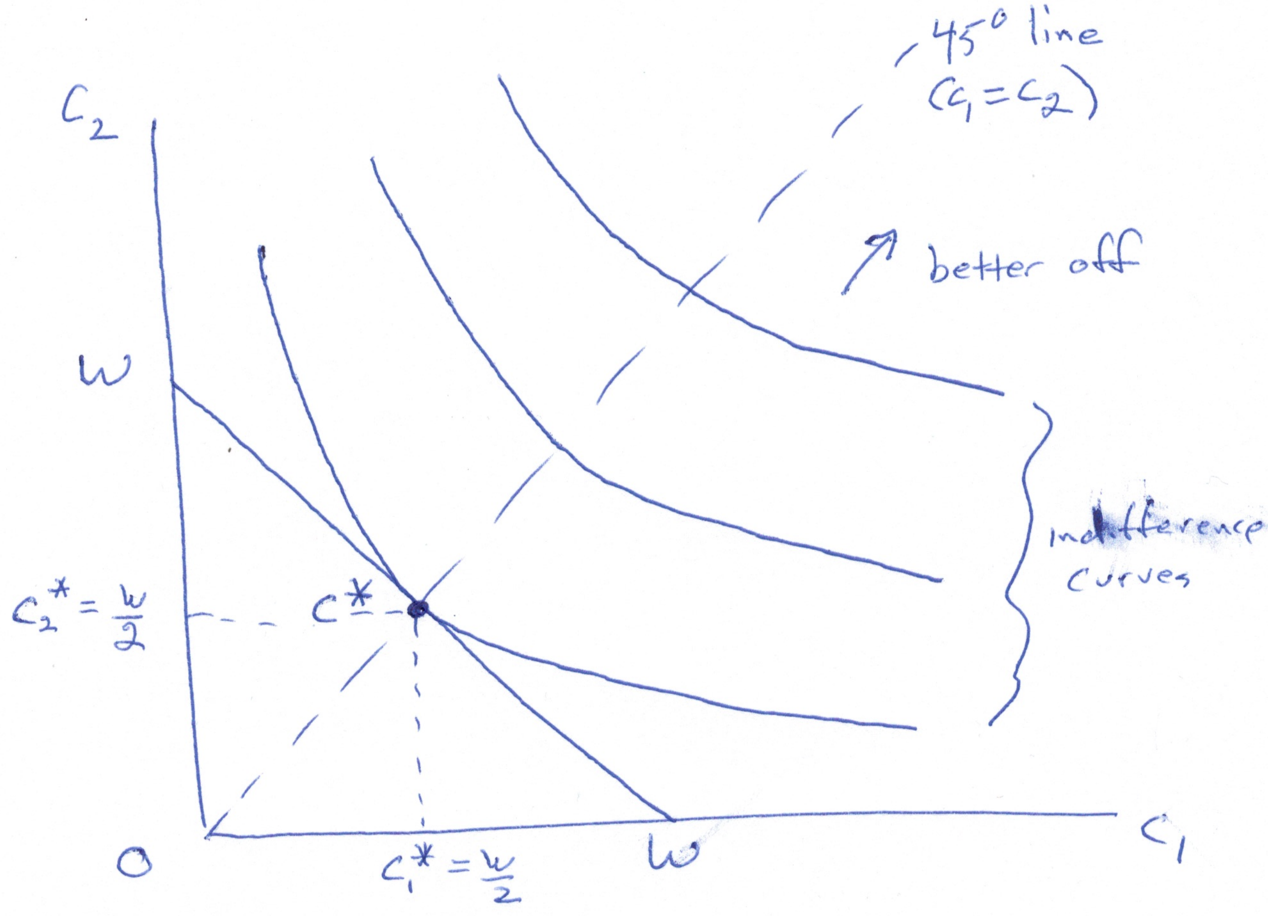

Figure 4

Indifference Curves and Constraint Line

($r = 0$)

It is not hard to see that an indifference curve must be downward sloping. If you increase c_1 this increases $U(c_1)$. In order to keep total utility constant, you must decrease $U(c_2)$, which means you must decrease c_2. The same argument works in reverse: if you decrease c_1 then you must increase c_2. Three typical indifference curves are shown in Figure 4. You can see that higher indifference curves are better because as we move out along the 45 degree line we increase consumption in both periods, which must raise total utility.

You might be wondering why the indifference curves bend toward the origin as shown in Figure 4. Here is the general idea. Choose any given point (c_1, c_2) in Figure 4 and define the *marginal rate of substitution* (MRS) at that point to be the absolute value of the slope of the indifference curve passing through the point. Using some calculus it can be shown that $MRS = MU_1/MU_2$ so that the marginal rate of substitution is equal to the ratio of the marginal utilities.

We know from the lower graphs in Figure 3 that MU_1 falls as c_1 rises, and MU_2 rises as c_2 falls. Suppose we are moving along some indifference curve, and c_1 is rising. Since the indifference curve is downward sloping, c_2 must be falling. This means that MU_1 is falling and MU_2 is rising, which means MU_1/MU_2 is falling, which means that MRS is falling, which means the indifference curve is getting flatter (the slope is closer to zero). Going in the opposite direction, as c_1 falls and c_2 rises, it must be true that MRS is rising, which means the indifference curve is getting steeper. This implies that the indifference curves must have the shape shown in Figure 4.

Now return to the optimization problem where we had to maximize $U(c_1) + U(c_2)$ subject to the constraint $c_1 + c_2 = W$. In Figure 4 the points satisfying the constraint are those on the line with the horizontal intercept (W, 0) and the vertical intercept (0, W), which has the slope -1. To solve the problem, we need to find the point on this constraint line that puts us on the highest possible indifference curve (which gives the highest total utility).

We know from previous arguments that the solution has $c_1^* = c_2^* = W/2$. This is the point where the 45 degree line intersects the constraint line. At this point we have a tangency between the constraint line and the indifference curve passing through c*. Or to put the same idea in a different way: at the point c* we have $MU_1 = MU_2$ so MRS = +1. Therefore the slope of the indifference curve is -1, which is the same as the slope of the constraint line. You should be able to see that moving along the constraint line in either direction would place the individual or family on a lower indifference curve, so no other feasible point can solve the maximization problem.

The last thing I will do with this model is consider a wider range of storage technologies. Suppose now we write $c_1 = W - s$ and $c_2 = (1+r)s$ where we interpret s as saving and r as a growth rate. When r = 0, we are back to the previous model. But in the modern world, if you save a dollar you can put it in the bank, wait a year, and then get your original dollar back plus interest. Small family-level societies don't have banks, but they can do similar things. For example, the Machiguenga can leave the roots of a plant underground and dig them up later to eat. Because the plant grows in the meantime, they get back more food than the amount they originally decided not to eat. This increase in food is like interest on a bank account. The same is true for the Nganasan: if they don't eat a living reindeer today, that reindeer could reproduce. If so, they will have more reindeer meat available in the future. In these cases we have $r > 0$, because saving one unit of food today yields more than one unit of food later.

On the other hand, it is also possible to have $r < 0$. Suppose the Shoshone save some of the pine nuts they harvested in the fall, but by the time winter comes, part of their stored food decays or is eaten by rodents. In situations like this, saving a unit of food now will give back less than one unit of food later.

To see what effect this has, take the equations $c_1 = W - s$ and $c_2 = (1+r)s$, solve for s, and substitute to obtain $c_1 + c_2/(1+r) = W$. Figure 5 shows the resulting constraint line for the situation where $r > 0$. The horizontal intercept is still W as before. However, the vertical intercept is $(1+r)W$. The constraint line is steeper, with a slope of $-(1+r)$ rather than -1.

For this reason the point c* in Figure 4 no longer gives a tangency between the constraint line and the indifference curve through c*. In fact, at any point on the 45 degree line, we have $c_1 = c_2$ so $MU_1 = MU_2$. This implies MRS = 1, so the indifference curve through the point has the slope -1. No point of this kind can yield a tangency with the constraint line, which now is steeper than -1 due to $r > 0$.

Now the highest feasible indifference curve is reached at the point c′ in Figure 5. This is the solution to the new utility maximization problem with $r > 0$. Again, it turns out that the solution involves a tangency point, but in this case we must be above the 45 degree line, with $c_1' < c_2'$ as in Figure 5. This is necessary to make the slope of the indifference curve equal the slope of the constraint line. The result should make economic sense: $r > 0$ is like a positive interest rate, which increases the incentive to store food. Accordingly, people respond by tilting their food consumption toward period 2 (eating more later).

When we have $r < 0$ (maybe some of the stored food is taken by rodents), the effects go in the opposite direction. The vertical intercept is lower, the constraint line is flatter than -1, and in order to have a tangency point where total utility is maximized, we must be below the 45 degree line where $c_1 > c_2$. This makes economic sense: an imperfect storage method where some of the stored food is lost reduces the incentive to save. Thus, people respond by tilting their food consumption toward period 1 (eating more now).

This analysis is a type of comparative statics. We are treating r as an exogenous variable that describes the storage technology, changing its value, and studying the effects on the endogenous variables (c_1 and c_2). Another endogenous variable in this model is the total utility the individual or family can achieve. Using graphs like the ones in Figures 4 and 5, you should be able to convince yourself that the individual or family is always better off with a higher value of r. For example, if they start with $r < 0$, they prefer $r = 0$, and if they start with $r = 0$, they prefer $r > 0$. Hint: assume that for a given level of r, the family always maximizes utility and is at a tangency point. Now increase r and show that with the higher value of r they can do better.

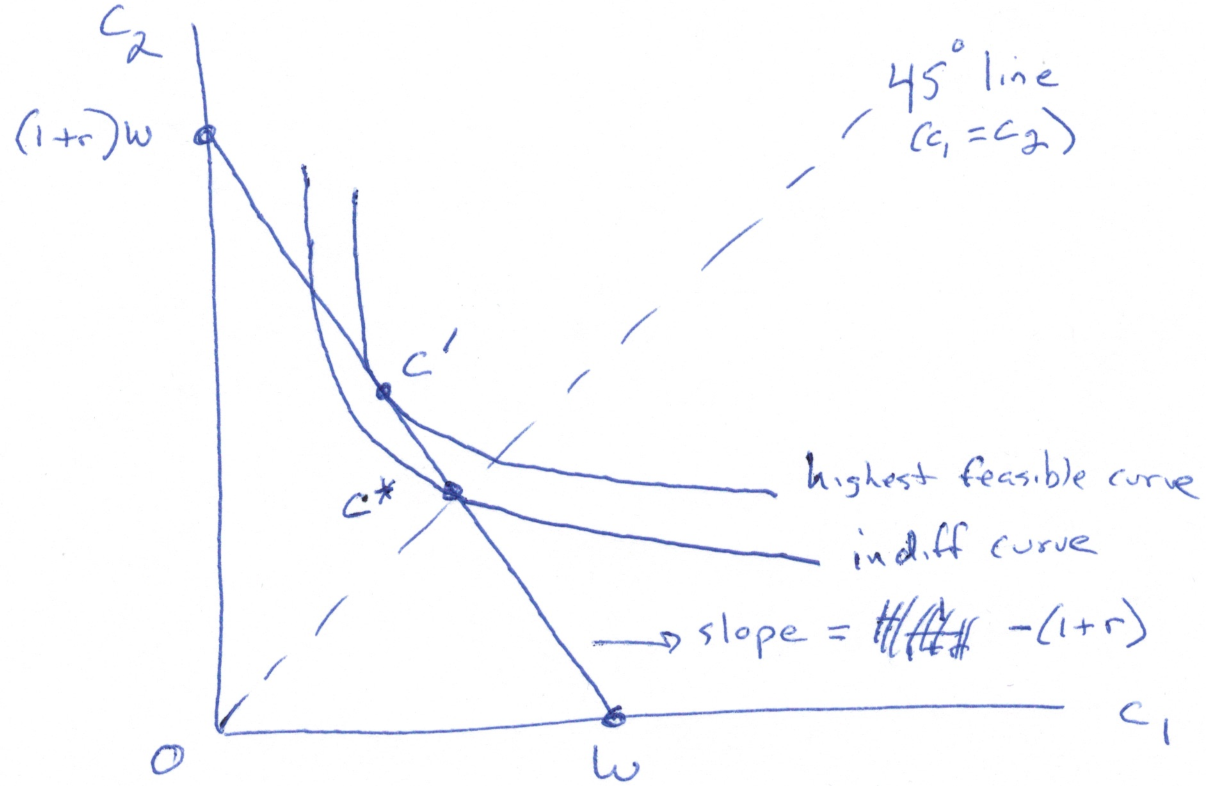

Figure 5

Indifference Curves and Constraint Line

$(r > 0)$

Local resource depletion. Small-scale groups like the ones in Part I of JE (and also some of the ones in Part II) face a dilemma. Larger groups are better for spreading risk (if one hunter doesn't catch an animal, some other members of the group might, and the resulting food can be shared). However, a larger group tends to use up the resources in a local area more rapidly, so the group must move to new locations frequently. This creates pressure to keep the group relatively small.

Here I want to create a simple model of a related problem. Suppose we have a group of foragers, where the size of the group is fixed. How often should the group move? You will see that there is tradeoff. Moving is costly, so you don't want to do it too often. On the other hand, the longer you stay in one place, the more you deplete the local resources and the costlier it becomes to continue collecting food in the same area.

The model is based on the case study of the !Kung (see especially p. 70) but the general principles apply to several societies in the book. The idea for the !Kung is that they set up a campsite in the mongongo forest and collect mongongo nuts from the nearby trees. They start with the area closest to their camp. After one week, they need to walk about 1.5 km from their camp to find food. After two weeks, they need to walk 3 km to find food, after three weeks they walk 4.5 km, and so on. Eventually it takes too long to walk to distant mongongo trees every day, so they move their entire camp somewhere else and start over.

Note: they could also stay in one place longer but eat less desirable foods. I will return to this issue at the end.

Similar issues arise for the Machiguenga, although the time periods are measured in years rather than weeks. The problem in their case is that the soil fertility in their gardens starts to decline after 1-2 years of cultivation so at that point it is best to move to a new location and set up new gardens. Again local resource depletion creates an incentive for people to move periodically to places where natural resources have not yet been overused. Often it is true that when old locations are abandoned, the natural resources gradually regain their former productivity (mongongo nuts grow back, soil regains its fertility), so this lifestyle does not permanently damage the resources as long as population density remains low.

Here is the model (look at Figure 6 at the end of these notes as you read this discussion). Suppose a group sets up a camp in a new location. On day 1, they harvest all the food in a circle of radius r_1. On day 2, they have to travel across this circle to collect more food, and cover a larger circle of radius r_2. Notice that although they have to travel throughout the larger circle to get back and forth to their camp, they only obtain food in the doughnut shaped area between radius r_2 and radius r_1. On day 3, they travel across the entire circle of radius r_2 where food has already been collected, and use some larger circle of radius r_3 to gather food in the doughnut-shaped area between the circles with radius r_3 and r_2. This pattern continues as long as they keep using the same camp.

We make the following assumptions. Each day, the group needs q calories. We treat this as a biological requirement that cannot be changed (it is exogenous). Food resources like

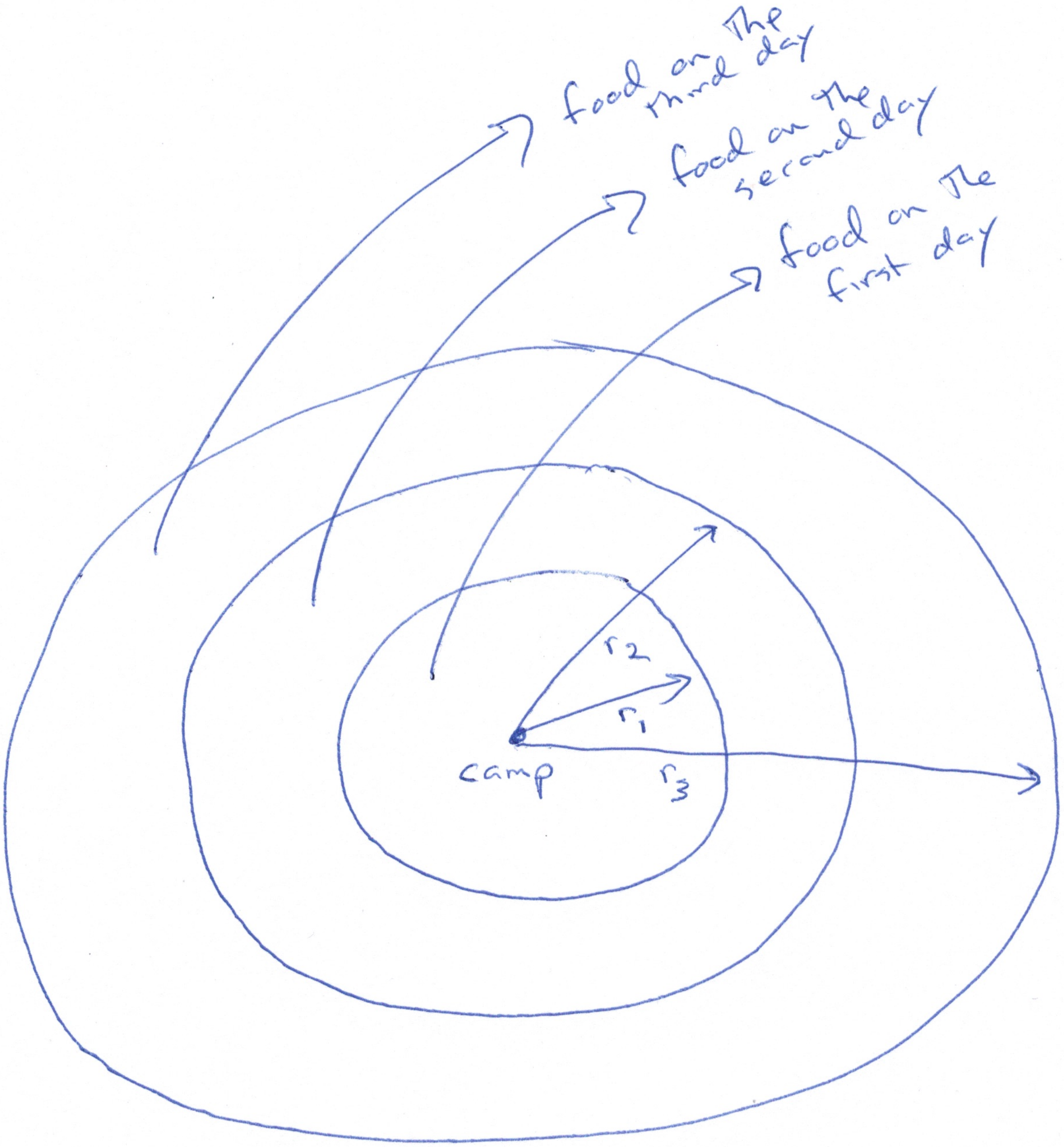

Figure 6
Local Resource Depletion

mongongo nuts are distributed uniformly across the landscape, with b food units per unit of land area. The cost of getting food on a given day is proportional to the land area over which it is necessary to travel, with a cost of c (measured in food units) per unit of area. Recall that a circle of radius r has the area πr^2.

The radius r_1 of the circle on day 1 is determined by $q = b\pi r_1^2$. The travel cost is $c\pi r_1^2$. We write the net utility on day 1 as $b\pi r_1^2 - c\pi r_1^2$ or equivalently $u_1 = q - c\pi r_1^2$.

The radius r_2 of the circle on day 2 is determined by $q = b(\pi r_2^2 - \pi r_1^2)$ because the group can only get food in the part of the circle that was not harvested on day 1. However, the cost is $c\pi r_2^2$ because people have to walk across the entire circle of radius r_2. We write the net utility on day 2 as $u_2 = q - c\pi r_2^2$.

The radius r_3 of the circle on day 3 is determined by $q = b(\pi r_3^2 - \pi r_2^2)$ because the group can only get food in the part of the circle that was not harvested on days 1 or 2. The cost is $c\pi r_3^2$ because people have to walk across the entire circle of radius r_3. We write the net utility on day 3 as $u_3 = q - c\pi r_3^2$.

What is the pattern? On day n = 1, 2, 3 . . . , utility is always $u_n = q - c\pi r_n^2$. Therefore we can always calculate u_n if we know r_n^2.

The pattern for r_n^2 is as follows. On day 1 we have $q = b\pi r_1^2$ which gives $r_1^2 = q/b\pi$. On day 2, we have $q = b(\pi r_2^2 - \pi r_1^2)$. Plug in the solution for r_1^2 and solve this for r_2^2. The result is $r_2^2 = 2q/b\pi$. On day 3, we have $q = b(\pi r_3^2 - \pi r_2^2)$. Plug in the solution for r_2^2 and solve this for r_3^2. The result is $r_3^2 = 3q/b\pi$. The pattern should be clear: on day n we will have $r_n^2 = nq/b\pi$.

Now return to our previous result $u_n = q - c\pi r_n^2$ for day n. Substituting the solution $r_n^2 = nq/b\pi$ yields the net utility $u_n = q(1 - cn/b)$ for day n. Because q, b, and c are constants, this shows that utility drops as n increases. This is logical, because the more time you spend in the same area, the longer you have to travel each day to collect food, and this increasing travel cost reduces utility.

At some point you should think about moving your camp to a new location and starting over. But this also has a cost, which I will call F. Each time you move your camp, you pay this cost (measured in food units to keep everything consistent).

Suppose you consider the following strategy: keep your camp in one place for n days, collect food as above, and then pay the fixed cost F and start again. Keep repeating this cycle. Assume you want to choose n to maximize average utility per day. The average utility from a cycle of n days can be written as

$$U(n) = (u_1 + u_2 + . . . + u_n - F)/n$$

$$= [q(1 - c/b) + q(1 - 2c/n) + . . . + q(1 - nc/b) - F]/n$$

$$= q - F/n - (qc/nb)(1 + 2 + 3 + . . . + n)$$

Here we need an algebraic trick, which is that the sum of the first n integers is $1 + 2 + . . . + n = n(n+1)/2$. Plugging this in, the average utility per day is

$$U(n) = q - F/n - (qc/2b)(n + 1)$$

We want to choose n to maximize this expression. Notice that q is a constant so the first term is irrelevant. Therefore we choose n to *maximize* $- F/n - (qc/2b)(n + 1)$. But this is the same as choosing n to *minimize* $F/n + (qc/2b)(n + 1)$.

Here is an economic interpretation. Think of F as a fixed cost, and call F/n the average fixed cost (fixed cost per day). I will abbreviate this as AFC. Think of $(qc/2b)(n + 1)$ as the average variable cost (time spent traveling per day). I will abbreviate this as AVC. We will call the sum of these two expressions average total cost or ATC, where

$$ATC = AFC + AVC = F/n + (qc/2b)(n + 1)$$

We want to choose n to minimize this expression.

The shapes of these cost curves are shown in Figure 7. If we ignore the fact that days are measured in discrete units and instead treat n as a continuous variable, we can use some calculus to find the number of days n* that minimizes ATC. If you don't know calculus, don't worry about this. If you do, just take a derivative of ATC, set it equal to zero, and solve for n. The result is

$$n^* = (2Fb/qc)^{1/2}$$

Unlike our previous models, we have enough algebraic information that we can solve explicitly for the endogenous variable (n) as a function of the exogenous variables (q, b, c, and F). So here it is easy to do comparative statics: just change one of the exogenous variables and see what happens to n*. For example:

If F increases, n* increases, and the group spends more time at each camp before moving.
If c increases, n* decreases, and the group spends less time at each camp before moving.
If b increases, n* increases, and the group spends more time at each camp before moving.

These results make economic sense. If it is more expensive to move, then you move less often. If it costs more to travel around looking for food, the variable costs rise rapidly so you should move more frequently. If there is more food per unit of land, you can satisfy your calorie requirement each day without much travel, so the variable costs don't rise as rapidly and you can move less frequently.

This is a simple model of local resource depletion. We could make it more complicated (and more interesting) in various ways.

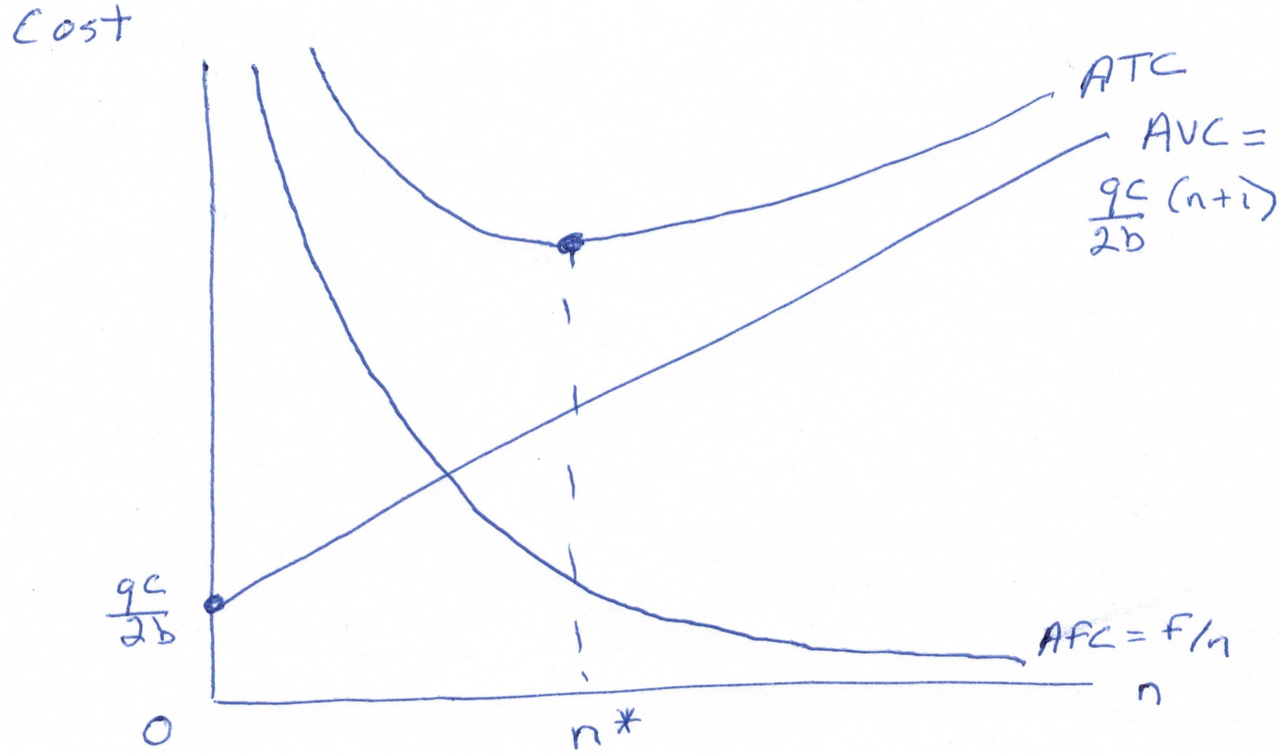

Figure 7

Cost Minimization for The Resource Depletion Model

1. Multiple resources. Instead of just eating mongongo nuts, people could eat various different foods. Then it makes sense to go after the best and easiest resources first, but there are tradeoffs between distance versus other factors such as the difficulty of finding or processing a particular food, its quality, taste, and so on. The group might run through several species of plants and animals before getting to foods of low enough quality that it would be worthwhile to move the camp and start again.

2. Patchiness of resources. I assumed that food was uniformly distributed over the land, but in reality, food is often concentrated in patches, with not much food in between. For this situation, it makes economic sense to put your camp in the middle of a rich resource patch, collect food first in that patch, and then start traveling greater distances each day. At first variable cost rises slowly because you are using up a rich patch of food close to your camp, but later it rises more rapidly because food is harder to find when you travel further away from this patch.

3. Variable numbers of calories. I assumed that people need a fixed number of calories q per day (although I subtracted off some calories to reflect the effort from traveling across the landscape). You could have a more general model where the food intake q is allowed to vary. This would give people the option of staying at one campsite and avoiding high variable costs from travel time by reducing q and becoming hungrier. Of course at some point people will become hungry enough that they will need to move their camp.

4. Renewable resources. In this model, I ignored the possibility that resources may grow back after they are harvested. This might be a reasonable assumption in the short run (it may take a year for mongongo trees to produce more nuts, and it takes more than a year for the soil to regain fertility for groups like the Machiguenga). But if there are multiple species located in one area and they grow back fairly quickly, it might be possible to stay in one place forever without changing campsites, as long as you don't overharvest any of the local resources. Again, there are tradeoffs: if the group is too big, it may use the local resources too intensively, which would force people to move. But there are examples of hunters and gatherers who stay in one place and have rich enough resources that they can enjoy a sedentary lifestyle without running into depletion problems.

5. Domestication. This is an extension of point 4. If a group has domesticated plants and animals, it may be able to remain in one place and produce enough food without ever having to move. This is not always possible though. For example, the Machiguenga use domesticated plants and the Nganasan use domesticated animals (tame reindeer). Both of these groups move around a lot. But if agricultural technology is productive enough, and you can store enough food to eat while waiting for the next crop to be harvested, and the fertility of the soil does not decline over time, then you may be able to enjoy a sedentary life without having to change locations in response to local resource depletion problems.

This concludes my lecture notes on Part I (chapters 2-4) of Johnson and Earle. The next set of notes will discuss Part II (chapters 5-8).

Econ 354

Greg Dow

January 24, 2021

Notes on Allen W. Johnson and Timothy Earle, "The Evolution of Human Societies" (second edition, 2000)

Part II (chapters 5-8)

This part of the book discusses local groups. Chapter 5 gives an overview of the subject, while chapters 6-8 provide a series of case studies. These are organized roughly in order of increasing scale and social complexity. Some of these societies are based on foraging, some on farming, and some on pastoralism.

What they all have in common is that people face social problems that cannot be solved at the level of the individual family or household. These problems vary with the society, and may involve risk, warfare, technology, or trade (or some combination of them). As a result, social systems beyond the level of the individual family start to become important.

In these notes I focus mainly on warfare, which I will define as organized lethal conflict between social groups. This is different from individual homicide. A society can have occasional killings due to theft, jealousy, revenge, and so on without necessarily having warfare between organized groups.

Anthropologists often find high rates of homicide in hunter-gatherer societies compared to contemporary societies. This is not surprising. HG societies lack the institutions that modern societies use to restrain this type of violence, such as police, courts, and prisons. But this is not relevant for what I want to discuss below. Here I am concerned with war, not with forms of violence we would normally label as 'crime'.

There are a number of important topics in Part II of the book. You should pay attention to what JE say about risk, technology, and trade, among other things. Specifically, you should ask yourself whether these factors help to explain why societies evolved from the level of family groups to local groups. However, I concentrate on war for two reasons.

First, although warfare is absent in Part I, it becomes prominent in Part II. This raises a number of interesting questions. Does war cause increased social complexity? Or does increased social complexity cause war? Or are both things caused by some third factor?

Second, there has been a huge debate, starting before I was an undergraduate student and continuing today, about whether humans have some instinct for violence, with war being one expression of this genetic programming. If you believe this, you may be pessimistic about the prospects for eliminating or decreasing warfare in the modern world. The case studies from Johnson and Earle are relevant in thinking about this issue.

The good news is that based on the material from JE, it appears unlikely that humans are genetically programmed to engage in warfare. The family-level groups in Part I are all at the peaceful end of the spectrum. If you believe prehistoric societies looked like this over the hundreds of thousands of years during which humans evolved, there is little reason to think natural selection would have favored warfare. In fact, you could argue instead that natural selection would have favored cooperative behaviors based on risk sharing, team hunting, or trade.

The bad news is people are obviously capable of engaging in warfare, and under certain conditions this can become a chronic part of social life. The mortality rates from war in small-scale foraging or farming societies are often high. In societies that do have chronic warfare, as many as 25% of adult males might die from war. This is much higher than in modern global society where the figure is under 1%. So while humans may not have any biological programming for warfare, human nature clearly does not prevent it either.

Some of the societies in Part II have warfare while other societies do not. This suggests to me that warfare is not inevitable. In my view it is a function of economic, social, and environmental conditions. As social scientists we should seek to understand the reasons for the variations we observe in the frequency and intensity of warfare across societies.

Note: I will argue that economics can help explain why groups sometimes use organized warfare to grab resources from other groups. Even if these explanations are correct, this does not mean that raiding, kidnapping, killing, or stealing land is morally justified. It is important to remember that there is a large difference between explaining something and justifying it. In fact, if we want to prevent war then it is useful to understand its causes.

Let's begin by placing the societies from Part II into two broad categories. The relatively peaceful cases are the Tareumiut, the Turkana, and the Kirghiz (although the Turkana do engage in some raiding of animal herds). The more warlike societies are the Yanomamo, the Tsembaga Maring, the Central Enga, and those on the Northwest Coast.

Note: the societies of the Northwest Coast of North America are located in the area from northern California to Alaska, including the coast of British Columbia where Vancouver is located. The descendants of these people continue to live in this region today, and we are using their land. When I put this case study into the 'warlike' group, I am referring to the time before European contact (about 200 years ago). Britain and the U.S. eventually took control of the region and imposed peace. This conquest was accompanied by a lot of disease and colonial oppression, so the resulting peace came at a heavy cost.

All seven societies listed above have significant social organization beyond the family level, such as villages, clans, or lineages. Among the subset of societies that are peaceful, in which local groups did not develop for reasons of aggression or defense, what were the motives for these new forms of social integration?

For the Tareumiut the primary factor is cooperative whale hunting, which requires large investments in boats. Both production technology and risk management are relevant for social organization beyond the family level.

The Turkana are mobile pastoralists who live in an unpredictable environment. The key issue is risk, which is managed using decentralized social networks for insurance.

The Kirghiz are also mobile pastoralists. They experienced externally imposed resource scarcity due to the policies of powerful nearby states. The result was the development of central leaders who provided insurance and managed trade.

These three examples make it clear that local groups can evolve for reasons unrelated to warfare. What about the cases where war was important?

I find it useful to distinguish between three different kinds of war, which have somewhat different motives and tend to arise in different kinds of societies.

Raiding. The idea here is that the attacking group is relatively small, moves quickly, uses surprise, and steals moveable property. This could include food, animals, equipment, and small valuable objects like jewelry. It could also include kidnapping people who are held for ransom or used as slaves. Women are often particularly targeted for kidnapping.

Displacement. Here one group seizes the land occupied by another group, with the goal of permanently holding the new territory and using it as a source of food. The previous inhabitants are either driven away or killed.

Conquest. In this case, one group takes control of new land but does not drive off or kill the existing inhabitants (except maybe their leaders). Instead, the inhabitants continue to work on the land and must hand over food surpluses to the new rulers. Usually this only occurs in societies with social stratification, so we don't see it in Part II. However, there will be examples in Part III.

In the remainder of these notes, I focus on displacement. We see this in the examples of the Yanomamo, the Tsembaga Maring, the Central Enga, and the Northwest Coast. Can we construct a theory that will explain the presence or absence of this type of warfare?

I will not develop a full economic model of warfare. However, here are several factors I think would be relevant for an economic approach to the issue.

1. Geographical circumscription. Roughly speaking, this means there is nowhere else for individuals or families to go. All the nearby areas have poor natural resources, diseases, or hostile people, or there are barriers to movement such as mountains, deserts, or oceans. This implies that although people may be vulnerable to war, there is no better alternative. One rational response to the threat of warfare is to run away and look for a peaceful place to live that offers a reasonable standard of living. But with geographical circumscription, this option is not available.

2. Territories matter. To explain warfare, it is not enough to say that resources are scarce and this causes people to fight over them. Resources were scarce in Part I of the book, at least sometimes, but these societies did not have wars. For warfare of the 'displacement' kind to make sense, resources must be predictable and concentrated at specific places, so people want to settle in these places and stay around for a long time. This implies that a good territory is worth defending, and also possibly worth attacking. This is frequently reinforced by long-term investments that make a territory more valuable, such as clearing land for farming, planting trees, or building houses. These investments make the territory a more tempting target for attack. In certain situations we might also have local resource depletion. As a result, over time a group finds that its territory is becoming less valuable, which gives them a motive to attack another group and try to take over their territory.

3. Larger groups are militarily stronger. Larger groups have more effective defense and tend to have offensive power if they want to use it. This is fairly obvious but we need to spell it out, because it is important in explaining why warfare leads to larger-scale social structures. When there is a threat of attack, people tend to cluster together for defensive reasons. In the cases from Part II this frequently involves 100 or more people in a single village. In societies with frequent warfare, people often establish military alliances with nearby friendly groups to reduce the danger of an attack by hostile forces.

4. Smaller groups make economic sense. In foraging, farming, or pastoral societies, it is generally not good from an economic point of view to have a lot of people clustered in one place. This causes depletion of local resources and increases travel time to foraging areas, gardens, or grazing lands. Also, large groups have more internal conflict because there are fewer ties of kinship and reciprocity linking group members, more opportunity for jealousy and theft, etc. Thus, there is a tradeoff between the need to cluster together for defense versus the need to spread out for economic efficiency. Although it may make sense militarily for everyone to live in one huge group, these other factors tend to place a limit on group size. If a group is small, it may try to get bigger in order to achieve more security, but if it becomes too big, it may split into small neighboring groups (who could become military allies).

5. Costs and benefits of aggression. A war can only occur if some group wants to attack.
(a) What are the costs of an attack? This is a risky thing. Your group might lose, which may lead to the loss of your land and even the extermination of your group. Even if your group wins, you may suffer deaths and injuries. Also, preparing for war takes resources away from food production (there is an opportunity cost).
(b) What are the benefits of an attack? Your group can potentially increase its resources, making your group richer. For example, your group may keep its existing lands and gain some new lands, giving more land per person. A large group may be militarily strong but have relatively low resources per person. Such a group may be tempted to attack another group because it is likely to win, and its members will have a higher standard of living if it does win.

Figure 8 provides a simple sketch that is consistent with these ideas. Suppose there is a lake, and around the shore of the lake there are territories controlled by several different groups. I indicate the central village for each group with a round dot and the boundaries between groups by lines. The villages are located at particularly good locations (maybe where rivers enter the lake or there is good soil, good fishing, etc.). The territories used by each group are indicated by the dashed curves. The region is encircled by mountains that are hard to cross and bad for food production. This captures the idea of geographical circumscription.

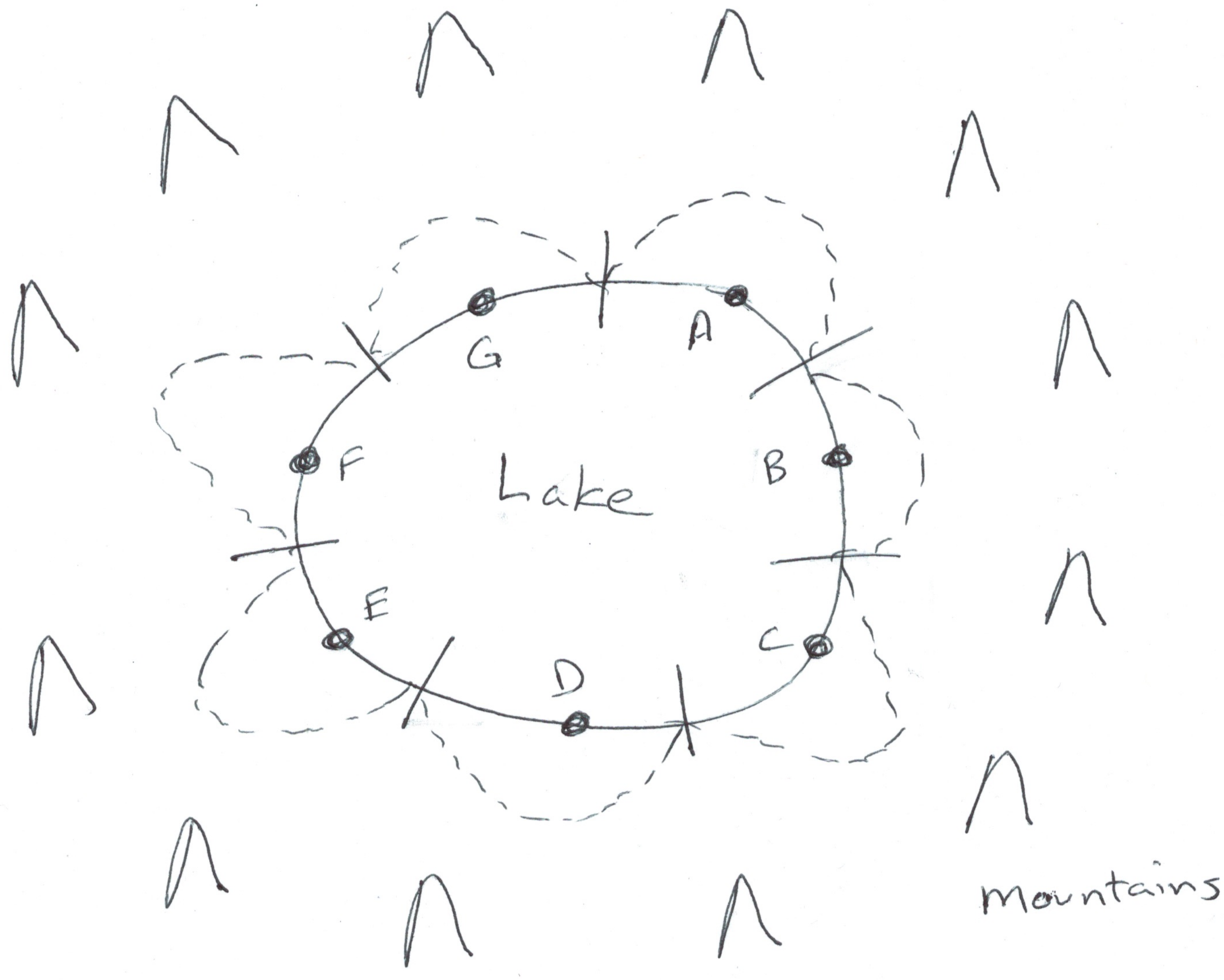

Figure 8
Warfare Among Local Groups

For each group, consider the ratio of resources to population (R/P). Resources reflect the quantity and quality of land; any investments in land clearance, tree planting, or housing; plus other valuable factors (good hunting or fishing opportunities, availability of unusual raw materials, and so on).

If R/P is the same for every local group and defensive military technology is effective, we would not expect a war, because the probability of a successful attack would be small and the benefits would be low relative to the costs.

But both resources and population can fluctuate over time. On the resource side, people may make additional investments in their site, making it more attractive as a target for an attack. Also, people may suffer local resource depletion due to decreasing soil fertility or other factors, making them poorer and possibly more tempted to launch an attack. On the population side, the sizes of the groups will go up and down through random changes in fertility, mortality, migration, and so on.

For these reasons, at a given point in time R/P will be high for some groups and low for others. If the gap becomes too large, a group with a large population and few resources may decide that the benefits of an attack outweigh the costs because (i) they have a high probability of winning and (ii) they get a major gain in resources per person if they win.

Algebraically, if $R_A/P_A > R_B/P_B$ then group A is a tempting target for B, especially if P_B is substantially larger than P_A so military strength is seriously unequal. Assuming group B attacks and wins, and assuming its population does not decrease significantly due to the war, it will have resources per person equal to $(R_A + R_B)/P_B$ so its members are better off. In this situation, the members of group B will probably spread out to occupy sites in both their old and new territories. However, they might also simply move to the new territory and abandon the old one, if it is no longer usable or the new one is much better.

Will this yield a new equilibrium? Temporarily, yes. But for random reasons, it is likely that eventually two other groups will have a large gap in R/P. When this occurs, another war may occur.

What does it take to prevent this? There are two main factors that might tend to restrain warfare. First, if military defense is effective enough, even large groups may decide that an attack is too risky, and this may ensure a peaceful equilibrium where each local group can maintain its independence. Second, institutions may develop that prevent war. One way this can occur is by having one group become powerful enough to impose peace on all of the other groups in the region. When we get to Part III we will see that chiefdoms can suppress warfare among villages, and states can suppress warfare among chiefdoms. In general, larger-scale political units tend to ensure peace within their own boundaries, although they may continue to engage in warfare with external enemies.

Econ 354

Greg Dow

January 31, 2021

Notes on Allen W. Johnson and Timothy Earle, "The Evolution of Human Societies" (second edition, 2000)

Part III (chapters 9-13)

This series of chapters is about 'regional polities' (chiefdoms and states). I will use the cases in these chapters to discuss three main issues: the role of markets, the origins of inequality, and the evolution of the state.

<u>The Role of Markets</u>.

As you know from Econ 103 or some other introductory course, in a competitive market we have a demand curve and a supply curve. At their intersection, quantity demanded is equal to quantity supplied. This determines price and the total quantity bought and sold.

In an informal sense, the equilibrium price is a compromise between the interests of the buyers and sellers. The buyers would prefer a lower price while the sellers would prefer a higher price. So from one point of view you could think about the equilibrium price as a reflection of the relative bargaining power of the people on each side of the market.

From another point of view, the equilibrium price is a measure of relative scarcity. To see this, imagine that the demand curve shifts to the right because there are more people trying to buy the good, while the supply curve stays unchanged. The model predicts that the price will rise. This indicates that the good has become scarcer from the standpoint of an individual buyer. Or imagine that the supply curve shifts to the left because there are fewer firms able to supply the good, while the demand curve remains unchanged. Again the price rises, reflecting the fact that it is harder for consumers to obtain the good.

Here are some examples of different types of markets in Part III of the book.

<u>Goods exchanged for other goods</u>.

(a) The Trobriand Islands (chapter 10). Within an individual island, the communities in areas that are good for agriculture focus on agriculture, while the communities in areas that are marginal for agriculture focus on fishing or craft activities. The latter trade their outputs for food. This is an example of the economic concept of *comparative advantage*: people specialize in the set of production activities for which their resources are relatively better suited. In these cases the trading process is decentralized (not organized by chiefs). Individuals trade goods among themselves using traditional exchange rates (it is not clear to what degree, if any, these exchange rates reflect supply and demand conditions). For trade that involves more than one island, the chiefs monopolize the canoes required for transportation. Hence, this trading process is not as decentralized, and the supply and demand model might be inappropriate (we might need a model of monopoly instead).

(b) The Basseri of Iran (chapter 11). People in this society are pastoralists (mostly they raise sheep and goats). However, their diet is mainly based on agricultural products. The way this works is that they give dairy products, wool, etc. to farmers in exchange for wheat, fruits, vegetables, etc. This is a very common sort of relationship between farmers and pastoralists (anthropologists see it in many places around the world). Again you can think about it as an illustration of comparative advantage: people are specializing in those activities for which their resources are best suited, and then they trade with each other to get the goods they don't produce themselves.

Labor services or agricultural output exchanged for land use.

(a) France and Japan in the Middle Ages (chapter 12). In each country, initially land was abundant and labor was scarce (due to low population density: few people per unit of land). Under these conditions, the lords (land owners) had to offer incentives to attract farmers. This might involve offers of private land ownership for the farmer, low service obligations to the lord, a high share of the crop kept by the farmer, and so on. But over time as population increased, land became scarcer (more people per unit of land). The result was that land ownership was carefully defined and enforced, and peasants became worse off. The supply and demand interpretation is that the price of land (land rent) was increasing because it was becoming scarcer, or equivalently the price of labor (the wage) was decreasing because it was becoming more abundant. I'll come back to this topic later and use supply and demand graphs to explain it.

(b) The Brazilian peasants, the Chinese village, and the Javanese village (chapter 13). In the Brazilian case, peasants competed for favors from the landlord and the landlords competed for peasants. There was an equilibrium rent that peasants paid for the use of land, which was about 25-30% of the food output they produced. In the Chinese village, labor was abundant and land was scarce. Although most peasants owned some land, their economic behavior reflected these relative scarcities. If there had been explicit prices in a labor or land market, wages would have been low and land rents would have been high. The situation with the Javanese village is similar.

Competition among leaders for followers.

Recall the potlatches (big feasts) along the Northwest Coast from chapter 8. The idea is that the Big Man and his followers invite neighboring groups for a feast and give away a lot of food and valuable objects. This is a highly competitive process in which a Big Man and his group gain prestige in relation to rivals by giving away or destroying more wealth than other groups do at their potlatches.

This doesn't appear to make much economic sense. Why give away or destroy valuable goods? But keep in mind that the Big Men are competing for followers. People do not necessarily remain in one location; they can choose which Big Man to follow (assuming they are not slaves). On the basis of family relationships most people are eligible to join several different groups, so commoners can usually move from one territory to another.

A common interpretation of potlatching (and similar competitive feasts in many societies around the world) is that the Big Man or chief is trying to attract more followers. Having more followers generally makes him wealthier and militarily stronger. Outsiders may not be able to observe a Big Man's resources directly, so he sends a signal about the scale of his resources through the quantity and value of the goods he gives away. Only a Big Man who is genuinely wealthy could afford to give away or destroy a large amount of food or other resources. Think about it this way: if you see two people, and one sets a $10 bill on fire while the other sets a $100 bill on fire, who do you believe is richer? Same idea.

Other cases of competitive signaling include the Enga (chapter 8); the Trobriand Islands (chapter 10) where chiefs display yams in large piles, and prestige rankings change based on economic performance; and Hawaii (chapter 11) where there was competition within the elite for leadership roles and among the chiefs to attract and retain commoners. Such behavior spans the range from local groups with Big Men to large complex chiefdoms.

Having discussed the role of markets in a general way, I want to move on to the origins of inequality. First I will present an economic model that helps to explain how inequality (and labor markets) could arise. After that, I will use supply and demand concepts to talk about stratified societies where elites own land and commoners do not.

<u>The origins of inequality</u>.

I will develop a simple model where chiefs compete for followers. The idea is to see how a labor market might emerge, along with inequality. In general, chiefs tend to have well-defined territories, which they either own, or manage on behalf of their group. The first thing to think about is how food output varies with the size of the group using a specific territory. During the following discussion, look at Figure 9.

In the top part of Figure 9, labor input (n) is on the horizontal axis. We interpret labor input as being the same as the number of people in the group. Food output (q) is on the vertical axis. The relationship between n and q is given by the TP (total product) curve. As n increases, we are adding more labor to a fixed amount of land. At first output rises slowly, perhaps because it is not yet possible to exploit specialization and a division of labor (or perhaps because small groups are militarily weak and have trouble defending their output). After a while, output starts to rise rapidly because the group can exploit a division of labor, invest in capital projects, defend itself more effectively, and so on. But when n becomes even larger, the rate of growth in output slows down (we hit diminishing returns), maybe due to local resource depletion, internal conflict within the group, etc. It is even possible that the total product might eventually start dropping, if large groups are so inefficient that total output falls as population continues to rise.

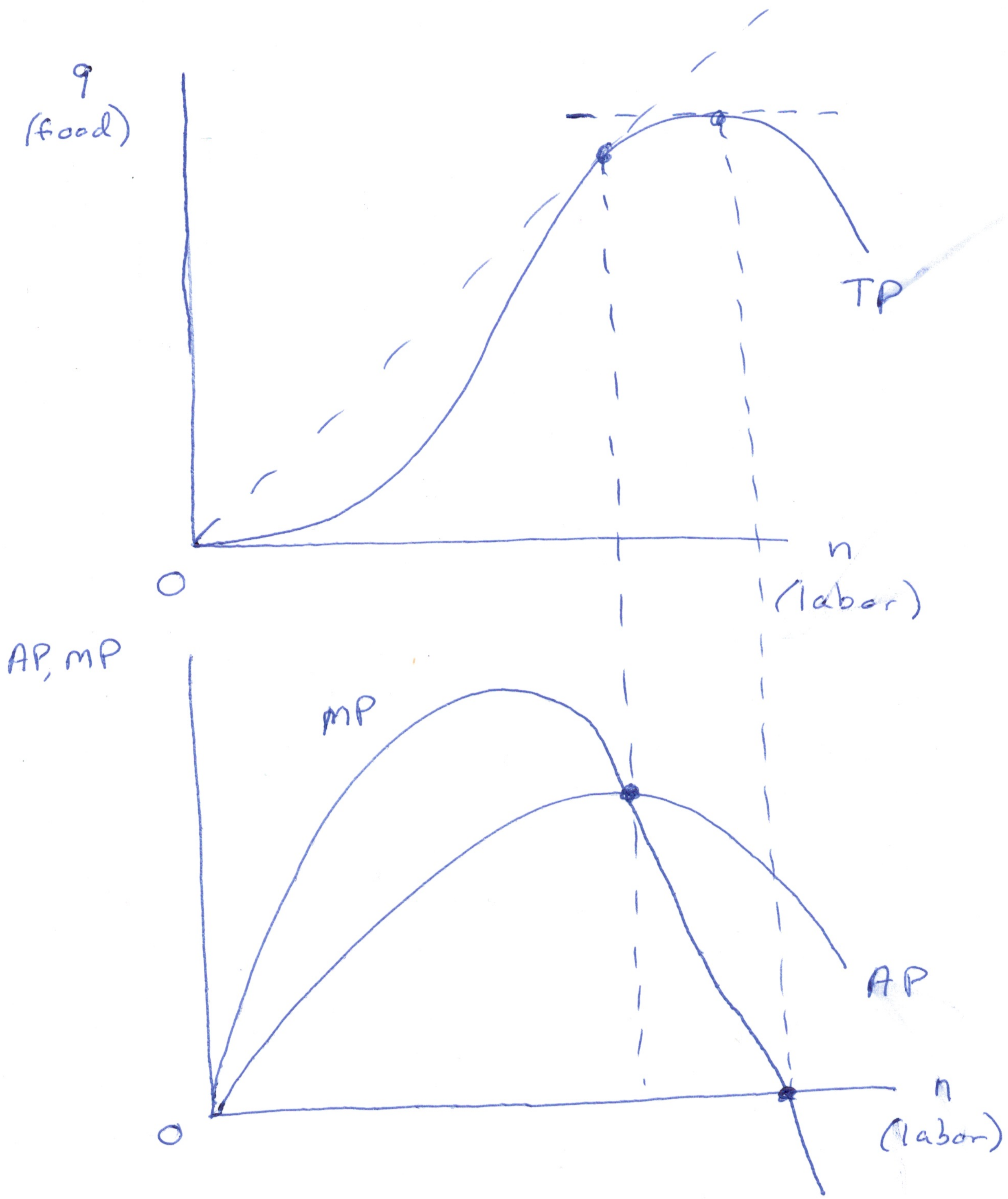

Figure 9
Total Product, Average Product and Marginal Product Curves

In the bottom part of Figure 9, we see two curves: average product (AP) and marginal product (MP). AP is just output per person (q/n). Graphically, the AP at a particular point on the total product curve is the slope of the ray from the origin to the point on the TP curve. You should be able to see that as n increases, the slope of this ray starts low, rises to a maximum, and then starts falling again. This means that AP is initially rising (when n is small) but eventually starts falling (when n is large).

MP is the rate at which TP is increasing at a particular point on the TP curve. You can think of it as the slope of a tangent line at a point on the TP curve. Algebraically we can write $MP = \Delta q/\Delta n$, where the change in n is small. Notice that as with AP, the MP curve initially rises, hits a maximum, and then declines. If TP eventually starts dropping, MP eventually becomes negative.

The AP and MP curves are not the same thing. In general, AP = MP only occurs at the point where AP reaches its maximum. At lower levels of n, we have MP > AP, while at higher levels of n, we have MP < AP. This is a mathematical fact that I will not prove in these notes, but it is easy to demonstrate if you know some calculus.

Now suppose there are three territories, with land of varying quality. Territory 1 has the best land, territory 2 has adequate land, and territory 3 has the worst land. This results in the AP and MP curves shown in Figure 10.

I want to run through a story about the origins of inequality involving three steps.

<u>Step 1</u> (a model with equality). Assume food is equally shared within each territory and people are free to move from one territory to another. We would expect an equilibrium where food per person is equalized across all three territories. If we had unequal food per person for two of the territories, then people would tend to move from the territory where food per person was low to the territory where it was high, and this would continue until the difference in food per person was eliminated.

On the graph, this means we must have a situation where $AP_1 = AP_2 = AP_3$. Write the equilibrium number of people in territory 1 as n_1^0 and likewise for the other territories. Assuming the entire region has a total population of N, the populations of the individual territories must add up to N, so we require $n_1^0 + n_2^0 + n_3^0 = N$.

<u>Step 2</u> (a model with inequality across territories but equality within territories). Now we assume each territory has a chief, and the chief decides which individuals are permitted to live on her territory. However, we continue to assume that food must be shared equally by people who live in the same territory, so each person gets the AP that corresponds to their particular territory.

It should be clear from Figure 10 that if we start from the equilibrium (n_1^0, n_2^0, n_3^0) where average products are equalized, the chief of territory 1 can raise her food consumption. She can do this by expelling some people from the territory, which decreases n_1, which increases AP_1. As a result, each person who continues to live in territory 1 has more to

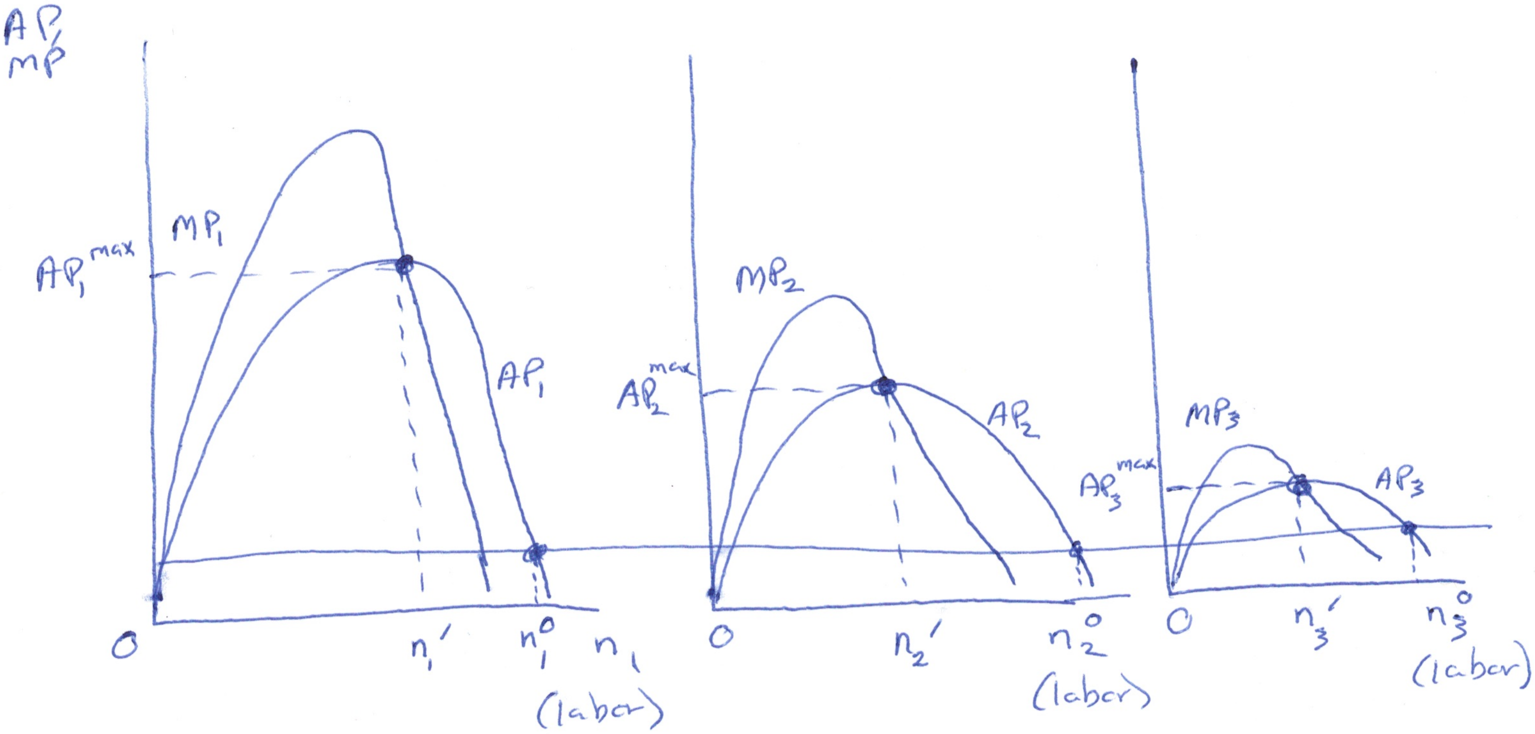

Figure 10

Three Territories with Different Land Qualities

(AP = average product
MP = marginal product)

eat (don't worry for now about what happens to the people who are thrown out). Chief 1 keeps reducing n_1 until we get to the population level n_1' where AP_1 is maximized. I will write the resulting average product level as AP_1^{max}. Clearly it doesn't make any sense to reduce n_1 further, because then food per person would start falling in this territory.

Now suppose the people who are thrown out of territory 1 go to territories 2 and 3. This will push down the AP there. But if the chief of territory 2 also has the power to expel people, she will reduce n_2 until her AP_2 is maximized at n_2'. This yields food per person of AP_2^{max}. And if the chief of territory 3 can expel people, she will set her group size at n_3', giving AP_3^{max}. This causes inequality across the groups, because the three territories have land of different qualities and people can no longer move from places where AP is lower to places where it is higher. However, we still have equality among the individual members of each group (there is equal sharing of food within territory 1, and so on).

There is a problem with this story: each chief reduced the number of people living in their territory as compared to Step 1, so now we must have $n_1' + n_2' + n_3' < N$. What happens to the remaining people? We could deal with this by assuming that there is a large region with very poor resources and a horizontal average product curve (maybe this is a desert), so people who are not allowed to live in any other territory can always go to this region and get some bad outcome AP_{min}. I don't want to make the model any more complicated than it already is, so I will ignore this issue.

Step 3 (a model with inequality both across territories and within territories). You might wonder whether the outcome in step 2 is actually an equilibrium. If the chief of territory 1 is really powerful, she might be able to impose inequalities among the members of her own group. Specifically, suppose she offers the following deal to a person at territory 2: "I will pay you w if you come to work in my group. However, I am not promising that w will be as high as the food income received by the other people living in territory 1."

If chief 1 is clever, she will choose w so that it satisfies the inequalities $AP_2^{max} < w < MP_1$. The first inequality ensures that a person at territory 2 will say yes to the offer (they are currently getting AP_2^{max} and w is better). When we add the new person at territory 1, the food output there will go up by the amount MP_1. However, the second inequality implies that chief 1 only has to pay the new person a smaller amount w. The surplus $MP_1 - w > 0$ can be consumed by the chief or distributed among her family and friends.

How do we know this is even possible? We are currently at AP_1^{max} because the average product for territory 1 is maximized. Mathematically, when AP_1 is maximized we must have $MP_1 = AP_1$. Because $AP_1^{max} > AP_2^{max}$ due to the difference in land quality between the territories, it is always possible to choose some value of w between AP_2^{max} and MP_1.

Therefore, chief 1 can attract a follower away from chief 2 while raising food per person for the other people who already live at territory 1. But to achieve this, it is necessary to have inequality within the group. Notice that when we start from n_1' and increase n_1, this will decrease AP_1. If food were shared equally, this would imply that everyone would be worse off. But if there is inequality, some people (like the chief and her cronies) can become better off even though there is less food on average.

Similarly, chief 2 can offer a wage that satisfies $AP_3^{max} < w < MP_2$ and so on. As a result, we might expect the chiefs to start competing with each other to attract new followers by offering better deals than what the other chiefs are offering. In particular, suppose each chief announces a 'standard of living' (w_1, w_2, w_3) that they are willing to provide to newcomers. I will call these offers 'wages' (measured in food units).

In equilibrium we must have $w_1 = w_2 = w_3$ (the chiefs all announce the same wage and the commoners don't care which territory they go to). If we did not have this equality, every commoner would go the chief who offered the most, she would have an excess supply of labor, and she would have an incentive to cut her wage offer (this would leave more food for herself and her close kin). At the same time, the other chiefs would raise their offers in order to attract at least some followers.

What determines the level of w in equilibrium? The key idea is that we must have $MP_1 = w$, $MP_2 = w$, $MP_3 = w$, and so on (for any chief who stays in business). To see this, think about any chief i = 1, 2, or 3. If $MP_i > w$ then chief i recruits more group members (total output rises faster than wage payments, creating a surplus for the chief) and if $MP_i < w$ then chief i expels some group members (total output falls less than the savings in wage payments).

For a given wage w*, let n_1* be the group size for territory 1 that makes $MP_1 = w^*$ and so on. The level of the wage w* will be determined so that $n_1^* + n_2^* + n_3^* = N$. At this wage, the supply and demand for labor are equal (the supply is the regional population N, which is fixed, and the total demand is the sum of the labor hired by each chief on the left hand side).

Because the marginal products are equal to the same wage, they are equal to each other. This implies that total food output for the region as a whole is maximized. The logic is the same as when we maximized total utility by equating the marginal utilities across two time periods, or minimized total cost by equating marginal costs across two food sources.

In effect, what we have now is a labor market, where the chiefs act like firms and hire the optimal number of workers given the current wage. We have inequality between the elite (the chief, her family, and her close friends), who control access to land, and commoners, who do not own any land and get their food entirely through wage payments.

Consider an extreme case where a chief gets the total food output q from a territory and everyone else in that territory gets w. If the chief wants to maximize her own food, she chooses n to maximize q(n) - wn where q(n) is total product as a function of group size (number of workers) and w is the market wage that must be paid to each worker. This is simply profit, and the chief is the owner of a firm who maximizes profit. This is what we would expect from a chief who owns all the land in a territory and has complete freedom to determine how many other people can live there.

Using supply and demand curves for land and labor.

Now that we have some ideas about the origins of inequality, I want to show how supply and demand curves can be used to think about the distribution of income between elites (who own land and don't provide any labor) and commoners (who don't own any land but do provide labor). Before you read this part, it might be helpful to go back and look at what I said earlier about France and Japan in the Middle Ages.

Let's start by assuming there is a labor market where w is the wage rate. The total supply of labor is given by the total population of commoners, which is fixed at N. The supply curve is vertical (the supply of labor is the same no matter what the wage is). There is a downward sloping demand curve for labor that comes from profit maximization by the elite landlords, who would like to hire more labor when the wage falls. See the left side of Figure 11. The equilibrium wage w* (measured in food units) is determined by the intersection of the two curves. The total food income for commoners (labor suppliers) as a group is w*N in equilibrium (area A). It is not obvious from the graph, but the total food income for the elite (land owners) as a group is the area under their demand curve and above w* (area B).

Now assume instead there is a land market where r is the rent per unit of land (again in food units). The total supply of land is fixed at L (see the right side of Figure 11). The supply curve is vertical because there is the same total amount of land no matter what the rental price is. However, commoners have a downward sloping demand curve for land, because they would like to use more of it when the price is lower. The equilibrium rent r* is determined by the intersection of supply and demand. In equilibrium the total food income of the elite landlords as a group is r*L (area C), and the total food income of the commoners as a group is the area under the demand curve for land and above r* (area D).

An interesting fact about this model is that the distribution of income between suppliers of labor and suppliers of land is the same regardless of whether there is a labor market or a land market. I won't prove this, but it can be shown that the area of the rectangle w*N in the left graph of Figure 11 is equal to the area under the demand curve but above r* in the right graph of Figure 11 (area A is equal to area D). This means that commoners as a group get the same total amount of food either way. Similarly, the area of the rectangle r*L in the right graph is equal to the area under the demand curve but above w* in the left graph (area C is equal to area B) so the elite as a group get the same total food either way.

This shows that from the standpoint of income distribution, it doesn't matter whether the economic institution we use is a labor market or a land market. Here is the logic: because total land and total labor are the same in the two cases, total output is the same. Thus all that matters is how the total food output is divided between elites and commoners. But there is no change in the relative scarcities of land and labor when we change institutions from a labor market to a land market (or to put it another way, there is no change in the relative bargaining power of the two groups), so food will be distributed in the same way regardless of whether landowners pay workers or workers pay landowners. This is only

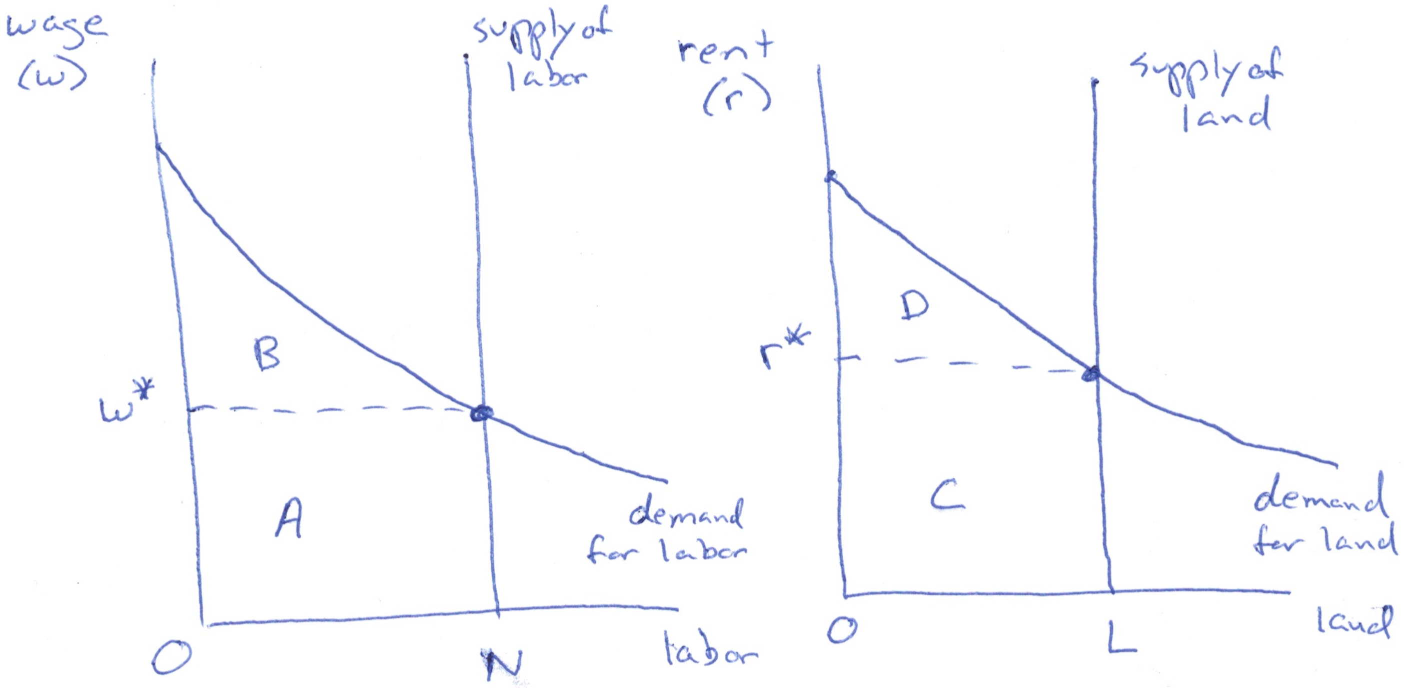

Figure 11
Labor and Land Markets

true if we have perfectly competitive markets (everyone is a price taker). In some other situation like monopoly, we would not necessarily get the same result.

Another thing I want to do with this model is discuss comparative statics. Remember that when we do comparative statics, we change an exogenous variable and look at the effects on the endogenous variables. In their discussion of France and Japan, JE treat population as exogenous and they talk about the effects of population growth. In particular, they say that this made peasants (or commoners, or workers) worse off.

This is easy to see in a supply and demand framework. Consider a labor market like the one on the left side of Figure 11. If population (N) increases, the vertical supply of labor shifts to the right. Because nothing happens to the demand curve, the wage w* must fall. This makes each individual peasant worse off (each is getting less food than before). It can also be shown that the elite as a group are better off (their total food income rises). We can't be sure what happens to the total food income of the peasants as a group (w*N) because there are two things moving in opposite directions: w* is falling and N is rising. The net effect depends on the shape of the demand curve for labor.

Based on the earlier discussion, it doesn't matter whether we have a labor market or a land market, so we should get the same conclusions if we use the graph on the right side of Figure 11. To see how this works, notice that the supply of land is not changing, so the vertical supply curve in the right-hand graph does not move. However, there are more commoners who want to rent land, so the demand curve for land moves up and to the right. This pushes up the equilibrium rent r*. Clearly this makes the landowners better off. It also makes any individual commoner worse off, because now land is more expensive. However, we can't tell whether commoners as a group get more food or less food, because again two variables are moving in opposite directions: although there are more commoners, each individual commoner gets less food.

<u>The Evolution of the State</u>.

I don't have a model for this topic but I will comment on what JE say about it. Keep in mind that if we are thinking about the evolution of states, we are mainly thinking about early states that developed thousands of years ago in places like Egypt, Mesopotamia, the Indus River valley, and China. These states were run by elites and they were not political democracies in the modern sense.

The most basic question is: what is a state? Political scientists think it is an institution with a monopoly on the use of force within some geographic area. Economists think it taxes people and supplies public goods. Archaeologists and anthropologists say that in a state, members of the elite have specialized roles (warriors, tax collectors, public works managers, religious leaders, and so on). JE like to draw a line between chiefdoms and states by saying that chiefs are generalists (they do everything themselves) while states have specialized bureaucracies that engage in various different activities.

Let's suppose we agree on a definition of the state. There are two main questions: Why did early states arise? And did early states make commoners better off or worse off? As you will see, these two questions are related (or at least, they could be).

Economists say that a change that makes everyone better off is a Pareto improvement. No one doubts that elites benefited from early states, so if you think that commoners also benefited, you are saying that the state was a Pareto improvement. If you think that the commoners became worse off, then it was not.

In archaeology and anthropology, there are two general schools of thought about this.

Integration theorists say that early states arose because they solved problems facing the society as a whole (for example by providing insurance, security, infrastructure, or trade). In this perspective, early states made everyone (or almost everyone) better off, and that is the reason why they emerged.

Conflict theorists say that early states were institutional devices used by the elite for its own benefit, at the expense of commoners. In this perspective, early states were mainly about the use of force (conquest, class conflict, or both). Commoners would have been better off if such states had not arisen because the commoners would have suffered less oppression, but they did not have enough power to resist the elite.

JE come out somewhere in the middle between these two schools of thought. They rank societies by scale and complexity from family groups to local groups, simple chiefdoms, complex chiefdoms, archaic states, and agrarian states. In their book they often say that this developmental process occurred in response to various problems that were created by increasing population and subsistence intensification. In particular, they believe political integration and social stratification are responses to risk, conflict, inefficient resource use, and local resource deficiency (take another look at the end of chapter 1). When they say things like this, they sound like integration theorists.

On the other hand, they also emphasize that elites act in their own self-interest. As we go to larger and more complex societies, we get less family autonomy, more coercion, more inequality, etc. They also say that there must be some economic basis for elite control of the society (land ownership, control over trade routes, and so on). When they are talking about the expansion of the political economy this way, they sound like conflict theorists.

It is not necessary to be just one type of theorist or the other. For example, you could say that elites try to solve social problems that affect everyone, but also try to get most of the benefits for themselves. You could also say that elites pursue their self-interest, but they sometimes do things that turn out to be beneficial for the commoners as well. Whether or not commoners get a net benefit from the state may vary from case to case. For example, they may have become worse off in ancient Egypt but better off in ancient Mesopotamia.

What do JE emphasize as causes of early states? They identify two necessary conditions: high population density and (as mentioned above) some basis for economic control by the elite. They think the latter usually involves technology or trade.

In this context, when they say technology they are thinking about large-scale investments in public works, infrastructure, or capital projects; for example, irrigation systems, flood control systems, and land terracing to raise agricultural output. There is some evidence for their argument. Early states arose in places like Mesopotamia, Egypt, India, China, and later in Mexico and Peru. In several of these regions, large-scale irrigation or flood control projects were important.

On the other hand, people often argue that such projects were the *effects* of early states, not the *causes* of early states. Maybe the state arose for other reasons, but once it existed, it made large-scale investments of this kind. Also, people frequently argue that irrigation could be done on a small scale, and it wasn't necessary to have state bureaucracy in order to manage such projects.

JE tend to downplay warfare and insurance as reasons for the development of early states because they think these factors are insufficiently important as a basis for elite control. A lot of people disagree with them on the issue of warfare. Many archaeologists think that early states frequently arose through warfare between rival chiefdoms. You can see how this might happen: conquered populations can be used to raise funds to support the army, which then conquers more people, and so on. What is the limit to this process? Probably armies can become overextended, border populations could have low density and not be worth conquering, communication and supply lines can become too long and expensive, etc. But even if there are limits of this kind, it may be true that large territorial states can arise through military conquest.

What are the principal benefits from having a state, according to JE? The following list is based mainly on their case study of the Inkan Empire in chapter 12.

1. Public works projects like roads.
2. Domestic peace (personal security and also the security of property rights).
3. An internal division of labor, specialization, scale economies, and trade.
4. Insurance through large-scale risk sharing across regions within the state.

They provide some evidence that commoners had a better diet and longer life expectancy after the Inkan conquest. This may be a case where commoners became better off from the formation of an early state. But again, keep in mind that the same thing may not be true for all other early states.

JE explicitly mention insurance, warfare, technology, and trade as possible reasons for states. There is a fifth factor one could consider, which JE hint at but do not emphasize: preventing resource depletion. One social problem that could face early societies is the need to control the use of common resources and prevent overuse (for example, through soil erosion, deforestation, excess water use, or overgrazing of pasture lands).

If you read carefully, you will find references to topics like this scattered around in their chapters on chiefdoms and states. You will also find that land is often owned or managed by chiefs or the state. Why? If you want to provide an 'integration theory' argument, you can say that these societies needed central control to avoid resource depletion, and at least in the early stages this was in everyone's interest. However, at some point the prevention of resource depletion stops being voluntary and force is used to ensure compliance. Once this occurs, most of the benefits from preventing resource depletion go to the chief or the state, and these elites can use their power to benefit themselves in other ways as well.

This is a subtle way of transitioning to the next book (by Elinor Ostrom), which discusses how institutions can be used to preserve common pool resources and prevent a tragedy of the commons.

Closing remarks on JE.

I want to conclude with a few general comments based on this book.

JE only consider non-industrial societies, and states that are not political democracies. But nevertheless it is interesting to ask where we stand today on the big issues of their book: technology, population, resource depletion, and so on.

1. Since the industrial revolution, technological innovation has been more rapid than population growth at the level of the world as a whole. This has led to rising real wages and standards of living in most regions, although economic growth has certainly not been smooth, and there is a great deal of inequality both within countries and across different countries of the world.

2. World population continues to rise. It was about 3 billion in 1960, hit 6 billion on October 12, 1999 according to the United Nations, and hit 7 billion in 2012. We will arrive at 8 billion soon. However, the rate of increase has been slowing down since the 1970s. Population doubled in 40 years between 1960 and 2000, but no one is forecasting that it will double again in the next 40 years. Most experts believe world population will stabilize somewhere between 9-12 billion people by the end of this century. The rates of population growth have slowed dramatically in developed countries (some of which now have zero or negative growth), and more recently have been slowing down in most less developed countries. It is clear that improving technology no longer leads to population growth (by contrast with the kinds of societies JE discuss). We will come back to this at the end of the course, but economists tend to believe that as people have become richer, they have started to have fewer kids for at least two reasons: technology has made it more important to invest in human capital like education, so kids are more expensive than they used to be; and women have more opportunities to participate in the labor market, which means that they give up more income when they have kids. There are undoubtedly other factors that reduce fertility rates as societies become richer, but there is a consensus that these two factors are both important.

3. There is clearly a lot of resource depletion: for example, loss of tropical rainforests, mass extinctions, overfishing, and climate change.

4. Global institutions have been created to manage problems that are beyond the reach of individual nation-states. Examples include security issues (peacekeeping, anti-terrorism), economic issues (the World Bank, the International Monetary Fund, the World Trade Organization, coordinated regulation of financial markets), and environmental issues (the Montreal Protocol to stop ozone depletion, the Paris Agreement on climate change). You can interpret these developments as a continuation of a point made by JE: when there are new problems that go beyond what existing institutions can handle, people tend to invent larger-scale institutions to address the new problems.

5. We are all geographically circumscribed. For the foreseeable future, it will not be practical to escape from our problems by moving to the Moon or Mars. Therefore, we need to invent institutions that will solve problems confronting people here on Earth.

If you want to see how JE apply their theoretical framework to the modern world, you can read chapter 14 of the book. This chapter is optional and will not be on the exam.