Econ 452W

Seminar in Economic Prehistory

Greg Dow

Spring 2022

Welcome to Econ 452! I'll begin by introducing myself.

I have been a professor in the economics department at SFU since 1995. It's been a great place to work. My central research and teaching interests are economic prehistory, labor-managed firms, microeconomic theory, and institutions.

Since around 2003, I have been working with an economic historian named Clyde Reed, who is also at SFU, on topics related to economic prehistory. We have published several journal articles on the origins of agriculture, inequality, warfare, and similar subjects.

Clyde and I have written a large book about all of this research: "Economic Prehistory: Six Transitions That Shaped The World". It will be published by Cambridge University Press, probably in August 2022. Unfortunately it is not available now so we can't use it for this course, but you will get the flavor of our research as the semester goes along.

Contact information.

My office is WMC 4659, which is in the far northwest corner of the West Mall Complex, one floor up from the main economics office. Due to the pandemic situation I will not be in my office during the first two weeks of the semester.

I'll announce some Zoom office hours at our first class. Assuming we return to in-person classes eventually, at that point I'll switch to in-person office hours as well.

My office phone number is 778-782-5502. However, it is unlikely that I will pick up the phone and frequently I forget to check my voice mail.

By far the best way to contact me is email:

gdow@sfu.ca

I am happy to answer questions by email. If anything is unclear, please let me know.

I also have a website:

http://www.sfu.ca/~gdow/

You won't need the website for this course because we will do everything using Canvas, Zoom, and email (as well as in-person classes, I hope!). But you might want to look at it if you are curious about my career or my research and teaching fields.

Zoom classes.

For the period from Tuesday January 11 through Friday January 21, I will be lecturing via Zoom in our normally scheduled class times (2:30 - 3:20 PM on Tuesday and 2:30 - 4:20 PM on Friday). I will send Zoom links to the class email list the day before each lecture. I'm hoping we can start meeting in person after that.

Grading.

You will need to write two 5-page papers. Each paper is worth 25%. There will also be a midterm (on Friday March 4) and a final exam. Each exam is worth 25%.

The final exam is not cumulative. It will only cover the material after the midterm.

If you miss the midterm for any reason, I will transfer the 25% weight to the final. Of course, it is better to have two exam grades rather than one in order to minimize risk.

The exam questions will not be tricky but they will test whether you were conscientious about doing the reading and paying attention to the lectures.

Assuming we have in-person exams, you will not be able to use books, notes, or devices. You can only use information stored in your brain. If we need to have exams online, I'll let you know the procedures when the time comes.

Canvas materials.

In addition to these introductory notes, the following documents are posted on Canvas:

The course outline
A reading list that includes a schedule for the topics to be covered in the course
Guidelines for writing the papers
A bibliography that you will need for writing the papers
A large number of old midterm and final exams

I assume you have already seen the course outline. If not, please take a look.

The most important thing is the reading list, which gives you an overview of the course and says which readings you should do each week.

You should look at the 2-page guidelines about written assignments in the next few days. This will tell you when the papers are due and provide background information.

There is no need to look at the bibliography right now.

I have posted all my past exams since 2007. The final exam in 2007 was comprehensive (there was no midterm that year), but every time I have taught the course since then, there was both a midterm and a final. The style of the questions this year will be similar. You may find that these exams are useful as a study guide throughout the semester, not just in the days leading up to an exam.

How to get the readings.

As you will see from the reading list, there are three kinds of materials involved.

Items on the list indicated by (b) are books you need to purchase. There are two of these, one by Jared Diamond and the other by Peter Bellwood. Both are available in the Kindle format from amazon.ca (Diamond costs about $14 and Bellwood costs about $57).

If you prefer physical copies, feel free to order these books from any reputable online bookseller. However, I will lecture on the Diamond book during the first week so you should get it as soon as possible. We won't use Bellwood until February 8 so there is more time on that one.

Items on the list indicated by (c) are in an electronic coursepack available from the SFU Bookstore. This costs $66. Just go to the bookstore website and you can order it there.

You can also use the following link:

https://www.campusebookstore.com/integration/AccessCodes/default.aspx?bookseller_id=124&Course=ECON-452+D100+(1221+-+BUR)&frame=YES&t=permalink

Items on the reading list indicated by (d) are journal articles you can download from the SFU library. In each case, go to the library site and where you see "library search", type in the title of the journal. Then look for a box that says "journals" (below the box that says "databases"). Where it says "availability", look for "online access" and click on that. There may be more than one way to get access to a given journal; make sure you click on a service where the dates include the year you want.

This should get you to the website for the journal. Next, you need to use the year of the article, the volume number, the issue number, the month, and possibly the pages in order to track down the specific article. On some sites this may require a bit of searching. Try looking for something that says "browse" or "all issues" to find a list organized by year.

Once you find the listing for the article, you should be able to download a PDF version of the complete article for free. If you have problems with this process, let me know.

Please start the book by Jared Diamond as soon as possible, especially the prologue and chapter 1 as indicated on the reading list. I will lecture about these on Friday January 4. I will probably also say some things about the chapter by Campbell from the electronic coursepack on the same day, so you should read that one too.

I want you to read all of chapters 1-14 in Diamond during the semester. I won't lecture directly on every chapter but there may be exam questions on anything through chapter 14, so you should be prepared. The reading list mentions a couple of milestones where you should be finished with particular chapters.

For Bellwood, you only need to read the chapters that are specifically mentioned on the reading list. I won't ask exam questions about any other chapters.

Course format.

Mostly I will lecture. However, I will try to be interactive and will expect questions.

Everyone should do the readings before the days on which they will be discussed, so I can take it for granted that you have already seen the material when I talk about it.

You will probably encounter many unfamiliar terms and concepts in the readings, both from economics and from other disciplines like archaeology and anthropology.

I will try to explain the most important terminology and concepts, but it is a good idea to write down notes about things you don't understand and ask me about them in class. Feel free to interrupt me if you need to get my attention.

There is no formal percentage of the course grade based on class participation, but I will be more likely to round up at the end of the semester if you were an active participant.

Prerequisites.

The only official prerequisite is Econ 302. I will assume everyone knows micro theory at the level of Econ 201/302, plus the kinds of math normally used in these courses.

Occasionally Econ 333 might be useful but it is not essential.

You will find that some of the readings involve no economics at all. Instead they come from archaeology, anthropology, geography, and similar disciplines. I will assume you have no background knowledge in these disciplines. At times you may be wondering if this really is an economics course. No worries, we'll get to the economics eventually.

Other readings are economics but with a low level of math and/or theory. These should not cause much trouble.

Finally, some readings are economics and have a large amount of technical content. In these cases, I will use lectures to make this material understandable, identify key ideas, and so on. I will not expect you to do any difficult mathematics on the exams.

A comment on lecture notes.

For most of my career I have been reluctant to distribute my lecture notes. The reason is that I think students learn much more when they listen to what I am saying, watch what I am writing on the board, and have to take their own notes in real time. This forces people to think about how to organize the material, how ideas are related, and so on.

In the pandemic years, I have had to teach courses online and distributing lecture notes to my classes became unavoidable. In particular, beginning in March 2020 I had to provide lecture notes for Econ 452W.

Because these notes are already circulating, and it would be unfair for some students to have access while others do not, I have decided to make all of my lecture notes available. I will post my notes on Canvas a few days after I give the corresponding lecture.

Please do not rely too heavily on my written notes. It is still best to pay close attention to my lectures and write out your own notes as I talk. Later you can look through my notes to see if there were any points you missed, or to clarify ideas that were confusing.

Course objectives.

I hope that by the end of the semester you will have achieved the following things.

1. Learned some facts about prehistoric societies.
2. Learned that economic logic can often be applied to subjects that may not look much like economics at first glance.
3. Learned how to relate theories to evidence in ways that social scientists do. This includes thinking about a range of possible hypotheses that could explain a given set of facts, and deciding which hypothesis is most likely to be correct. The goal is to think like a researcher, not just a reader of textbooks.
4. Improved your writing skills.

That's all for now. In my next lecture, I will describe what economic prehistory is, and discuss how we can obtain information about it.

Econ 452W: Seminar in Economic Prehistory

Spring 2022

Greg Dow | Week 1

These notes provide a general orientation to the field of economic prehistory.

<u>What is economic prehistory</u>?

It is the study of economic behavior in societies that do not leave written records.

It is not the same as economic history, where written records do exist.

It is also not about biological evolution.

Roughly speaking, we can think of three broad stages in human development.

(a) The biological evolution of human beings.
(b) The development of prehistoric societies where people are modern in a biological sense but there are no written documents we can use as a source of information.
(c) The development of historical societies where we do have written documents.

This course is about stage (b).

Within this category, I will divide the course into three broad sections:

1. Pre-agricultural societies where people obtain food through hunting and gathering (also called foraging).

2. The reasons for the transition from hunting and gathering to agriculture.

3. The post-agricultural world, including the development of inequality, warfare, and the state, as well as cases of social collapse.

Please see the reading list for details on the topics we will cover.

<u>How did I become interested in economic prehistory</u>?

I am an applied microeconomic theorist. Much of my research has been on the theory of the firm, industrial organization, comparative economics, institutions, and so on.

As an undergraduate student, I took a number of courses in anthropology, sociology, and history. I have always been fascinated by large complicated questions about how social, political, and economic systems developed over time.

In the late 1990s, I started doing a selected topics course that led to Econ 354, which is on comparative economic institutions. This covered some material from anthropology about the evolution of human societies.

In the early 2000s I started talking with an economic historian, Clyde Reed (also at SFU), about the origins of agriculture. We thought this was an important subject (in fact, just as important as the origins of the industrial revolution), but at that time economists had not done much research on it.

Once we got underway, this topic led to additional questions. What determined whether hunter-gatherer societies had technological progress? How did inequality emerge? Why did warfare seem to become more common in agricultural societies and/or societies with a lot of inequality, as compared with egalitarian foraging societies? And so on.

This research agenda resulted in six journal articles, and eventually a book (currently in production). It also led to the creation of Econ 452W.

A timeline for prehistory.

I want to move next to a rough time line that should give you a perspective on key events in prehistory (see Figure 1.1).

Note: the information in this figure is more up to date than what Diamond and Campbell provide. Diamond was published in 1997 and Campbell was published in 2006. Here I am including new archaeological evidence obtained during the last 5-10 years.

Also note that KYA stands for "thousands of years ago".

At the far left we start around 300,000 years ago, which is the approximate time at which archaeologists have found the first evidence for anatomically modern humans in Africa. When we say "anatomically modern", we mean that skeletons resemble modern humans (if they were mixed in with modern skeletons, it would be hard to tell the difference).

For about 200,000 years, AMHs remained in Africa. Starting around 100,000 years ago, they began to migrate to other continents: Asia, Australia, Europe, and the Americas.

As we will see later in the course, the first evidence for agriculture occurs around 12,000 years ago. The industrial revolution is much more recent (it started about 250 years ago).

At the top of the timeline, I indicate two climate periods: the Pleistocene, which goes far into the past (it started around 2.6 million years ago), and the Holocene, which started at about 11,600 years ago. The Holocene marks the transition from the most recent Ice Age to the milder global climate that has prevailed for the last ten thousand years or so. We will say more about this climate shift later in the course.

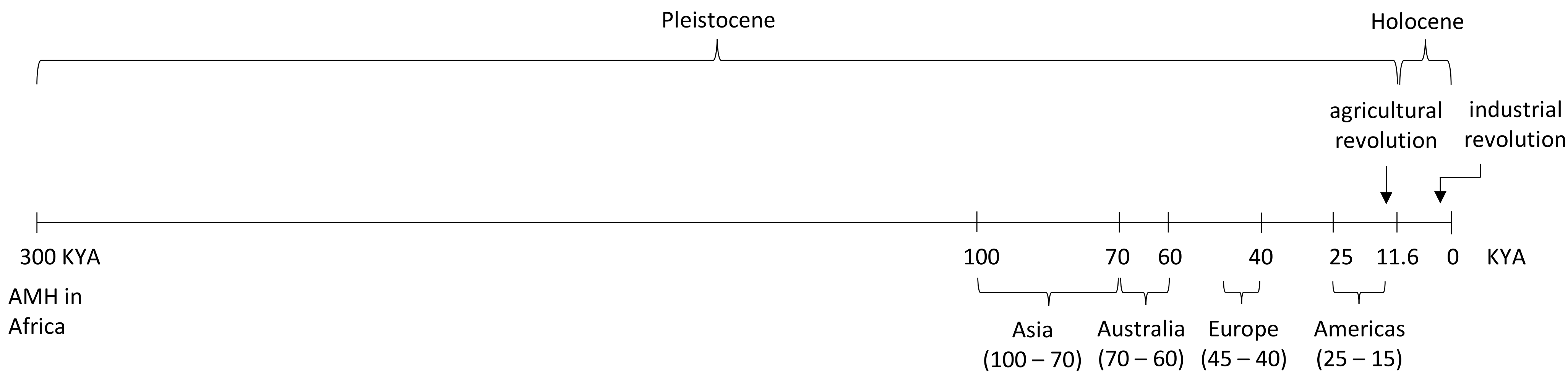


Figure 1.1

Time Line for Economic Prehistory

(AMH = anatomically modern humans;

KYA = thousands of years before present)

This timeline should raise a few questions in your mind.

1. Starting with the biological evolution of anatomically modern humans around 300 KYA, there was a very long time span when people were not using agriculture. If agriculture was so great, why did it take so long to occur? If it was not great, why did people ever use it at all?

2. Did the emergence of agriculture have something to do with the climate shift from the Pleistocene to the Holocene? If so, what are the cause and effect connections?

3. This is not shown in the timeline, but even after agriculture began in some parts of the world, thousands of additional years passed before the rise of cities, states, and writing. These did not develop until about 5000 years ago. Why the lag?

4. Approximately 10,000 years elapsed between the "agricultural revolution" and the "industrial revolution". Again, why the lag?

The agricultural revolution was hugely important. Before it occurred:

(a) There were only about 5-10 million people on the planet. This is about the size of modern New York City, and implies extremely low population densities, perhaps one person per square kilometer for inhabited areas of the world.

(b) People lived in small hunter-gatherer groups and generally moved around looking for food. There was very little wealth accumulation or food storage.

(c) There was probably not much inequality or organized warfare, although there may have been considerable violence among individuals (no police, courts, or prisons).

(d) There were no towns, cities, or governments.

(e) There was no writing and there were no universities.

In short, without agriculture we would all still be living in small foraging bands, getting our food by gathering wild plants and hunting wild animals. We would have a radically different world compared to the complex global society we enjoy today.

Along the pathway to the modern world, several crucial transitions occurred in the ten thousand years between around 15 KYA and 5 KYA. These include (i) the shift from mobile to sedentary foraging, (ii) the transition from sedentary foraging to agriculture, (iii) the emergence of economic, political, and social inequality, (iv) the emergence of warfare over land, (v) the development of cities, and (vi) the development of states.

In our book entitled "Economic Prehistory: Six Transitions That Shaped The World" (to be published this year by Cambridge University Press), Clyde Reed and I try to provide economic explanations for these transitions.

What is an economy?

We want to study the economies of prehistoric societies. First we need to know what an economy is.

I will define an economy very simply as "a social system that allocates resources". The key elements are:

1. A set of people living in a given geographic area (population).

2. A set of resources provided by the natural environment (climate, geography, and ecosystems).

3. A set of production activities (technology).

4. A set of needs or wants (preferences).

5. A set of social rules or norms (institutions).

For example, institutions could include rules about resource ownership, group production activities, food distribution, market exchange, inheritance, marriage, and so forth.

Given that prehistoric societies do not leave written documents, how can we get any data on economies of this kind? Let's run through each of the five variables listed above.

1. Population. Archaeologists can often estimate total populations in various regions of the world. They do this by excavating caves, houses, campsites, and villages. This leads to rough guesses about population densities in geographic areas and the sizes of residential communities. Even when archaeologists cannot estimate the absolute level of population in a region, they can often say whether it was rising, falling, cyclic, or stationary over some period of time.

2. Resources. Archaeologists have a lot of evidence about past climate conditions. Often we have direct evidence about the plants and animals that were available in a given region and time period from plant pollen, animal bones, and so on. We also frequently know a lot about geology, geography, rivers, lakes, elevation, the nature of terrain (flat or steep), and the existence of barriers to movement such as deserts, mountains, and jungles.

3. Technology. Archaeologists have good data on stone tools as well as tools made from durable materials like bone and antler. They also know a lot about pottery and methods of house construction. Modern researchers can often determine how tools were made, what they were used for, and where raw materials came from. The main problem is that some important materials do not preserve well, such as

cloth or wood. Thus for example, boats made from tree trunks (canoes) or wood planks (rafts) are unlikely to be observed by archaeologists.

4. <u>Preferences</u>. It is difficult to determine directly the preferences of people living in prehistoric societies. But it is safe to assume that humans in the past wanted most of the same things humans want today such as food, clothing, shelter, health, kids, long life, and useful tools. They probably disliked intense effort, or high risks of injury or death. They probably preferred consumption today to the same amount of consumption tomorrow, other things being equal. They probably had concerns about the welfare of close relatives. In this course I will make simple assumptions of this kind and see whether the resulting models can explain the evidence. I will also assume that for at least the last 50,000 years or so, people were just as smart as people today and had similar language abilities. These last assumptions would not be regarded as controversial by most archaeologists.

5. <u>Institutions</u>. The main institutional issues of interest in this course are inequality, warfare, and the state. We have reasonably good information about inequality in prehistoric societies based on differences in nutrition and health, or differences in house sizes, or differences in the richness of grave goods. We also have evidence (although more controversial) about the frequency and intensity of warfare among prehistoric societies. We also know quite a bit about the formation of early cities and states. Aside from relying on direct archaeological evidence, researchers can look at recent hunter-gatherer societies for information about the sizes of foraging groups, marriage practices, risk management strategies, and so forth. This offers insight into the kinds of institutions prehistoric hunter-gatherers may have had.

<u>Note</u>: As you do the readings in this course, I recommend that you focus on information about the five elements of an economy I described above. This is the information that will be important for the course. The archaeology and anthropology readings sometimes discuss a lot of other things, so try to read selectively and pay the most attention to the economic factors.

If you have taken Econ 333, you know that economists typically test hypotheses using regression techniques. Unfortunately, when we are dealing with prehistory, we do not usually have datasets that would make it possible to use econometric methods. What we generally have are narrative accounts from archaeologists about the sequence of events in various regions of the world over various time periods.

If we can't run regressions, how can we test hypotheses?

For example, if someone claims that the transition to agriculture was caused by factor X, how do we know whether this claim is right or wrong?

We will take the following approach. A theory about a major prehistoric transition like agriculture normally makes predictions about some sequence of events involving climate, population, technology, and so forth. The theory will usually say which things happened first, which things happened next, whether certain variables increased or decreased, etc.

We can then look at descriptions of events in a given region provided by archaeologists to see whether the facts are consistent with the theory. If we have multiple theories, we can try to make a judgment about which theory's predictions are more consistent with the observations available from archaeology.

A related approach is to make comparisons across independent regions of the world. In some regions a transition to agriculture did occur, while in other regions there was no such transition. A good theory should be able to explain why a transition occurred in some times and places but not other times and places. Ideally a theory will provide a list of necessary and/or sufficient conditions for a transition, and these conditions will match up well with the available evidence.

You will find that often just a little empirical knowledge is enough to rule out certain theories. For example, a theory might make predictions that are not even remotely close to the facts, or the theory might emphasize things that seem irrelevant while ignoring things that seem crucial.

One goal of the course is to develop your ability to evaluate theories through the use of logic and evidence. You should learn to ask what a theory predicts about the facts that should be observed if the theory is true, and then ask whether the available evidence is consistent with those predictions.

In this course, testing a hypothesis is a little bit like solving a mystery. Detectives do not usually run regressions but they do solve crimes. They may start with a hypothesis about who is guilty of the crime, and then they check whether the evidence in the case supports this hypothesis. If not, they move on to another suspect and go through the same process. Sometimes the clues make it possible for a detective to rule out all of the suspects except one, so the detective can be reasonably confident about who did it. In a similar way, we may be able to reach confident conclusions about what caused a given prehistoric event.

Comments on Jared Diamond, Guns, Germs, and Steel (1997).

This is a very famous book. It won the Pulitzer Prize and led to a TV series on the Public Broadcasting System in the U.S. Diamond is not an economist but he has been invited to give presentations at the conferences of the American Economic Association. His books have significantly influenced the research of numerous economists. If you only read one book on history or social science in your undergraduate career, I recommend this one.

Why is the book important?

1. JD asks a very big question: why are there such enormous economic and political inequalities among countries of the world today?

2. He delves deeply into history and prehistory to answer this question, and he is looking for patterns that can help to provide a scientific explanation.

3. Along the way he uses information from many disciplines such as archaeology, anthropology, geography, biology, history, and linguistics.

4. I think he does a good job of answering the question he raises, although I do not agree with all of the details.

Here is a short summary of JD's story.

(a) Regions of the world having a large set of plants and animals that were easy to domesticate tended to get a head start on the transition to agriculture.

(b) Compared to other societies, the societies that adopted agriculture early tended to have technological development, population growth, and political centralization thousands of years sooner.

(c) Societies having strong military technology, large populations, and centralized political institutions conquered or colonized other societies, especially hunter-gatherer societies with low population densities and no political centralization.

(d) Societies with high population densities (including cities) and proximity to farm animals tended to develop infectious diseases. The local populations evolved a level of immunity to these diseases, but eventually came into contact with other societies that didn't have any immunity. The newly contacted societies tended to be destroyed by diseases like smallpox and measles, which may have killed 70 or 80% of native populations in North and South America.

(e) The book is called "Guns, Germs, and Steel" because Diamond argues that these were three of the most important advantages Europeans had when they colonized other parts of the world. For example, he thinks these are the reasons why Spain conquered the Incan Empire rather than the reverse.

Note: JD is not asking exactly the same questions as we are asking in this course, but there is a lot of overlap. In particular, he believes that events in prehistory still have a major impact on the world today, and I agree with that.

Comments on human evolution and early migration.

The rest of these notes focus on human evolution, early migration, and related subjects. You will find some information on these subjects in Diamond Ch. 1 and the reading by Campbell. Notice that Diamond was published in 1997 and Campbell was published in 2006, so Campbell is a bit more up to date than Diamond. I will add some remarks on more recent archaeological research where relevant. First, though, I want to say a few things about dates and terminology.

Dates.

A preliminary question: "how archaeologists know how old something is?"

For this class, the most important technique is carbon dating (which is sometimes called radiocarbon dating).

Remember from high school that the nucleus of an atom has protons and neutrons. The number of protons determines what chemical element it is. For example, carbon atoms have 6 protons in the nucleus.

However, some carbon atoms have 6 neutrons, some have 7 neutrons, and some have 8 neutrons. These are called 'isotopes' of carbon. The isotope with 6 neutrons is called ^{12}C, the one with 7 is called ^{13}C, and the one with 8 is called ^{14}C. About 99% of the carbon in the world is ^{12}C and about 1% is ^{13}C. A tiny fraction is ^{14}C, which is radioactive and will decay over time into other isotopes.

The natural ratio of the three isotopes is determined by cosmic rays hitting the Earth's upper atmosphere. Living organisms take up all three isotopes of carbon while they are alive. After they die, the ^{14}C in their bodies will decay while other isotopes of carbon do not. We know that half of the ^{14}C decays roughly every 5200 years. Thus by measuring the ratio of ^{12}C to ^{14}C, archaeologists can estimate the number of years that have passed since the organism died.

This technique works for human bones, animal bones, teeth, wood, plant seeds or pollen, and almost anything else left behind by living organisms. The most accurate dates come from a technique called AMS (accelerator mass spectrometry), which can be used on very small samples (e.g., one seed).

Carbon dating has a few limitations.

(a) It cannot be used for non-organic materials like stone.

(b) It is limited to events in the last 40-50 thousand years, because older material has too little ^{14}C to be dated reliably. But this time interval covers almost everything we will do in the course.

(c) The natural ratio of ^{12}C to ^{14}C has fluctuated over time and we have to adjust for these fluctuations (a process called calibration) to obtain dates in calendar years. I will not spend a lot of time on this issue. You can assume that dates in this course are calibrated (and therefore expressed in calendar years) unless I say otherwise.

Terminology (see timeline on p. 416 of Campbell).

Paleolithic means "old stone age" (paleo = old, lithic = stone). This is often broken down into the following intervals:

Lower Paleolithic: 2 MYA - 250 KYA
Middle Paleolithic: 250 - 40 KYA
Upper Paleolithic: 40 - 10 KYA

Mesolithic means "middle stone age". It is often defined to mean the period from 10 KYA to the arrival of agriculture.

Neolithic means "new stone age". It starts with the arrival of agriculture and includes the period where people are using stone tools but not metal tools.

This dating system was originally constructed for Europe, where agriculture arrived more recently than 10 KYA. However, agriculture began at different times in different places, so we often need to modify the terminology depending on what region we are talking about.

In southwest Asia, the label 'Mesolithic' could be applied to the interval 20 - 11.6 KYA, with the 'Neolithic' starting around 11.6 KYA, because agriculture was adopted sooner in southwest Asia than in Europe.

For Africa, archaeologists use slightly different terminology and technologies associated with the Upper Paleolithic go back as far as 70-80 KYA.

In all cases, this is a technological classification system based on the tools archaeologists find. After the Neolithic we have periods involving the use of metal tools such as copper, bronze, and iron. This happened in some places but not others.

In fact, some regions of the world such as Australia did not adopt agriculture at all until it arrived recently from elsewhere, so these regions did not have a Neolithic period.

You should also become familiar with two climate periods.

The Pleistocene covers everything in the last 2.6 million years, except for a brief period since the end of the last Ice Age around 11.6 KYA.

The Holocene is the period of relatively warm, wet, and stable climate following the end of the last Ice Age. This covers the period from 11.6 KYA to the present.

Human biological evolution.

Our species is called Homo sapiens. Biologists like to give each species two names. The first ("Homo" in our case) is called the genus and the second ("sapiens" in our case) is the species name. Think of an individual species as a subset within a genus. For example, as I will explain below, we are part of the genus Homo, but there have been other species in this genus besides sapiens.

You should take a look at the figure on the next page to see a simplified summary of how our species arose. All of these events took place in Africa.

The line that eventually led to humans split from chimpanzees around 5-7 MYA. The first stage on the branch leading to humans is a genus called "Australopithecines" that walked upright but had brain sizes similar to chimps. This group lasted until 1 MYA.

Another genus called "Homo" branched off from the Australopithecines. This occurred somewhat before 2 MYA, and led to several species called Homo habilis, Homo erectus, and so on. These species had brains about twice as large as the Australopithecines. This marks the beginning of our genus but not yet our species.

In order to be clear, I will use the following terminology.

When I say "archaic humans", it means the genus is Homo but the species is not sapiens (not anatomically modern). The most famous people of this kind are Neanderthals, who had brains about as big as ours.

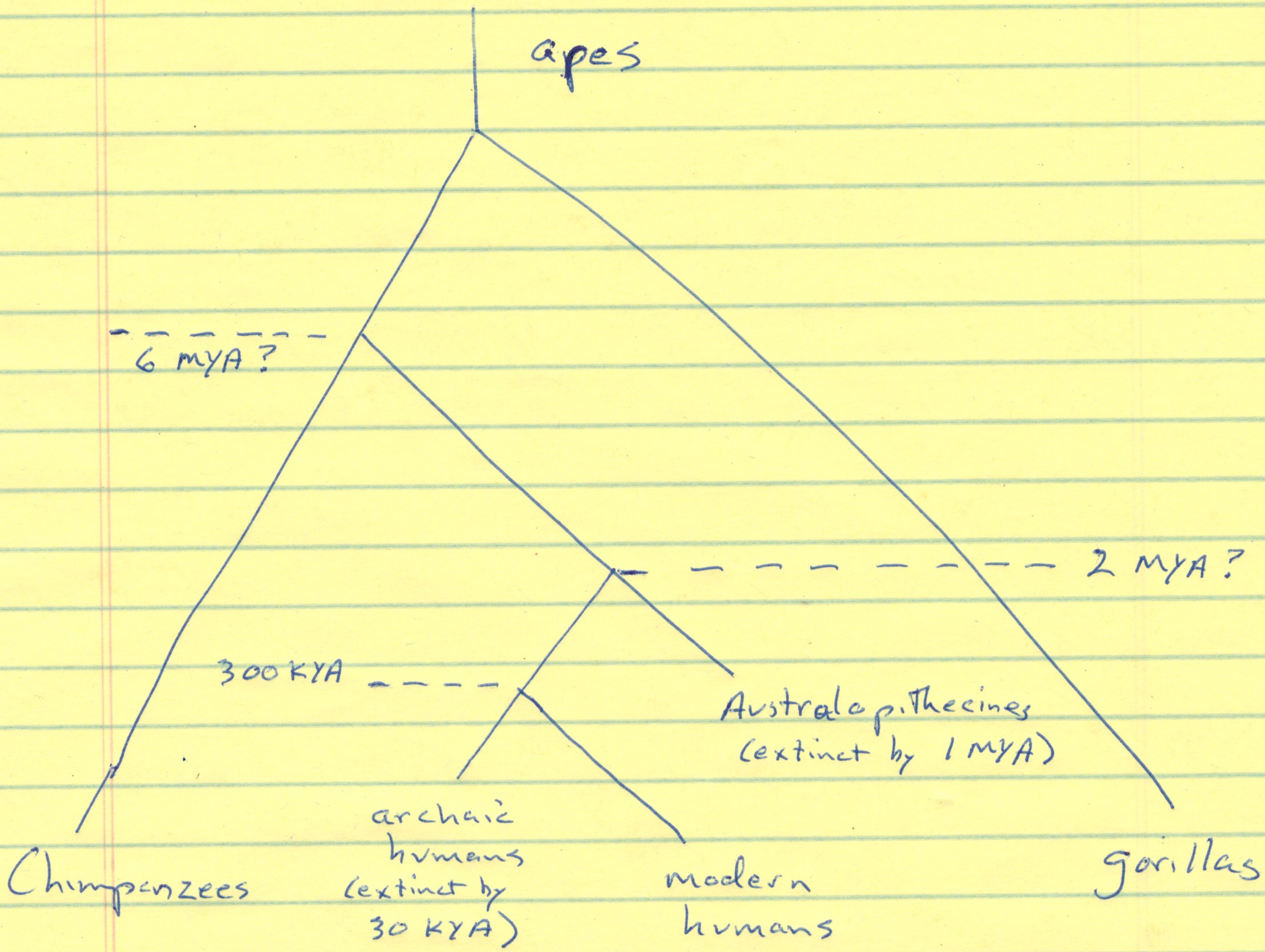
When I say "modern humans", it means anatomically modern humans, which is the same as saying Homo sapiens.

What are the anatomical features of modern humans? (See Campbell for more on this.)

1. A smaller face than archaic humans.
2. The skull is globe shaped, not flattened.
3. We have vertical foreheads.
4. We have small brows over our eyes.
5. We have distinct chins.
6. Our molar teeth are smaller.
7. We have smaller jaws.
8. Our vocal tract is different.
9. We tend to have less body mass.
10. Our brain size is about 1330 cubic centimeters.

This is how archaeologists recognize skeletons of anatomically modern humans (AMHs).

Genetic evidence (mitochondrial DNA for women, DNA on the Y chromosome for men) generally points to a single origin for modern humans in Africa. Estimated dates vary but



A very simplified diagram of human evolution

Note that "archaic humans" includes numerous species in the genus Homo: habilis, erectus, neanderthalensis, etc.

tend to be around 200 KYA. Note that this is a bit later than the recent skeletal evidence suggesting 300 KYA. The archaeologists and geneticists will have to sort this out, but it is not an issue that will be important in this course.

Migration history.

Did any archaic humans leave Africa before Homo sapiens?

Yes, Homo erectus and its descendants reached Asia quite early (going back to around 1.8 - 2.0 MYA).

There were archaic humans in China and Indonesia by about one million years ago, and there were Neanderthals in western Asia and Europe for hundreds of thousands of years.

However, archaic humans did not reach Australia (probably due to a lack of boats). And as far as anyone knows, archaic humans never migrated to the Americas.

The important point is that there were already various species of archaic humans in most of the eastern hemisphere before modern humans (sapiens) arrived on the scene.

For decades there was a big controversy between people who believed in the 'multilinear model' and those who believed in the 'out of Africa model'. You will see that this debate was still unresolved when Diamond wrote his book in 1997.

The 'multilinear model' said that archaic humans evolved into modern humans on parallel tracks in Africa, Europe, and Asia, so modern populations in these areas inherited certain features from the archaic humans who previously lived there (with some gene flow across regions so everyone ended up being part of the same species today).

The 'out of Africa model' said that modern humans evolved from archaic humans within Africa, and then the modern (sapiens) group migrated out of Africa and replaced archaic humans who previously existed in Asia and Europe.

Today the genetic evidence is overwhelmingly in favor of the 'out of Africa' idea and no one really talks about multilinear evolution of modern humans any more.

However, there is one important qualification: the genetic evidence reveals a significant amount of interbreeding between modern and archaic humans. All of us have inherited a small fraction of our DNA from Neanderthals and probably from other archaic humans.

What we still don't know is why archaic humans disappeared while the modern humans survived. People have theories about differences in language abilities, social networking abilities, dietary preferences, climate change, warfare, and so forth. However, I have not seen convincing evidence that one of these theories is better than the others. It continues to be an unresolved puzzle.

Given that modern humans migrated out of Africa, what are the most important dates?

By 100 KYA, moderns had moved into southwest Asia, although major migrations into Asia may not have occurred until around 70 KYA.

Sometime around 70-60 KYA, moderns probably arrived in Australia. This was followed by Europe between 45-40 KYA, and then the Americas.

There have been major debates about when humans arrived in the Americas. For a long time people thought it was around 13,000 years ago. But human footprints dating back to 23 KYA have recently been found in New Mexico, so humans were in the Americas by at least that time and possibly earlier.

Technology.

What tools did Australopithecines use? Stone tools (probably).

What tools did archaic humans use? Better stone tools plus fire.

What tools did modern humans use? Really good stone tools by around 70-80 KYA in southern Africa.

Archaeologists normally draw the line between the Middle and Upper Paleolithic based on something called 'blade technology', which is discussed in the reading by Fagan.

Other innovations associated with modern humans include artwork, decorative jewelry, fancy funerals, musical instruments, better shelters, long-distance trade networks, boats, fishhooks, harpoons, and needles for sewing clothes. Some of this dates to 70-80 KYA, but many of these innovations came tens of thousands of years later. Innovations that occurred late in the Upper Paleolithic include spear throwers and the bow and arrow.

Climate change.

The most recent Ice Age occurred between about 116 KYA and 12 KYA. During an Ice Age, a lot of water is locked up in ice sheets on the continents, so the ocean level tends to be much lower. This makes migration among continents easier. For example, around 20 KYA it was possible to walk from Asia to North America. A warmer spell around 40-50 KYA in the middle of the last Ice Age could have made it easier to migrate from western Asia into Europe.

Mass extinctions.

Australian megafauna (big animals) had a wave of mass extinction around 35-40 KYA. The same was true for North American megafauna around 13-10 KYA. People argue about the extent to which these extinctions were caused by climate change or human hunting, but most people seem to believe that the arrival of humans was a key factor.

A few more comments on Jared Diamond.

1. When JD says 'human history', he is often including everything since the split between chimpanzees and the line leading to humans (e.g., Australopithecines, Homo erectus, Neanderthals, and so on). He does not carefully limit this term to anatomically modern humans. For clarity I consistently refer to 'archaic humans' and 'modern humans', where the latter means Homo sapiens.

2. A related point: his Figure 1.1 on p. 37 talks about the "spread of humans" but includes Homo erectus. He is not distinguishing between two different waves of migration out of Africa by two different species at two different times: the early wave by archaic humans, and the much more recent wave by modern humans.

3. JD often uses the term 'Eurasia', which means the landmass including both Europe and Asia. This makes geographic sense because Europe is really just a peninsula hanging off the western end of Asia. I don't have any problem with this term. It is often convenient and I will sometimes use it myself.

4. JD asks what the world situation was in 13 KYA. This is an interesting time to consider because (a) people had occupied all of the major continents by then, (b) the climate transition from the Pleistocene to the Holocene was about to occur, and (c) agriculture did not exist yet but was about to begin.

   Diamond's point is that if you looked at the world in 13 KYA, it would have been difficult to predict which parts of the world would take off in terms of technology, population, military power, and so on.

   If you thought technological head starts were the most important factor, you might have predicted Africa, where people developed Upper Paleolithic technology long before people on other continents.

   If you thought land area and environmental diversity were more important factors, you might have predicted the Americas instead of Africa.

   If you thought land area alone was the most important factor, you would have predicted Eurasia.

   If you thought early development of boats was important, or early cave paintings, you would have predicted Australia.

   The bottom line is that in 13 KYA, there were no strong indications that different parts of the world would develop in different ways. The rest of JD's book builds a theory about why some regions took off before others and attempts to explain how this led to the emergence of large inequalities across nations in the modern world.

Econ 452W: Seminar in Economic Prehistory

Spring 2022

Greg Dow Week 2

The first half of these notes covers the Fagan reading, and the second half covers Kelly.

Brian Fagan, Chapter 4, People of the Earth, 2006 (available in the coursepack).

The purpose of this reading is to provide background information about climate, natural resources, technology, population, and lifestyles in the Upper Paleolithic (40 - 10 KYA).

As I mentioned in class, when reading material by archaeologists you should focus on the economically relevant information about population, resources, technology, preferences, and institutions. There is also information on artwork and other cultural matters that will be less relevant for this course.

The best data on life in the UP comes from Europe, which has been heavily studied. But Fagan also makes some comments on northern Asia, which is interesting both because it was challenging for humans to adapt to the harsh climate of Siberia and also because this was the pathway for migration to the Americas.

Climate.

The key idea involves ice ages. These are long periods with cold and dry weather as well as very low sea levels. Usually they start gradually with a slow expansion of glaciers and continental ice sheets, and end rapidly with the melting of the ice sheets on the continents (which leads to rapid sea level rise).

The definition of an ice age is a little arbitrary. Fagan estimates that Earth has been in ice age conditions for 60% of the time during the last 730,000 years. Other people would say that ice ages last for an average of about 100,000 years, and are separated by inter-glacial periods (warmer, wetter) that last about 10,000 years. These climate cycles are caused by cyclic changes in the Earth's orbit around the sun.

The Upper Pleistocene (notice that this is different from the Upper Paleolithic) started around 126 KYA with an inter-glacial period called the Eemian, which lasted 10,000 years. At its peak temperature, the Eemian might have been slightly warmer than our current global temperature.

The planet then started shifting into a new ice age called the Weichsel glaciation, which lasted for about 100,000 years (with warmer and colder stages). This led to intense cold around 73 KYA and again after 27 KYA, with less bad conditions from 64-32 KYA.

The lowest temperatures occurred around 25 - 15 KYA, and people often refer to the period around 20 KYA as the Last Glacial Maximum (LGM). Take a look at Fagan, p. 123, Table 4.1 for a graph showing periods of warmer and colder temperatures.

By 15 KYA the planet was warming substantially, and by 11.6 KYA the ice age ended. The Earth then moved into the Holocene climate period. Holocene conditions involved higher mean temperature and precipitation, lower variances in both these variables, and considerably higher sea levels.

Variations in the intensity of the last Ice Age may be directly relevant to the timing of the migration of modern humans into Europe from western Asia. This occurred about 50-40 KYA, which coincided with a somewhat warmer phase within the ice age. The earliest European sites are in places like Bulgaria (southeastern Europe) and due to the low sea levels there was probably a land bridge between Turkey and the Balkans (Fagan, p. 37).

Archaic humans (Neanderthals) were already present in western Asia and Europe before modern humans arrived. They were physically well adapted to cold ice age conditions.

Ecosystems.

During the most recent ice age, there were huge ice sheets over northern Europe. To the south of the ice there were three main ecological zones in Europe (moving from north to south): (a) tundra (very little vegetation), (b) steppe (grassland, maybe a few trees), and (c) forest.

Closer to the equator, there were huge deserts due to low precipitation. Many areas of the world that have rainforests today had open woodland or grassland in ice age periods.

To find climate conditions similar to the Holocene, we would have to go all the way back to the Eemian interglacial, which was short (only about 10,000 years). At that time there were very few (if any) Homo sapiens outside of Africa.

Migration.

Fagan agrees that modern humans initially moved out of Africa around 100 KYA. He thinks this involved very small groups, maybe about 50 people. This is consistent with broader views among archaeologists that the earliest migrations out of Africa tended to be small and had little lasting impact. Most people think that major migrations to Asia may not have occurred until around 70 KYA.

Fagan refers to modern humans as "Homo sapiens sapiens" where the third term is called a subspecies name. He is doing this because he wants to allow for the possibility of some interbreeding with Neanderthals and other archaic humans in Asia. The genetic evidence for this is now much stronger than it was when Fagan wrote his book. However, we don't need to get hung up on biological terms, and I will continue to call us "Homo sapiens".

For at least 10,000 years, modern humans and Neanderthals overlapped in Europe. They probably overlapped for much longer (40,000 years?) in western Asia.

However, after about 45 KYA, modern humans are clearly dominant in southwest Asia and Europe. The reasons for the dominance of modern humans and eventual extinction of Neanderthals are unclear.

Although Fagan accepts the 'out of Africa' view about the emergence of modern humans, he also discusses something called the 'candelabra' hypothesis. This is another name for the multi-linear hypothesis discussed in my previous notes. As I said earlier, this was an active debate around 2006, but today the multi-linear hypothesis is obsolete.

Technology.

The definition of the Upper Paleolithic is based on technology. In the Middle Paleolithic, archaic humans used something called 'flake technology', which produced relatively poor stone tools. The UP is associated with an innovation called 'blade technology', which led to much more sophisticated stone tools, as well as tools made from other materials.

For an description of blade technology, see Figure 4.5, p. 130 in Fagan. Here are the key ideas:

1. Start with a core, which is a cylindrical piece of rock, usually made of flint. The core is generally prepared in advance so it has the right shape.

2. Using a punch and hammerstone, chip off long pieces called blades from the core.

3. Shape the blades into a variety of specialized tools (scrapers, knives, awls, and so on) according to standardized patterns for each type of tool.

4. Use these stone tools to work other durable materials like antler, bone, and ivory. This produces tools like fishhooks or harpoons that cannot be made from stone.

5. Make composite tools involving multiple materials; for example, you can attach a stone blade to a wooden handle to make a spear.

6. Make needles out of bone, antler, or ivory, and use the needles to sew clothes.

Modern humans had blade technology when they arrived in western Asia and Europe, and it may have originated in southern Africa around 70-80 KYA. Some people think that blade technology was the basis for the migration of modern humans out of Africa, and Fagan thinks it facilitated the migration of modern humans from southwest Asia to Europe (see p. 129).

Neanderthals initially had something called Mousterian technology, which was not the same as blade technology (more like high quality flake technology). But there is some evidence that they later imitated the blade technology used by modern humans.

Because the start of the Upper Paleolithic is generally defined by the presence of blade technology, and modern humans took blade technology with them when they migrated to new continents, it doesn't make much sense to use a single fixed date for the beginning of the Upper Paleolithic.

For example, you could say that the UP began in Europe around 40 KYA, but this just means that modern humans reached Europe at that time, and brought blade technology with them. The UP began earlier in western Asia and Africa because modern humans were in those locations at earlier dates and were already using blade technology there.

It is unclear what caused the development of blade technology. Fagan tells stories about connections to climate change. Maybe as climate dried out, people became more mobile, they had to conserve supplies of good flint, and blade technology made more economical use of the available flint (see p. 128). Such stories may seem reasonable but I don't know of any strong archaeological evidence to support them.

A lot of other innovations are associated with the Upper Paleolithic (it is not just about blade technology). Fagan talks about a general "cultural explosion" involving artwork and other developments. He offers various explanations but none are fully convincing:

1. Economic specialization (but he doesn't provide any evidence of increased long distance trade or more complex forms of occupational specialization).

2. Social change (this is vague, and not clear whether it is a cause or an effect).

3. Technological change (again, not clear whether this is a cause or an effect).

4. Better human speech capabilities (but Campbell et al. claim that speech capability was the basis for anatomically modern humans dating back to 200 KYA; is Fagan claiming that modern humans subsequently became even better at language?)

5. "Cognitive fluidity". Fagan likes Mithen's hypothesis that humans have different types of intelligence, such as natural, technical, and social intelligence, and that in the Upper Paleolithic new brain wiring evolved where these types of thought were integrated and functioned together (but this is just speculation, no real evidence).

In any event, Fagan identifies a number of late Ice Age trends (p. 132) including higher population densities (though still quite low); regular social gatherings; stylistic variations in tools; more hunting of herd animals; more jewelry; and more use of raw materials from distant sources. He suggests there may have been more cultural variation across groups.

Natural resources (for central and western Europe during the UP).

The animals available for hunting included bison, horses, reindeer, goats, mammoth, rhinoceros, oxen, and deer. Plants available for gathering included berries and nuts.

Frequent climate shifts meant that people had to move around a lot, and maybe modify their technology a lot depending on the food that happened to be available.

During the periods of more intense glaciation (35 - 16 KYA), people were mostly in the Iberian peninsula (modern Spain and Portugal) and in southwestern France. To the east, and north of the Alps, there were open plains with less ecological diversity.

Good territories had higher population densities for two distinct reasons: (a) people tend to migrate toward locations with abundant resources and (b) when standards of living are higher, people tend to have higher fertility and lower mortality, so in the long run human population tends to rise.

What would make a particular site attractive?

1. Diversity and predictability of resources. This means that people don't have to move around as much when looking for food.

2. Availability of water (almost all of the sites occupied by humans were near lakes, rivers, springs, or marshes).

3. Availability of shelter (especially caves with entrances facing south).

4. Good views of the landscape (in order to observe animals and other humans).

Social patterns.

A standard pattern among hunter-gatherers is that people often disperse to search for food at some seasons of the year but then come together in larger groups in other seasons when food is more concentrated in one place. This is called seasonal aggregation, and it offers an opportunity to trade, share food, find marriage partners, exchange information, etc.

Anthropologists have found that social complexity tends to increase when foragers have predictable resources at a fixed location and therefore become more sedentary. Groups become larger, they defend their property rights, and there is often more inequality and warfare. However, sedentary foraging was probably rare prior to the Holocene.

Artwork.

I won't say much about this because it is a bit off track for our purposes. But one feature of the UP in Europe was frequent use of ornaments like beads, pendants, necklaces made of animal teeth, and so on.

There are many famous cave paintings by modern humans in France and Spain (and also equally good but less well known cave paintings in Australia). There are also examples of sculpture and musical instruments.

This kind of artwork starts around 30 KYA and was widespread through the Last Glacial Maximum, but tended to disappear as the ice age waned (mostly gone by about 13 KYA).

What was this about? Nobody really knows. Maybe it involved hunting magic (a lot of the paintings involved animals), fertility rituals, record keeping, or religious beliefs. Or possibly it just reflected the desire to create something of lasting beauty. If that was the goal, the painters succeeded.

<u>Central/Eastern Europe, Russia, Siberia</u>.

Now I want to shift the geographic focus further to the east. In order to survive in these areas, people needed good cold-weather technology. This included:

1. Clothing (bone needles were used to create tailored clothes with multiple layers).
2. Hunting (bone and antler weapons, accompanied by spear throwers, were used to hunt mammoths and other large dangerous animals).
3. Housing (there were few trees or rock shelters on the open plains, so people often used mammoth bones and animal hides to gain protection from bad weather).

The main food resources were animals like mammoth and bison, plus sometimes fish and birds. Plant foods would generally have been scarce except briefly in the summer.

Site locations were usually near rivers and had good views of the surrounding landscape.

Food storage is easier in cold climates. There is some evidence that people dug deep pits in the permafrost in order to store large quantities of meat for later use.

To give you a sense of population sizes, one site in Moravia had 100-120 people and may have been used in both summer and winter. Another site in Ukraine had about 50 people, and enough effort went into housing construction that inhabitants must have been at least partially sedentary. These are among the largest known communities in the period before the Holocene, and most people probably lived in considerably smaller groups or bands.

There is evidence for long-distance trade at these two sites (sea shells from 600-800 km away, amber from 160 km away).

In central Asia, we find numerous Neanderthal sites with Mousterian technology, dating to early in the Weichsel glaciation (starting around 116 KYA). The eastern boundary of the Neanderthal range seems to have been the Altai Mountains and they are not found in East Asia. However, various other archaic humans have been found there.

Homo sapiens probably arrived in central Asia by around 35 KYA, but the exact timing of the transition from Neanderthals to Homo sapiens is unknown.

Siberia had a very poor climate for humans. Not only was it cold (even colder than now), but it also had very little precipitation. For this reason, despite the cold there were no ice sheets (unlike in Europe and North America, which had very large ice sheets). Summers were short and in the north there were vast treeless plains. Although low sea levels made it possible for people to walk from Siberia to North America, people had to learn how to survive in Siberia first.

When Fagan wrote his book he said that known Siberian sites date back to about 20 KYA (again, mostly near rivers and lakes). He says that claims about Siberian sites earlier than 30 KYA are highly controversial (p. 150). But recent archaeological research has pushed evidence for humans back to around 40 KYA, at least in southern areas of Siberia. Over tens of thousands of years, humans gradually moved further north.

Recall also that recent archaeological evidence indicates migration to the Americas by at least 23 KYA, which is substantially earlier than what most archaeologists thought when Fagan was writing his book 15 years ago. This implies that humans would already have been in northern Siberia at an earlier date than Fagan suggests.

Microblade technology.

This is a type of blade technology where the blades tend to be very small (for example, small enough to be used as the point on an arrow). Microblades were generally part of composite tools, often with handles made of antler, bone, or wood.

After 25 KYA, microblades appear across Africa, Europe, and Asia. Fagan thinks they may have originated in northern China. In any case, this technology became common in northern China, Korea, Japan, and northeastern Siberia. Probably microblades were part of the toolkit used by the first people who migrated to the Americas.

Why did this innovation occur? Fagan suggests that it started in temperate parts of Asia where people were hunting over wide areas and needed tools that were easy to carry and manufacture. Microblades would have been effective as tips of spears and eventually for bows and arrows. This technology would have been attractive in regions where supplies of flint were scarce. Because microblade tech was highly portable and had a wide range of potential uses, it spread as humans moved into northern Asia and Alaska. I think this is an interesting example of economic reasoning by an archaeologist.

Robert Kelly, Chapter 5, The Foraging Spectrum, 1995 (available in the coursepack).

Some background information on this reading:

1. Kelly is an anthropologist but he thinks like an economist (there are not many anthropologists who do).

2. He is looking at relatively recent foraging societies (mostly those studied in the last century). He is not looking at societies from 40-10 KYA.

3. We have to be careful about extrapolating back from recent foragers to prehistoric foragers.

4. Recent foragers tend to live in rainforests, deserts, or the Arctic, while prehistoric foragers lived in more diverse environments. Also, modern society has often had large effects on recent foragers (colonialism, disease, trade, technology, etc.).

5. But for certain types of institutions, we can't observe what foragers were doing in prehistory, and observations of modern foragers provide some clues.

This chapter is concerned with institutions for food sharing and land use. Kelly thinks that similar variables are important in both cases, so he analyzes them together.

He emphasizes the variation of practices across foraging societies; they are not all alike. Therefore we need to explain why certain social rules or institutions occur in particular natural environments, with particular technologies and population densities.

RK has an implicit model where institutions adapt to the environment, technology, and population. He doesn't spell this out, but at a general level his theory looks like this:

institutions = f(environment, technology, population density)

Kelly wants to use economic logic to explain institutions. They need to be consistent with individual rationality, not just what would be beneficial for a group as a whole.

Intellectual history.

In the 1960s there was a famous conference of anthropologists called "Man the Hunter". One of the conclusions reached at this conference is that hunter-gatherer societies rely extensively on food sharing, and another conclusion was that they do not have strong territorial boundaries.

RK says there are many exceptions to these broad generalizations. There is a spectrum from individual to communal rights over food, and a similar spectrum for land use.

We need to explain why specific rules are used in specific societies (in other words, we need a theory that can explain the observed variations in institutions across societies).

Institutions do not just come from some 'instinctive' or 'innate' behavior (they are not determined by our genes).

We need to look for the economic foundations. When we see an institution, we should ask what economic problem it is solving.

Sharing food.

Some foraging societies engage in a lot of food sharing, while others do less. Why?

First we will consider possible benefits from sharing. Then we consider possible costs or problems that could arise.

According to RK, the big benefit from food sharing is risk reduction (that is, reduction in the variance of food consumption). He makes the following points.

The returns from time spent on foraging activities are uncertain. The food obtained from hunting animals is frequently more uncertain than the food from gathering plants.

Sources of risk include an inability to find particular plants or animals (search is needed), random variations in weather (temperature and rainfall can affect the availability of plants and animals), and injuries or illnesses (which cause a temporary inability to obtain food).

Because food supply is a matter of life and death, foragers tend to be risk averse toward it, and they want to limit the variance in their food consumption if they can.

There are several potential strategies for risk management:

1. Exploit multiple resources (have variety in your diet).
2. Store some of the food you collect today so it will be available tomorrow.
3. Exchange various types of food with neighboring groups.
4. Share food among the members of your own group.
5. Migration (follow the food resources).

The usefulness of each strategy depends on the local circumstances. For example, some resources may be much more abundant than others, so exploiting multiple resources may not really be practical; food storage might be infeasible or inefficient (think about a large animal kill where the meat will decay); opportunities for different groups to specialize in different food resources may be limited; and so on.

For the food sharing strategy, two things matter: the variance of your own output and the covariance between your output and the output of others.

When the variance of your own output is high, your desire to reduce risk is strong.

But if covariance is also high, sharing food with someone else is not very useful. When you have a lot of food, so does the other person, and when you don't have much, neither does the other person.

Sharing helps the most when there is a perfect negative correlation between two people (or groups). In that case whenever I get one more unit of food, you get one less unit of food, and vice versa.

Another way to say the same thing is that total food production is constant; the only thing that is random is the distribution of food output across individuals. This means that if we share our food equally, we will always get constant consumption levels, with zero risk at the level of individuals.

In the real world, we don't find perfect negative correlations. However, we might have a zero correlation (food output is independent across individuals) or perhaps small positive correlations. In such cases, food sharing does reduce risk, although it is not eliminated.

Suppose individuals have significant variance in their own food output (if this variance is already low, people won't care about reducing risk). RK's theory yields some predictions:

(a) When local correlations among individuals are high, people should use strategies other than food sharing (such as storage, non-local exchange, or migration) to deal with shortfalls.

(b) When local correlations among individuals are low, people should share food at a local level (within their own foraging group), maybe with some household storage if this is feasible.

However, there are two puzzles. Why don't individuals cheat by refusing to share when they have a lot of food and others don't? And why do some people with consistently high productivity share, although on average they do not appear to benefit much from sharing?

<u>Incentives to cheat</u>.

I will model this issue using the Prisoner's Dilemma game. There are two players, A and B. Each player chooses between two strategies called Nice and Nasty.

When a player chooses the Nice strategy, that person gives half of their food output to the other person.

When a player chooses the Nasty strategy, that person keeps all of their own food output.

Assume individual output is uncertain: it could either by high (Y) or low (y). These two outcomes have equal probability. Let the mean output be m = (y + Y)/2.

The output for person A is indicated by y_A and the output for person B is indicated by y_B. These are random variables. We don't know in advance who will get the high output and who will get the low output.

Also assume there is a perfect negative correlation across individuals, so whenever player A gets y, player B gets Y, and vice versa. So the total output for the two players together is y + Y, which is a constant. This assumption means that we are looking at a situation in which food sharing could potentially have large benefits. However, individual incentives to cheat can still cause problems, as we will see.

First consider the top payoff matrix on the next page, where the payoffs are the average or expected food consumption for each player. Ignore the bottom payoff matrix for the moment (the Greek letters reflect risk issues to be discussed later).

When both players are Nice, both share food. One player will produce y and the other will produce Y. We don't know who will get the small output and who will get the big output. But it doesn't matter because the total output is always y + Y and equal sharing means that each person gets y/2 + Y/2, or m = (y + Y)/2. Hence, the individual payoffs are (m, m) and these occur with certainty.

When player A is Nice and player B is Nasty, then player A gets $y_A/2$ because A gives away half of her own output and gets nothing from B. There is a probability 1/2 that $y_A = y$ and a probability 1/2 that $y_A = Y$. Thus on average A will get (1/2)(y/2) + (1/2)(Y/2) = m/2. Player A bears some risk because it is uncertain whether A will get the big output or the small output.

Again assume that A is Nice and B is Nasty. Player B gets $y_A/2$ from player A plus all of y_B because B keeps all of his own output. With the probability 1/2, B's payoff is y/2 + Y because A gets the small output and B gets the big output. Also with probability 1/2, B's payoff is Y/2 + y because A gets the big output and B gets the small output. On average B will get (1/2)[y/2 + Y] + (1/2)[Y/2 + y] or equivalently (3/4)(y + Y) = (3/2)m. B bears some risk because it is uncertain who will get the big output and the small output.

In the cell of the payoff matrix where A is Nasty and B is Nice, the payoffs are reversed, so on average A gets (3/2)m while B gets (1/2)m. The reasoning is the same as before.

In the cell of the payoff matrix where both are Nasty, there is no food sharing. A gets y_A and has the expected food consumption (1/2)y + (1/2)Y = m. B gets y_B and has expected food consumption (1/2)y + (1/2)Y = m. Therefore, in expected value the payoffs are (m, m), which might appear to be identical to the case where both are Nice.

However, there is a crucial difference. When both are Nasty, both bear some risk (each person is uncertain whether they will get y or Y). But when both are Nice, no one bears any risk, because each person gets m for sure.

B

	Nice	Nasty
A Nice	m, m	$\frac{m}{2}, \frac{3m}{2}$
A Nasty	$\frac{3m}{2}, \frac{m}{2}$	m, m

Payoffs Using Expected Consumption

B

	Nice	Nasty
A Nice	m, m	$\frac{m}{2} - \epsilon, \frac{3m}{2} - \delta$
A Nasty	$\frac{3m}{2} - \delta, \frac{m}{2} - \epsilon$	$m - \gamma, m - \gamma$

Payoffs Adjusted for Costs of Risk

If the players are risk neutral then all that matters is the top payoff matrix. But if they are risk averse, they bear a cost whenever they bear risk. In the bottom payoff matrix, I have subtracted off a positive Greek letter in each situation where a player bears risk in order to represent these costs.

Now let's think about the equilibrium of the game when the Greek letters are positive but not too large, so the players are somewhat risk averse but not extremely risk averse.

If you are familiar with game theory, you can see that player A has a dominant strategy. If B uses Nice, it is optimal for A to choose Nasty because $3m/2 > m$. If B uses Nasty, it is optimal for A to choose Nasty because $m > m/2$. Therefore, no matter what B does, it is best for A to choose Nasty.

Because the game is symmetric, player B also has a dominant strategy, which is Nasty.

Thus we have a dominant strategy equilibrium where both players are Nasty and both get $m - \gamma$. Because both players are risk averse, this is less than m. Both would be better off if they were both Nice, because then they would both get m with certainty.

This is the usual outcome in a Prisoner's Dilemma game. We have a dominant strategy equilibrium that is inefficient. If both people cooperated, both would be better off (we could have a Pareto improvement).

Notice, however, that this conclusion holds only when the players are risk averse. If the players are risk neutral we have $\gamma = 0$ and we get identical payoffs from (Nice, Nice) and (Nasty, Nasty).

Now let's go back to the case with risk aversion. If (Nasty, Nasty) is an equilibrium, why would anyone ever share food? There are two major reasons.

(a) Foraging groups often consist of close relatives. People tend to care about family members (such as siblings or cousins), and this concern might be large enough to outweigh the individual benefits from refusing to share food.

(b) The food sharing game will be repeated many times. If someone cheats today, the other foragers could punish that person by not sharing food tomorrow. Whether such threats are sufficient to support food sharing depends on how much weight people put on future payoffs relative to present payoffs, the size of the individual temptation to cheat, and the size of the group benefit from having everyone share rather than having no one share. In small groups that interact frequently over a long time period, it is likely that a social norm of food sharing can be enforced.

    The worst punishment is generally ostracism (expelling someone from the group). In a foraging band, this could be a very severe punishment (an isolated individual might die if no one is willing to help them). On the other hand, in large groups it may be difficult to detect individual cheaters, or an individual might cut back on their own effort when food output is shared (there may be a free rider problem).

As the size of a foraging group expands, the gain per person from spreading risk through sharing increases but at a decreasing rate (there are diminishing returns). At some point the marginal cost associated with a larger group (due to free rider problems) could exceed the marginal benefit.

This may help explain why foraging groups in the real world are relatively small (about 20-25 people is typical). Taking into account that there will be some kids and some old people, such groups tend to have about 7-8 healthy adults who can search for food. This could be enough to reduce risk significantly through food sharing, without running into serious diseconomies of scale due to free riding.

The argument about repeated games is related to what RK calls "tit for tat reciprocity". Similar concepts apply when people (or groups) are trading goods and one person can cheat the other (for example, by promising to provide a good in the future but then not doing so). In cases of this kind, the benefits from cooperation are usually the standard gains from trade rather than risk reduction, although risk might also play some role.

In addition to the reasons for sharing discussed above, RK mentions "tolerated theft". What he means is that if people have bad luck in hunting or gathering, they may become desperate and steal food from others. The rightful owners of the food may tolerate theft of this sort because it is too costly to prevent it, or because they know they may become desperate themselves for similar reasons in the future.

RK also mentions "cooperative acquisition", which is the idea that people sometimes get food by working in teams (such as groups of hunters). If it is difficult to distinguish the contributions made by individuals, the resulting food may be shared among the team.

RK believes that these two reasons for sharing are less important than risk reduction.

I mentioned a second puzzle earlier: why do unusually productive hunters continue to share food with others, even though they don't appear to get much benefit from this? If they just kept their own output, they might be better off. Note that if we assume unequal productivities, we are departing from the symmetry assumption we used in the Prisoner's Dilemma model.

One possible answer is that even good hunters face risks. This is true, but then why don't they bargain for a larger share of the total food output to compensate them for their larger contributions? Another possible answer is that they are compensated in some other way. For example, anthropologists have found that in a foraging society called the Ache (from South America), good hunters tend to have more kids (anthropologists somewhat crudely call this "sex for meat"). More generally good hunters may earn high prestige, which can provide various benefits. Another idea is that if they contribute substantially to the group when they are young and healthy, good hunters are likely to be supported in their old age by the other members of the group.

That's all I want to say about food sharing. Let's switch gears and talk about land use.

Land tenure.

When we are talking about access to land, we are talking about claims to an input, rather than claims to an output like food.

Common questions include: (a) Is land owned individually or by a group? (b) Are the property rights tightly defined, with outsiders systematically excluded, or are the rules relatively loose? (c) What happens to people who violate the rules?

Most anthropologists and archaeologists probably agree that individual land ownership doesn't make much sense (and is rarely if ever observed) in foraging societies. In what follows, I will focus on 'ownership' of territories by groups.

Again, RK emphasizes that we don't want to explain institutions about land use as being somehow 'instinctive' or 'innate'. He doesn't like stories claiming that people have some genetic programming to be 'territorial'. Instead, he wants to explain institutions for land use by relating them to the environment, technology, and population.

The relevant factors include population density, as well as the variance and covariance of the food output obtained from parcels of land.

Here is some intuition. If population density is low and resources are distributed across the landscape randomly, it makes sense to follow the resources (mobile foraging), rather than stay in one place and get a risky return (sedentary foraging). Thus, we can think of mobility as a risk reduction strategy, although it also has costs. RK would expect that in cases of this kind, there will be weak rules about which people can use which territories.

On the other hand, if population density is high and the variance of output for individual locations is low, we would expect the largest populations to be at the best locations. The population at a good location may be high enough that insiders can prevent further entry by outsiders, using force if necessary. In such a situation, we expect strong rules about who can use a given territory.

This is essentially what RK calls the "economic defensibility" model. Compared to RK, I would give a bit more emphasis to the idea that different territories have different average productivity, and that the people at especially valuable locations have strong incentives to exclude outsiders. There may be other places with lower average productivity and lower population density where incentives to exclude outsiders are weaker, or there are too few insiders to enforce group property rights over a given territory.

The other main idea RK discusses is "social boundary defense". This may seem similar to the economic defensibility model but it is somewhat different. In the SBD framework, individual foragers can move from one territory to another as long as they can negotiate membership in the group that controls a given territory.

For example, a person who is currently in group A may have relatives in group B, and may be able to convince the members of group B to let them join. If so, the person will gain access to the land used by group B. This often occurs through informal reciprocal visiting between groups.

In this framework, loose definitions of group membership help reduce the variance of individual food consumption, because then people can move easily from one group to another, depending on where resources are currently most abundant.

Social boundary defense involves getting permission to use another group's land. Why not just trespass and use the land without permission? RK gives several answers:

(a) Because then permission may be denied in the future (but so what? Why not just trespass again?)

(b) Because you may lack knowledge about the local resources and need cooperation from local people in order to exploit those resources efficiently.

(c) Because you may be detected and punished (intruders are sometimes killed).

I think the bottom line on Kelly's analysis of land tenure and property rights is like this. Assume the variance of each group's food supply is high enough that risk is important.

1. If covariance with neighboring groups is relatively low, people will rely on social boundary defense, territories will be defined in fairly loose ways, and it will often be possible for individual people to move from one group to another using kinship connections. This tends to reduce the consumption risks facing individuals.

2. If covariance with neighboring groups is relatively high, sharing access to group territories will not be very helpful for reducing consumption risks. Furthermore, if population density is high enough, the groups that control good territories will try to prevent outsiders from using their resources. Territorial boundaries will be tightly defined and the perimeter will be defended. Under some conditions, there may even be warfare between groups for control of good land (organized warfare is rare among mobile foragers but sometimes occurs among sedentary foragers).

Econ 452W

Advice for Revising Papers

Greg Dow February 11, 2022

These notes are intended to supplement the comments I made on individual papers. The advice here is relevant for everyone so I wanted to distribute it to the entire class.

1. Organization

(a) Have a title page. This should include the topic of the paper, the course number, your name and student ID number, the date, and the nature of the assignment (for example, the final draft of the first paper). These are the basics, but you can add other information if you feel it would be useful. The title page is not included in the 5-page limit for the paper.

(b) Have a reference page. This comes at the end and is separate from the main text. It should include a complete citation to each source you mentioned in the text of your paper. If you aren't sure about the appropriate format for a citation, you can use the references at the end of the journal article you are discussing as a model. Because I do not expect any additional research, in most cases the reference page will just have a single citation to the journal article you are writing about. The reference page is not included in the 5-page limit.

(c) When citing an article or book in the text of a paper, economists use the names of the authors followed immediately by the date of publication in parentheses: for example, Bowles and Choi (2019). When there are three or more authors, such as Oana Borcan, Ola Olsson, and Louis Putterman (2018), you can abbreviate this in the text as Borcan et al. (2018). However, you do need to write out all three of the names on your reference page.

(d) You don't need to repeatedly cite the authors and the date in the text of your paper as long as the source of the ideas is obvious. It is fine to say "the authors believe X" or "according to the writers, Y is true because Z is true". Be careful about the use of singulars and plurals. If there is only one author, say "the writer". If there are two or more authors, say "the writers".

(e) If you need to use a direct quote from the authors, then give a citation and include a page number so the reader can easily find the quote in the original article.

(f) Try not to overuse direct quotes. It is usually best to express the author's ideas in your own words. A direct quote is valuable only if it is important for the reader to know exactly how the author said something (for instance, maybe the author said something ambiguous and you are identifying possible alternative interpretations).

(g) You don't need formal citations to the sources cited by the author of the article. For example, if the author is doing a literature review and cites previous work by Allen, Baker, and other authors, you can simply mention the names of the earlier people and say why the author thinks their ideas are important. In cases of this sort, it is unnecessary to include full citations to Allen or Baker. If a reader really cares, they can get the journal article you are discussing and look at the references provided in the article.

(h) Use page numbers. This helps readers see how long your paper is, and also helps a reader to find things you said on earlier pages. It is especially helpful when the reader wants to discuss your work (for example, someone might want to say "you claim that X is true on p. 3, but really I think Y is true instead).

2. Style

(a) Use paragraph breaks! You should start a new paragraph whenever you introduce a new topic. This conveys the logical structure of your argument to the reader in a convenient visual way. It is very hard to follow an argument in a paper that does not use paragraphing. The reader will often have trouble understanding where the paper is going or what point the writer is trying to make. You will probably find that forcing yourself to think systematically about where to put paragraph breaks will clarify your thinking about the appropriate sequence of ideas for your paper.

(b) There is no fixed rule about how long a paragraph should be (it depends on the subject matter) but normal writing by economists tends to have 3-5 sentences per paragraph and 3-4 paragraphs per page. To make life easy for the reader, indent the first line of each paragraph so the reader can quickly scan down the page and see where you are moving to a new topic. You don't need any extra line spacing between paragraphs. I often use the symbol ¶ to indicate places where I think it might make sense to start a new paragraph.

(c) Use short simple sentences. One idea per sentence is good where possible. It is sometimes necessary to include two ideas in the same sentence in order to explain how the ideas are related. But complex sentences containing three or four ideas are hard to follow and frequently confuse readers. Avoid prolonging a sentence unnecessarily through the use of commas, colons, semi-colons, dashes, and other punctuation marks. If you are writing this way, it is usually a sign that you should break a sentence down into 2 or 3 shorter sentences. As with paragraphs, there is no fixed rule about the length of a sentence, but if a sentence requires 4 or 5 lines it is probably too long.

(d) Have a clear opening paragraph that says what your paper is about. This should usually include the name(s) of the author(s) and the date the article was published. The opening paragraph should be no more than 4-5 sentences and should not have any quotes or technical jargon. It should also not include any details about theory, data, methods, etc. You can postpone discussions of those things until later. The goal of the opening paragraph is to say what the subject is, and why the subject is important. Try to get the reader interested.

(e) After introducing the paper in the first one or two paragraphs, it is often helpful to give the reader a brief road map describing what you intend to do in the rest of the paper. This is not always necessary, but it is useful if there will be several steps in your argument and you want the reader to know where you are going.

(f) Throughout your paper try to avoid making vague, general, or obvious statements. Instead, be specific, concrete, detailed, and precise. Make each of your sentences as informative as possible. Also, avoid excessive repetition. This takes up space that could have been used to convey additional information, and it tends to make the reader impatient.

(g) Use words efficiently. Don't use ten words to say something if five words can be used to say the same thing. Look for phrases or clauses that don't add anything to the substance of your sentences and delete them.

(h) Include a serious evaluation of the article at the end of your paper (about one full page). Don't just heap praise on the author, and don't make superficial criticisms. Every article has multiple strengths and weaknesses, so you should try to provide a balanced assessment and justify your opinions in some depth.

3. <u>Economics</u>

(a) You should go beyond simply reporting statements made by the author. Try to explain the author's reasoning. Why does the author think the statement is true?

(b) Remember to explain concepts or acronyms that would not be familiar to a reader who has not taken Econ 452. Some examples are "Upper Paleolithic", "PPNA", and "Malthusian model". For such terms, give a brief definition or explanation before moving on.

(c) Most of your paper should be verbal, but sometimes it is easier to explain ideas to the reader if you use one or two equations. In this case, be sure to define all of the symbols so the reader knows what they mean. Explain where the equation comes from, why it is true, and why it is important.

(d) If there is a theoretical model (which could be either verbal or mathematical), you should discuss the following things.

    (i) Assumptions: depending on the model, this might involve assumptions about demand, utility functions, production functions, cost curves, etc.

(ii) Economic reasoning: what are the logical steps in the argument? What are the cause-and-effect relationships among the variables? How is the author using the assumptions to reach the conclusions?

(iii) Conclusions: what are the key results obtained from the model? Why do the results make sense and why does the author think they are important?

(e) If there is empirical research, you will need a detailed description of the data set, the statistical methods, and the main findings.

(i) Data: provide details about the region of the world, the time period, the source of the data, how the key variables were defined and measured, the sample size, and similar information.

(ii) Statistical methods: does the author test for differences in means? Or use regression methods? Or some other technique? If regression is used, what is the dependent variable, what are the independent variables (including the control variables), and what hypotheses are being tested? Were there specific problems the authors faced, and how did they try to solve them?

(iii) Findings: which coefficients were positive, negative, or insignificantly different from zero? Were the effects quantitatively large or small? What were the levels of statistical significance? Were the results consistent with the author's expectations? Why or why not?

(f) Organize your paper so that related ideas are grouped together. Don't jump back and forth between theory, data, literature reviews, and so on.

(g) Put sections into a logical sequence. For example, after your opening paragraphs it might make sense to start with the author's general theoretical framework, then describe the hypotheses to be tested, then the data set, then the statistical methods, and then the main findings or results. Another option is to follow the organization of the journal article itself and describe it section by section. I am flexible about the organization as long as you carry out the tasks described in the assignment.

4. <u>Grading</u>

I will grade the final versions based on whether I think a typical economics major who has not taken Econ 452 would gain a clear understanding of what the author accomplished in the article.

So above all else, strive for clarity in the way you provide information to a fellow student. This goal should determine how you organize the paper, how you write, and how you explain economic ideas.

Econ 452W

Greg Dow

March 17, 2020

Notes on T. Earle (1997), How Chiefs Come to Power, Case Study of Hawaii

Natural environment of the Hawaiian islands:

All major islands have one or more central volcanic cones. The northeast side of each island is rainy (with rain forest vegetation) and the southwest side is dry (semi-desert). The islands are warm all year round.

There are river valleys separated by ridges running from the central highlands down to sea level. Often there is a lot of habitat diversity according to altitude and distance from the coast (multiple ecosystems within each valley).

Social organization:

At the time of European contact in the late 1700s, there were complex chiefdoms with a high degree of stratification (the elite were called the alii). In principle the alii were a hereditary aristocracy. In practice there was a lot of warfare, with intense political competition among close kin in the elite, and power was often taken by force. From an ideological standpoint, chiefs were viewed as divine, and other members of the elite were ranked in relation to the paramount chief.

Commoners engaged in farming (taro, bananas, sugar cane, sweet potato), fishing, and also some foraging. They also did some craft manufacturing. The elite granted land to a commoner for personal use in exchange for labor on elite-owned plots. If you don't work for the elite, you don't eat, because you would lose the rights to the land where you grow food for yourself and your family. Commoners were also bossed around by the elite on public works projects (like irrigation systems). The land rent paid by commoners was used by the elite to pay for their own consumption, to support warriors, for craft items valued by the elite, and so on.

History:

Different people give different dates for when the islands were first settled (Earle says about 400 AD). Everyone agrees the settlers were Polynesians. The islands were heavily forested before humans arrived, although with relatively few species. There were birds, fish, and sea mammals, but no land mammals except bats. Because the islands are very isolated, no other terrestrial animals could get there. Some bird species were wiped out early through over-hunting, so fish and sea mammals were the most important later on. People brought domesticated pigs, dogs, and chickens, along with various plants.

There was substantial deforestation and soil erosion, leading to loss of wild habitat. But even so, agriculture on the valley floors remained viable. Irrigation was easy and quite productive.

Significant population growth occurred, probably from a few 100 original settlers to a few 1000 by 800 AD (again according to Earle, others might disagree a bit on the dates). People occupied the best lands first. The population reached a long run equilibrium by about 1500 AD. There is a lot of disagreement about how large the population was at its peak, with a range of estimates from 160,000 to 800,000. Most archaeologists would say about 400,000. The population probably remained relatively constant from 1500 AD to European contact in the late 1700s.

Earle thinks there were local landholding descent groups by about 800 AD. Chiefdoms grew in scale over time. After 1500, irrigation systems expanded rapidly, but this was not a response to population growth. Finally, one chief (or king) called Kamehameha I became the ruler of all of the islands, although this was done partly through the use of European ships and guns.

There is strong evidence for stratification before Europeans arrived. This can be seen from archaeological evidence on house sizes, the value of grave goods, and other data.

<u>What explains this history</u>?

Earle wants to explain why this history occurred. He starts with a simple story, and then suggests an alternative story that he believes can provide a better explanation of the facts.

Here is the simple story: a small group of initial settlers arrived in a rich environment. As we would expect, this led to a rising population density. Greater intensity of agriculture caused resource depletion and degradation of the environment. As a result, people had to rely more on leadership from chiefs to manage the economy.

[Note: this is an example of integration theory as a way of explaining how stratification develops. Remember that according to integration theory, people explain inequality by saying that the elite solves collective social problems in ways that benefit everyone.]

Earle has a different story. He thinks that irrigation and stratified chiefdoms emerged abruptly and more or less simultaneously. It was not vital to have complex chiefdoms in order to run the irrigation systems (most of these were simple and small scale). Also, the development of widespread irrigation and stratification can't be explained by population growth, because it occurred after 1500 AD when the population was already stable.

Earle thinks that due to political competition and warfare among elite leaders, military activities had to be financed by an agricultural surplus. For this to occur, it was vital to put more resources into irrigation. In some places, irrigation had big benefit to cost ratios and was highly profitable to the elite. Earle says the chiefs extracted a lot of land rent in this way (50-70% of taro production went to the elite as land rent).

[Note: this is an example of conflict theory. According to conflict theory, elites pursue their own self-interest at the expense of commoners. In this case, self-interest meant war with other elite factions or leaders.]

Bottom line (apparently): The combination of population growth and increasing returns to scale in the use of military force led to big chiefdoms. The chiefs then took control of land and organized irrigation systems to finance their warriors. Whoever did the best job of extracting surpluses to finance military activities would win. For example, the person I mentioned earlier (Kamehameha) specifically constructed irrigated taro fields on the island of Oahu in order to support a 7000-man army which he used to invade the nearby island of Kauai.

All of this ended after European contact as people migrated from farms into cities to get jobs in the trade sector or on ships. The native monarchy ended in the 1890s, and Hawaii became an official territory of the U.S. It became a full state in 1959. Barak Obama was born in Hawaii in 1961 and grew up to be President of the U.S.

Econ 452W

Greg Dow

March 17, 2020

Notes on Dow and Reed (2013),

"The Origins of Inequality: Insiders, Outsiders, Elites, and Commoners"

I will skip over the first two sections of the article, which you can read for yourself, and start by describing the formal model. It will be helpful if you have a copy of the journal article so you can look at the various graphs as you read these notes. After describing the model, I will make a few general comments about empirical evidence and related matters.

One note on terminology: when we say "insider-outsider" inequality, we mean that the people at some sites are better off than people at other sites. However, there is equality within each site (equal food sharing among members of the group). When we say "elite-commoner" inequality, we are referring to inequality within a given site, where the elite control access to land and hire outsiders (commoners) to supply labor.

Short Run Equilibrium (section 3).

Consider an individual site where food output is $\theta s L^{\alpha}$ where

> θ = regional productivity
> s = local productivity of the site
> L = labor used for food production
> $0 < \alpha < 1$.

We think of θ as reflecting climate and technology (factors assumed to be identical at all sites within the region). We think of s as reflecting local factors like terrain, good soil, availability of fresh water, or favorable hunting and gathering opportunities, which may vary from one site to another. Each site has one unit of land. The assumption $0 < \alpha < 1$ implies diminishing returns to labor, which is what we expect when labor is variable but land and other local resources are fixed.

More assumptions about each individual site:

An individual agent is 'small' relative to the total population at a site.

Each agent is endowed with one unit of time (we ignore leisure).

Each agent can get the income w (in food units) by leaving the site and going somewhere else. Later, this will become the wage for commoners.

If food per person at a site is above w, there is an unlimited supply of outsiders who will enter the site and start producing food there, unless they are prevented from entering.

It takes d insiders at a site to prevent further entry. There are no specialized guards, etc. We just assume that if there are already d people at the site, they can costlessly prevent additional people from entering (maybe by threatening them with violence).

Let n = the number of agents born at the site. If $n \geq d$ then n-d agents will be kicked out and will get w units of food elsewhere (for example, this may be done according to birth order). If $n < d$ then up to d-n additional people could potentially enter before the site is closed.

Assumptions about the region:

Let the site quality s be uniformly distributed on the interval [0, 1]. This means that we have an equal number of sites of each quality level.

Let n(s) be the number of agents born at a site of quality s.

Total regional population is $N \equiv \int_0^1 n(s)\, ds$. This is just the sum of the local populations at the individual sites. It is exogenous in the short run, but becomes endogenous in the long run. The only issue in the short run is how N will be distributed across sites.

First suppose the wage w is fixed, and it is the same at all sites throughout the region.

Let L(s) be the labor input at a site of quality s.

(a) If $L(s) < d$ then the site is *open* (there are not enough insiders to prevent entry by outsiders). Free mobility implies that the average product of labor must be equal at all sites of this kind. The level of this AP is $w = \theta s L(s)^{\alpha-1}$. We say that such sites are "in the commons", meaning that anyone can use them.

(b) If $L(s) \geq d$ then the site is *closed* (there are enough insiders to prevent entry). If they want to, the insiders can hire outsiders at a wage equal to what the outsiders could get at an open site as in (a). The insiders choose L to maximize their net food income $\theta s L^\alpha - w(L - d)$ subject to $L \geq d$. In effect, the insiders maximize profit. The resulting land rent is defined as $r(s) \equiv \theta s L(s)^\alpha - wL(s) \geq 0$. You can think of this as the return to the insiders from controlling access to the site.

Note that in (b), we may have a corner solution where L(s) = d. This means that insiders do not find it profitable to hire any outsiders. In this case we say the site is closed but it is *unstratified*. Alternatively, we could have an interior solution where $L(s) > d$. Here the insiders hire some outsiders to work on their land. In this case, we say the site is closed and also *stratified*. The landowners at the site are called the *elite* and the hired workers at the site are called *commoners*.

See Figure 1 in the article for a graph showing what property rights look like for a fixed wage w. We often use the 'normalized' wage $x \equiv w/\theta$ in situations where θ remains at an unchanged level, because only this ratio really matters in the short run.

When the wage is high enough, all sites are open and there is no inequality.

When the wage is at an intermediate level, poor sites are open and good sites are closed, but no sites are stratified. This gives *insider-outsider* inequality.

When the wage is low enough, the poor sites are open, intermediate sites are closed but unstratified, and good sites are both closed and stratified. So at the intermediate sites we get *insider-outsider* inequality, while at the good sites we get *elite-commoner* inequality.

The only remaining issue is how we determine the wage w (or equivalently x) to get a short run equilibrium (SRE).

In SRE, we require $N = \int_0^1 L(s, x)\, ds$. This says that the total regional supply of labor (the left hand side) must equal the total regional 'demand' for labor (the right hand side), where $L(s, x)$ is the amount of labor at a site of quality s for a given (normalized) wage x $\equiv w/\theta$. Mathematically we can show that there is always an equilibrium wage, and this wage falls when the population N rises. This makes economic sense: when the supply of labor goes up, the equilibrium wage must go down.

See Figure 2 for a graph of the labor demand curve D(x), showing how the equilibrium wage depends on the population level N.

<u>The Aggregate Production Function</u> (section 4).

Total regional food output is $Y = \int_0^1 \theta s L(s, x)^\alpha\, ds$ where we are just adding up the outputs from all of the individual sites.

Let x be the (normalized) equilibrium wage as described above, and write the equilibrium wage x(N) as a function of total population.

Substituting this above, the aggregate production function is $Y(N) = \int_0^1 \theta s L[s, x(N)]^\alpha\, ds$. This shows how total food output depends on total population.

We can show that the marginal product of population is always positive (not surprising: more people produce more food).

At low population levels, all sites are open, and we get $Y(N) = \theta N^\alpha Q^{1-\alpha}$. This is a Cobb Douglas production function with constant returns to scale, where we can think of Q as the total supply of land, adjusted for variations in quality. In this case, labor is allocated efficiently across sites because the average products are equal everywhere, and for our particular production function, this implies that marginal products are also equalized.

At higher population levels, some sites are closed. There are two potential problems from an efficiency point of view:

(i) The sites that are closed and unstratified all have the same labor input d, even though their marginal products are unequal due to differences in site quality.

(ii) The stratified sites have marginal products of labor equal to w, which is also the average product of labor in the commons. This implies that marginal products are not equal to each other at the stratified sites and in the commons.

Whenever some sites are closed, (i) and possibly also (ii) reduce total output below its theoretical maximum described by the Cobb Douglas function above.

See Figure 3 for a graphical explanation of this idea.

An important point: despite these complications, aggregate food per person $Y(N)/N$ is always decreasing as a function of N. Thus, food per person must drop at the regional level whenever the regional population increases.

Long Run Equilibrium (section 5).

In LRE, we treat the regional population N as endogenous.

Each adult in period t has kids who survive to become adults in period t+1. The parents die at the end of period t. The number of surviving kids is proportional to the parent's food income. We assume all of the adults convert food into kids at the same rate γ.

This implies that population dynamics are determined by $N_{t+1} = \gamma Y(N_t; \theta)$ where $Y(N_t; \theta)$ is the aggregate production function from section 4 and we now include the productivity parameter θ explicitly. Recall that this is determined by technology and climate, which are the same at all sites in a given period.

We are making the usual Malthusian assumption here that more food per person leads to more fertility and lower child mortality. Due to the linear relationship between N_{t+1} and Y_t, this is an especially simple version of the Malthusian model.

In LRE, we require $N_t = N_{t+1} = N$. This implies $Y(N; \theta)/N = 1/\gamma$. Therefore in any LRE the regional average product on the left hand side is equal to the same constant.

We can show that if the productivity level θ rises, in the long run the regional population N must also rise. This is not surprising: in a Malthusian framework better technology or better climate means the region can support a higher population. We often write $N(\theta)$ to indicate that in the long run, population is an increasing function of productivity.

In the long run, the productivity θ determines population, and in the short run population determines the wage level and the pattern of property rights across the sites. Putting all of this together, we can determine how food income is distributed among the agents.

See Figures 4(a), 4(b), and 4(c) for graphs showing LRE at different productivity levels.

See Figure 5 for a graph showing how population approaches LRE if it is not yet there.

Poverty, Inequality, and Demography (section 6).

This section describes the main results from the model.

Poverty. The poorest agents get w, either in the commons or (possibly) through working at stratified sites.

Start from a LRE. What happens if productivity goes up permanently? We show that in the short run, the wage w rises while N remains fixed. Therefore, the poorest people are better off. But in the long run, N increases and the wage drops. If we end up with open access everywhere, in the long run the wage will go back to its previous level, as in the normal Malthusian model. But if we end up with some sites being closed, the new long run wage is lower than before, and poverty becomes worse.

Why? The reason is that as N rises, more sites become closed. The commons shrinks and the average quality of sites in the commons falls. Thus w falls due to endogenous property rights. The story is similar if productivity gradually rises over time, rather than jumping abruptly to a new permanent level.

[Note: most economists find it a little surprising that better technology makes the poor worse off, but that is because most models don't treat property rights as endogenous.]

Inequality. There are two issues: inequality within a single site, and inequality for the region as a whole. It is easy to deal with the first issue. We can show that in any SRE, stratified sites of higher quality have more inequality (the elite hires more commoners). Also, at a given stratified site, anything that increases N decreases the wage. This leads to greater inequality at that site.

The harder problem involves inequality at the level of the region. This is complicated, but if you know what a Lorenz curve is, you can see what one looks like in Figure 6.

Here is a summary. Suppose we have two populations N_1 and N_2. Assume $N_1 < N_2$ and also assume that N_1 is large enough to make some sites closed. We can show that the Lorenz curve shifts down when we increase population from N_1 to N_2. This leads to a higher Gini coefficient (this is a common way of measuring inequality; if you've never heard of it, don't worry about it).

We can also show that in the limit as population approaches infinity, the Gini coefficient approaches the share of food output that landowners would get in a perfectly competitive economy. The reason is that in the limit, almost everyone is a commoner, and almost all commoners are paid their marginal product, so the model looks like a competitive labor market where profit-maximizing landowners hire employees.

Demography. Assume N is large enough that some sites are closed.

Because inequality exists, some people obtain food income below the regional average product Y(N)/N, while other people obtain food income above this level. Remember that the number of kids a parent has is proportional to his or her food income. Therefore, the agents with high incomes produce more than one surviving kid in the long run, while the agents with low incomes produce less than one surviving kid.

In order to have constant population sizes for the elite and commoner classes, there must be some downward mobility where some of the kids of elite parents become commoners. In the article we assume this occurs according to birth order (the first-born kids remain in the elite while their younger siblings do not).

We show that elite membership is always hereditary at stratified sites (elite agents always have elite parents). At sites that are closed but not stratified, it depends on the quality of the site. Better sites have hereditary insiders, while at worse sites the insiders do not have enough kids to replace themselves, so in each generation they let some outsiders become insiders in order to maintain their property rights over the site.

Empirical evidence (section 7).

Before about 13,000 BP, almost everyone lived in small mobile foraging bands with low population density. In this situation, our theory predicts minimal inequality (maybe just a little bit of inequality among sedentary people at very good places, such as the Natufians in southwest Asia).

The Holocene brought better mean climate conditions and lower variance, so productivity increased. We also began to have learning by doing in cultivation, plus domestication of plants and animals, which reinforced the trend toward higher productivity.

Our prediction is that this should lead to rising population density and the establishment of property rights at the best sites. At first, this only led to what we call insider-outsider inequality (some people were at better sites than others and therefore had more food than others, but no stratification). Eventually elite-commoner inequality (stratification) began to develop at the best sites.

Archaeological evidence on prehistoric inequality supports these ideas. Evidence about house sizes, burials, health/disease, and so on reveals that inequality rose as the regional population density increased, as individual settlements became bigger, and as agriculture replaced foraging. This is what we would expect.

In the rest of the article, we go through a series of regional case histories. You can read the paper to get the details, but here is a brief sketch.

Southwest Asia. The Natufians probably had some insider-outsider inequality and maybe a bit of stratification, but inequalities were small. During the Younger Dryas, inequality disappears and there was probably open access at most sites except maybe the very best. Evidence for insider-outsider inequality returns In the Holocene, along with some elite-commoner inequality. Again, the degree of inequality is relatively modest.

Europe. This is an interesting comparison with SW Asia because it involved diffusion of agriculture, not a pristine transition. However, the arrival of agricultural technology was clearly associated with higher productivity. Initial hunter-gatherer population densities were mostly very low. As agriculture entered central Europe, population rose. The best sites were settled first. The earliest farming groups were relatively egalitarian. But over time insider-outsider inequality emerged, followed by elite-commoner inequality. There was probably inherited membership in the elite class.

Polynesia. This region consists of many islands in the Pacific Ocean, with considerable variation in land areas, climate, soil quality, and other geographic features. We look at two things: (a) cross-sectional comparisons across islands with different resources, and (b) time series data for two particular island chains (Tonga and Hawaii).

(a) Our model predicts more inequality on islands with better natural resources and we are right. The places with the best resources are Samoa, the Society Islands (which includes Tahiti), Tonga, and Hawaii. Both population and inequality are strongly correlated with productivity, as determined by the quality of the natural resources. In particular, Hawaii had the best resources, the highest population, and the most extreme inequality.

(b) FIgure 5 shows the adjustment path leading from a low initial population to LRE. We are interested in what happens to inequality along this path. For both Tonga and Hawaii, we find initially low population with only the best sites being used; then population grows and people spread into lower quality sites; then property rights develop at the best places; and eventually we find stratification at most locations, where the elite owns the land and the commoners work for them.

Channel Islands (off the coast of California).

These islands were initially occupied by hunter-gatherers who relied mainly on marine resources. There is evidence of gradually improving fishing technology, plus arrival of the bow and arrow, which increased productivity. As this occurred, the population grew. The best sites were settled first, followed by others. Eventually open access ended at the best sites, and we start to see insider-outsider inequality (this is indicated by skeletal data on differences in health across islands with different resources). Physical mobility across islands was not difficult, so this probably reflects social barriers to movement. Inequality also becomes clear from burial practices. When Europeans arrived, they found a society ruled by hereditary chiefs, with elite and commoner classes.

Section 8 of the paper is a summary.

Section 9 provides a review of the literature, which compares our theory with theories of inequality developed by archaeologists and other economists. There is no need for me to summarize this material here, the main points should be reasonably clear.

Econ 452W

Greg Dow

March 25, 2020

Notes on A. Johnson and T. Earle, 2000, The Evolution of Human Societies

Case studies of the Yanomamo, the Tsembaga Maring, and the Central Enga

These notes are not meant to be a substitute for doing the reading. You should still read the original cases carefully and see what J&E say. It would be good to consider whether the causes of warfare are similar in the three cases, and whether there are any important differences. I will summarize what I would have said in a lecture on this topic.

<u>The Yanomamo</u> (pp. 141-170).

Of the three cases, the Yanomamo have the lowest population density (about 2.0 people per sq. km. in the highlands). This society is notorious among anthropologists for the intensity of their violence, although relatively few anthropologists seem to have been injured or killed while studying them. The big question is why they fight.

<u>The environment and economy</u>. The Y. are located in the highland headwaters of the Orinoco/Negro river system in Venezuela and Brazil. There are hills and valleys, the soil is poor, and the altitude is 1000 - 4000 feet above sea level. The highlands lie above the tropical rainforest, so they are cooler and drier. Wild game is scarce, fish are scarce, and J&E say it is a marginal area in terms of natural resources.

The main crops are plantains, sweet manioc, peach palm fruit, and yams. There is little or no storage and the risk of crop failure creates a motivation to share food if necessary.

Foraging is used to supplement farming: crab, shrimp, small fish, frogs, ants, termites, fruits, and roots. People also hunt agouti, armadillo, monkeys, and birds.

Although people have year-round housing (they are sedentary), there is a lot of seasonal nomadism to obtain wild foods. Occasionally people have inter-village feasts where they eat tapir, peccary, and other "real foods". These are special occasions.

The tropical rainforest (lower elevation than the Y.) has diseases (yellow fever, malaria). Traditionally there were also strong enemies of the Y. located there. This probably kept the Y. from moving beyond their own usual territory.

J&E say that there is good garden land and hunting at lower elevations. I assume what they mean is at elevations that are relatively low within the territory of the Y, but not so low that it is in the tropical rainforest where the diseases mentioned above are a problem.

After getting steel tools and domesticated plantains from outside sources in the 1800s, the population rapidly increased. This is what one would expect from Malthus. There seem to be some indications that population had fallen recently, as of the time J&E wrote their description. Maybe the Y. were not in long run equilibrium? Unclear.

Social organization. Households are autonomous, own their own gardens, but live in villages. Population is heavily concentrated at good sites, which are rare. A site needs to be good for both gardens and hunting. Important features include soil quality, steepness, elevation, drinking water, and so on. Gardens involve some major long-term investments (planting trees). There is trade among people living at different altitude zones. Villages last a long time (40-50 years). Farming eventually leads to soil depletion and a reduction in agricultural productivity.

A "teri" is a village of at least 30-35 people corresponding to a specific territory. It is enclosed by a fence with a gate. In the highlands 70-75 people is about average (often consisting of two lineages who intermarry). A village with more than 100 people tends to become unstable, causing the people to split into separate groups. Intermarriage among the members tends to stabilize a teri and reduces problems with theft, insults, or violence internal to the group. When villages do split, it is usually along genetic lines, i.e. groups of more closely related people stick together. There is some cooperation across villages for food sharing, trade, and defence. There is an incentive to maintain a relatively large group for effective defence against outsiders, subject to the tradeoffs mentioned above.

Warfare. At lower elevations, ≥ 25% of adult males die from violence. There is less warfare at higher elevations, but raiding and homicide occur there too. Warfare involves significant resource costs (need to build defensive structures, and have people be sentries or patrol the area rather than obtaining food). Also an indirect cost: because people have to cluster together for security, they face higher travel costs to tend their gardens and get food (without warfare they would probably have spread out more for economic reasons).

Violence takes various forms. It may involve feuds and revenge killings, or treachery where one group invites another to a feast and tries to massacre them. Not surprisingly in this environment, groups try to establish reputations for toughness. Given the central role of warfare, "waiteri" men (strong, aggressive, fearless) are highly valued. It takes about 80-100 people for a village to have an adequate defence. The actual range runs from 30 to 100 at the level of an individual village, or up to 300 if we count regional clusters, that is, villages having defensive alliances with each other.

There is some leadership within a village. The leader is usually the head of the dominant family. In a larger village there might be a Big Man who speaks for the group, organizes the defence, and leads in battle.

So what causes all this warfare? First we need to distinguish between proximate causes and ultimate causes.

Suppose A causes B, which causes C, which causes D. The *proximate* cause of D is C. This is the most direct or immediate reason why D happens. But the *ultimate* cause of D is A, because this is what triggers the entire sequence of events leading to D.

For warfare among the Y., anthropologists have suggested a number of proximate causes: one group kidnapped women from another group, an attack was motivated by a desire for revenge, there are aggressive men in leadership positions, and so on.

Although these explanations may be correct (they really are the proximate causes), there is a problem: in many societies people have sexual jealousies or desires for revenge, and most societies do include some aggressive or violent men. However, such things do not lead to warfare everywhere. So what explains why they do in the case the Y.?

Another way to think about this issue is in terms of exogenous and endogenous variables. Remember that *exogenous* variables are determined by factors outside the model, while *endogenous* variables are determined within the model. It would not be surprising that in a society where warfare is common, people may want to put aggressive men in positions of leadership. But the selection of the leaders is endogenous. We need to understand the exogenous variables that caused warfare to be common in the first place, and thus led to the selection of this kind of leader.

According to J&E, the ultimate cause of the violence among the Y. is competition over scarce resources. People are very concerned with the definition, defence, and capture of territory. It is important to have a good site and there aren't many of them. Furthermore, once a group occupies a good site, it makes long-term investments that raise the value of the site by planting gardens, trees, and so on. This increases the temptation for another group to attack and take the site. Sites that are good at first eventually become bad due to the loss of soil fertility, tempting that group to attack some other group with a good site.

Warfare frequently leads to the permanent displacement of a group from its lands. This is less common in the highlands where there are large stable alliances. But where warfare is common, displaced groups tend to become desperate and attack another group. Running away from an attack is not an attractive option due to the scarcity of good locations, so a group often prefers to fight back when it is attacked.

So they are in a bad equilibrium. There is crowding due to warfare, which leads to local resource depletion, which leads to a need for new territory, which leads to more warfare.

This seems like a reasonable explanation. But we don't know very much about the earlier history of the Y. The ultimate causes of warfare could include technology shocks and/or resulting changes in population, which may be the factors that led to intense competition over land. In a long run equilibrium, population density might settle at a level where the incentives for warfare are not so strong.

The Tsembaga Maring (pp. 179-193).

This group is located in highland New Guinea and has about 200 people. It is part of a larger society in the region that has about 7000 people. The population density is much greater than the Yanomamo. In the case of the TM, it is about 60 people per sq. mile.

The environment and economy. This is a mountainous environment that is economically marginal relative to other parts of highland New Guinea. The elevation is around 2000-7000 feet above sea level, with narrow valley floors and very steep hillsides. The region is tropical and humid with rainfall throughout the year. At lower elevations, population growth is restrained by the prevalence of malaria.

The main crops are taro, yams, and sweet potatoes. Bananas, manioc, sugar cane, and other veggies are also eaten. Gardens are usually located at elevations below 5000 feet. There are investments in orchards (two species of trees give edible leaves and fruit).

Almost all food is obtained from plants. Some protein is obtained from rats, frogs, birds, and grubs. There are domesticated pigs and chickens. Pigs are important not for calories, but for protein and fat. Wild foods are not very important (deforestation due to farming has tended to destroy wild habitats).

Sites are heterogeneous in quality: some good, some not. The best farmland is limited and overused. Agriculture requires a fallow cycle due to soil depletion. This means that after the soil is exhausted, an agricultural area must be left unused for a long time in order to regain its fertility. This takes about 15 years in the lowlands and 45 years in highlands.

Social organization. The society is circumscribed by elevation: there is malaria at lower elevations and agricultural productivity is too low at higher elevations.

[Note: when anthropologists say a society is *geographically circumscribed*, this means it is surrounded by mountains, deserts, ocean, areas having diseases, or some other barriers that make it costly or difficult for people to move beyond the region.]

Group size is limited by the possibility of internal conflict in large groups, and by local resource depletion. The Tsembaga Maring are a relatively small group (200 people) but were recently defeated in a war, and probably had 250-300 people earlier.

There are several levels of social organization from smallest to largest. At the basic level there are households. The next largest unit is the hamlet, or patrilineal household cluster, where males are typically first cousins or closer in terms of genetics. These groups share a fence used to defend against attacks. The next unit up is the clan, with an average size of about 75 people. Clans are a formal social unit that controls a marked territory, which includes the full range of ecosystems. A clan may permit immigration if land is available and it wants to increase its military strength. The largest social unit is the local group or clan cluster. This is a collection of 2-6 clans with about 200-800 people. The average is roughly 380. People in an individual clan usually marry someone from another clan in the same cluster. Clans in the same cluster also trade with each other. The Tsembaga Maring are near the bottom end of the size distribution for clan clusters.

Warfare. Wars are periodic and intense. They occur about every 12-15 years and result in changes in the territorial boundaries among groups. The group that wins a war spreads out through the new territory gained from the losers. The losers spread out through other peoples' lands if they can, leading to more conflict. There is a tradeoff between clustering together for defence but wanting to spread out in order to use distant fields and raise pigs.

Truces are marked by the planting of a rumbin tree. As it grows, there is no war, and the local groups accumulate their pig herds. When someone uproots the rumbin tree, this is a signal that the truce is over. People eat their pig herds and engage in ceremonies where they show the strength of their group and obtain support from allies. Then they fight.

The J&E theory about warfare here is that exogenous growth in population density leads to more emphasis on agriculture, which leads to competition for land, which leads to war. This seems like an incomplete explanation to me. Why doesn't Malthus lead to a stable population in the long run? Why isn't the resulting population density low enough to restrain conflict over land? Maybe the region is not in long run equilibrium?

From other sources I have read, the highlands of New Guinea got sweet potatoes in the relatively recent past (a couple of generations before anthropologists arrived), which led to a lot of population growth and conflict over areas of land that were good for growing this particular crop. So maybe what the anthropologists were observing was warfare in response to a positive technological shock and the resulting changes in population.

The Central Enga (pp. 217-233).

These people also live in the highlands of New Guinea. The main differences with the Tsembaga Maring are (a) the CE live in the 'highland core', not off on the fringe like the TM; (b) the CE have twice the population density of the TM (85-250 people per sq. mile, which is near the maximum anywhere in highland NG); (c) the CE have permanent sweet potato gardens on prime land; and (d) the CE have "Big Men" who manage alliances for warfare and manage exchange networks for trade.

The environment and economy. The elevation of the CE is 3900-7900 feet above sea level. There is a lot of rain but with seasonal variations (there are sometimes droughts in the winter). At high elevations, the land is good for pigs and hunting but not for farming.

A typical clan has a very small territory (about 1-2 sq. miles) but due to the steepness of the valleys there is quite a bit of ecological diversity within the territory. Agriculture on the valley floors has led to deforestation, leading to loss of wild habitat, so wild foods do not play much role in the diet. Fertilization makes it possible to avoid the fallow periods found in the case of the TM, leading to more output per unit of land than in the TM case.

The main crops are sweet potatoes, yams, and bananas. Trees are cultivated for building material, fencing, and firewood. Pigs are primarily fed cultivated plants. They are very expensive in terms of the food they require but are needed as a source of protein and fat. In general, protein deficiency among the CE seems common.

Social organization. There are no villages. Farms are spread throughout the territory controlled by a clan. As usual there is a tradeoff between clustering together for defence but spreading out for economic reasons. In this case, the economic incentives appear to be important enough to cause dispersal rather than clustering. But as mentioned above, a clan controls a small territory, so maybe they don't really need to live together in a single village in order to have an effective defence against other groups.

Households own land directly. The next largest social unit is a 'clan segment', which is a patrilineal group where the males are close relatives. The mean size is about 33 people, so this is similar to a hamlet in the TM case. A subclan is larger, about 90 people, and is important for political and ceremonial reasons. This seems similar to what J&E called a clan in the case of the TM. The biggest unit is the clan, which has 100-1000 people and an average of about 350. This is similar to what J&E called a 'clan cluster' in the case of the TM.

A clan has a Big Man as a leader. It also owns a territory and restricts access to it. The clan may bring in new members if land is available and more defence is needed. These groups marry partners from other clans, and this is important for the regional system of exchange and alliances. The Big Man has a reputation in political and economic affairs, good public speaking abilities, and some control over wealth and exchange. He also gets multiple wives. It is important for the Big Man to be an entrepreneur and organize bigger exchange networks with more resources. The selection of the leader is based on personal qualities and kin support; candidates for the job may also buy support in competition with other candidates.

[Note: the position of Big Man is not inherited. This is not a stratified society with elites and commoners, or a chief who can coerce other members of the group, although it may seem to be headed in that direction.]

Beyond the clan, we have what J&E call the "intergroup collectivity". In practice anyone outside the clan is potentially hostile.

Warfare. A given group tends to be involved in warfare about every 2-3 years. Unlike the TM, there are no long truces. The population growth rate is important for military strength (having more people makes your group stronger). So in this case, although war does tend to kill people, warfare does not provide a check on population growth. Rather, it provides additional incentives for population growth. There are a number of proximate causes for warfare, but J&E say the ultimate cause is competition for land. The winners in a war take over the land previously owned by the losers.

To see what J&E are talking about, suppose a large clan has a shortage of land. If clan A has a lot of people, it might be militarily strong relative to clan B. However, if A has less land than clan B (or worse land), this creates an incentive for A to attack B, because A is likely to win, and if it does win, it gains a lot. For these kinds of reasons, weak clans may recruit newcomers to help with their defence.

Success in war leads to more land for the clan, more wives for the Big Man, and probably a larger clan size, which adds to the clan's military power. At the same time, a large clan may develop problems with local resource depletion, which may increase its incentive to attack someone else.

Given that there appear to be increasing returns to scale for military power (bigger groups are stronger, win more wars, and get even bigger) an interesting question is why no single Big Man ever gains control over all of the land in the region. J&E say there would be no economic basis for this kind of regional control: there is no food storage, the technology is simple, and trade is broad based. I'm not sure this really answers the question though.

J&E also suggest that in the eastern New Guinea highlands, the arrival of the sweet potato (mentioned earlier in the TM case) led to population growth and high levels of warfare. I think this is an interesting point: maybe the warfare among the CE was at least partly triggered by a technological shock that caused conflict between groups about who would control newly valuable land (some places were better for sweet potato agriculture than others). Again, we may not be observing a long run equilibrium in this case.

Econ 452W

Greg Dow

March 27, 2020

Notes on Dow, Mitchell, and Reed (2017), Journal of Development Economics

"The Economics of Early Warfare Over Land"

These notes are not meant to be a substitute for doing the reading. You should still read the article by Dow, Mitchell, and Reed. As usual with journal articles that contain some math, read all of the verbal sections and try to absorb as much of the math as you can but don't worry if you don't understand it all. I won't ask you to reproduce for all the details on the exam. These notes summarize what I would have said in a lecture on this topic.

1. Introduction

We (and many other people) define war as lethal conflict between organized groups. This is something different from random individual homicide. We are interested in warfare in small-scale societies (foragers or early farmers).

The focus here is on societies where groups are internally egalitarian (they share food among their members and participate equally in decision making). We are not talking about stratified societies with an elite and commoners, although warfare in stratified societies is also an important topic.

We want to explain variations in the intensity of warfare across societies. What other characteristics of a society is it correlated with? Why? A related question is whether warfare has been happening forever, or whether it is a relatively new development in prehistory. If it started relatively recently, what caused it to start?

There are big debates about the relationship of warfare to human nature. Some people argue that all modern humans, as well as all human ancestors, engaged in warfare and it is part of our biological makeup. Others say that there are many examples of peaceful societies, both today and in prehistory, which indicates that environment, technology, population, and institutions help to determine whether warfare occurs. This is a more optimistic view in terms of the possibilities for peace in the modern world.

If we want to explain variations in warfare over time and space, thinking about the issue in biological terms doesn't seem very helpful. Assuming that human genetics is roughly the same around the world and has been roughly the same for about the last 15,000 years, trying to explain warfare by using biological arguments is like trying to explain a variable using a constant. It doesn't get you very far.

Our approach takes economics as a starting point. We focus specifically on warfare over land. We assume that when warfare occurs, it is motivated by the desire for food, and we focus on explaining variations in the amount of warfare. We want to identify theoretical conditions under which war is likely to occur. We have found that it is surprisingly hard to construct models with persistent warfare. In general, repeated wars require repeated shocks to exogenous variables like climate or technology.

According to the theory we present, warfare would have been uncommon among small mobile foraging groups where individuals could move easily from one group to another using kinship connections. It would have been more common among sedentary foragers or early farmers, who had larger communities, stayed in one place, had stronger group identities, and thus stronger social barriers to individual movement across groups.

2. Evidence

Archaeologists mainly look at evidence of war involving skeletal trauma, or the use of defensive structures or locations. There are ambiguities about skeletal evidence: if we observe injuries that probably caused death, did these come from war, or was it just an individual homicide? Mass killings or mass graves provide stronger evidence that war was involved.

We sometimes observe that settlements had fences, walls, or other structures that were probably designed to make an attack difficult. People also sometimes lived at sites that were economically inconvenient like hilltops or on cliffs, but easy to defend. Such finds indicate that people were worried about potential attacks, but not that warfare actually occurred (maybe the potential attackers decided they would fail, and so were deterred).

The earliest widely accepted example of warfare comes from the Nile Valley in modern Sudan, about 13-14 KYA, where there were 59 skeletons in a mass grave and 24 of them had fatal wounds from projectiles. But even this case is controversial! Some people say it was just a cemetery, and a lot of people died from individual homicide over the years.

Ferguson (2013) provides a useful summary of time series data for Europe and the Near East. In the case of Europe, there is almost no evidence of warfare (or any other type of violence) in the Upper Paleolithic, scattered evidence in the Mesolithic, and it becomes common in the Neolithic. In the Near East, there is nothing in the southern Levant for a period of about 10,000 years, starting with the early Natufians at about 15,000 BP and continuing until the first Egyptian state was emerging at about 5000 BP. This is a major counterexample to the idea that warfare has always existed. However, there was quite a bit of warfare in neighboring areas of southwest Asia beginning in the Neolithic.

Evidence from anthropology: as usual, we have the question of whether observations on recent societies apply to those in prehistory. Putting this aside, we can look at the SCCS (Standard Cross Cultural Sample, a data set with evidence on 186 societies studied over the last century or so by anthropologists). We find that warfare is more frequent among sedentary and non-egalitarian foragers than it is among mobile and egalitarian foragers.

Population pressure (the ratio of people to food) is positively correlated with warfare but population density (the ratio of people to land) is not. The best predictor of warfare is a history of natural disasters (but not chronic resource scarcity, which seems to have little effect). Warfare is strongly correlated with segmented societies (those that have strong group identities). We believe our theory is consistent with these patterns.

3. Production and Warfare

There are two sites, A and B. All agents are identical, risk neutral, and maximize their expected food consumption. Each person has one unit of labor time.

The production function for food at site i is

$$Y_i = s_i n_i^{\alpha} \qquad \text{with } 0 < \alpha < 1 \qquad\qquad i = A, B$$

where Y_i is total food output, s_i is the quality of the site, and n_i is the labor input. As usual we assume each site has one unit of land and diminishing returns to labor.

Because the groups are internally egalitarian, we assume food is equally shared within a group. Thus if there is no warfare, an individual at site i gets food consumption equal to the average product of labor (Y_i divided by n_i):

$$y_i = s_i n_i^{\alpha-1}$$

The regional population is $N = n_A + n_B$. For the moment we treat the size of each group and the quality of each site as exogenous (the group sizes will become endogenous in sections 4 and 5, but site qualities will continue to be exogenous).

If there is a war, group A wins with the probability $p_A = n_A/(n_A + n_B) = n_A/N$. In the case of group B, we reverse the A and B subscripts.

This is the simplest possible military technology. It says that the probability of winning a war depends on the relative sizes of the two groups. This seems reasonable in a situation where there are no specialized warriors or weapons. Think of people as fighting with the same weapons they would use for hunting: spears, bows and arrows, and so on.

A war occurs if either of the groups chooses to attack the other. Peace occurs if neither group chooses to attack.

If there is a war and group i wins, this group gets both sites. The losers go away and get zero (this is the utility of being dead, or fleeing into the mountains). The winners spread their population between the two sites to maximize the total food output for their group.

The resulting total food output for the winners (group i) is

$$H(n_i) = \max \{s_A L_A^{\alpha} + s_B L_B^{\alpha} \text{ subject to } L_A \geq 0,\ L_B \geq 0,\ L_A + L_B = n_i\}$$

In order to maximize total food, the winners set the marginal products of labor equal to each other across the two sites. With our particular production function, this implies that the average products of labor will also be equal.

It turns out that we can write the H function in the following form:

$H(n_i) = \phi(s_A, s_B)n_i^{\alpha}$

The resulting food per person for the winners is

$h(n_i) = H(n_i)/n_i = \phi(s_A, s_B)n_i^{\alpha-1}$

The function ϕ here only depends on the ratio of site qualities s_A/s_B, not the individual site qualities separately. In order to simplify notation we often call this ratio $\sigma \equiv s_A/s_B$.

If war occurs, the expected total food for group i is $p_iH(n_i)$ where p_i is the probability of winning. If peace occurs, the total food for group i is $Y_i = s_in_i^{\alpha}$. One can use this to set up a payoff matrix for a game where each group chooses between two strategies: attack or don't attack. The conditions required for an attack to occur in equilibrium are fairly obvious, so I won't go into details about this game here.

The next question is how the outcome of war or peace depends upon the group sizes (n_A, n_B) and the site qualities (s_a, s_B). The results are shown in Figure 1 of the article. For a given ratio $\sigma \equiv s_A/s_B$ on the horizontal axis, there is a war if the population shares along the vertical axis are far away from the point where the average products of the groups are equal. There is peace if the population shares are close to the level at which the average products are equal. The reason is that when we are far from equal AP, one group has a big population advantage over the other, and a high probability of winning a war, which makes their expected food higher if they fight than if they don't. If we are close to equal AP, neither side has a high enough probability of winning, and each group prefers peace as long as the other will not attack.

4. Individual Mobility

I will consider a simple model where at the first stage, individuals are free to move to whichever site they prefer. After this process determines the group sizes, at the second stage each of the groups decides whether or not to attack the other. The version of the model in the published article uses complex assumptions about the cost to an individual of moving from one site to the other, but I'll ignore those issues here.

Imagine that each person chooses the site at which they want to live, taking the location choices of all the other people as given. So essentially this is a Nash equilibrium story. At the second stage the individuals can no longer move, and the groups make decisions using the payoff matrix for the warfare game described in section 3 above.

In equilibrium, all of the following things must be true: the groups at the second stage are in a Nash equilibrium with respect to decisions about whether to attack or not; at the first stage, people correctly anticipate the outcomes at the second stage; and at the first stage no individual wants to change their location, given where everyone else is located.

What we can show is the following. Consider any fixed productivity ratio $\sigma \equiv s_A/s_B$. There is always a unique peaceful equilibrium, in which the sites have equal average products of labor. Each site has some positive population, and the equilibrium is stable (a small change in the initial distribution of population between sites would create dynamics that take us back to the equilibrium).

There are two equilibria resulting in warfare: one has the entire regional population at site A and the other has the entire population at site B. Such equilibria are stable but not very interesting. In each case we have a trivial equilibrium where the entire population attacks an empty site, wins with certainty, and then distributes the regional population N between the two sites to maximize total food output.

In some cases there may be an equilibrium with war that is non-trivial, in the sense that there is a positive number of people at each site. However, any equilibrium of this kind is unstable. A small change in the initial population distribution would lead either to the peace equilibrium, or one of the trivial warfare equilibria.

So in the only interesting equilibrium in this model, the outcome is peace!

And by the way, this equilibrium not only equalizes average products across sites, it also equalizes marginal products, so it is Pareto efficient (total food output is maximized).

Conclusion: when individual migration between groups is unconstrained, we get peace.

Why does this happen? As we have discussed earlier in the course, when there is free mobility across the sites in a region, equilibrium requires that each site have the same food per person (otherwise, people would move from places with low food to places with high food). In order to achieve this result, higher quality sites must have more people.

This creates a positive correlation between site quality and group size, and a correlation of this type makes it unattractive to attack the other group. If you have a big group, you have a high probability of winning a war, but the other site is low quality and you won't gain much if you do win (and there is still a chance you could lose). If you have a small group, your site is poor and the other site is rich, so it would be great to attack if you can win. However, your chance of success is low, so you don't want to try.

5. Malthusian Dynamics

Migration is one way to make the group sizes endogenous. Another way is to think about the long run, and use a Malthusian model of population growth or decline.

The journal article does some complicated things by combining migration issues with Malthusian issues. Here I will keep it simple. Suppose that no one ever moves from one site to the other (this is too costly). Instead the population at each site is determined only by Malthusian forces.

Periods of time are $t = 0, 1, \ldots$ In period t, adults produce food, have kids, and die. In period t+1, their kids become adults and are located at the same site as their parents.

For an individual agent, let ρy be the number of kids who survive to become adults, where y is the agent's food income and $\rho > 0$ is a positive constant. This is the same assumption we made in our inequality article (Dow and Reed, 2013, JPE).

There is a sequence of site qualities (s_A^t, s_B^t) for $t = 0, 1, \ldots$
These site qualities are determined exogenously by nature and technology.

There is also a sequence of group sizes (n_A^t, n_B^t) for $t = 0, 1, \ldots$ and a resulting sequence of total populations $N^t = n_A^t + n_B^t$. The group sizes are endogenous.

Given n_A^t/n_B^t and s_A^t/s_B^t, we can determine whether there is war or peace in period t using the methods from section 3. Once we know this, we can determine the population ratio n_A^{t+1}/n_B^{t+1} for the next period. Then we combine this information with s_A^{t+1}/s_B^{t+1} to find out whether there is war or peace in period t+1 and so on.

The main conclusions from the analysis are as follows:

(a) As long as the productivity ratio s_A/s_B remains constant, there is peace, regardless of whether earlier periods had war or peace.

(b) If there is a big enough shock to s_A/s_B then the group with the poor site attacks the group with the rich site.

(c) A series of wars requires a series of shocks (so it is hard to get persistent warfare).

The intuition for the result (a) is similar to the earlier section. Even though we don't have individual migration between sites, there is a second factor that tends to equalize average products: Malthus. As long as the two groups are similar in their demography (by which I mean the relationships between their food income and their fertility and mortality rates are similar), they will have a similar value of y*. You will recall that this is the level of food income that occurs in the long run when population is in equilibrium. But y* is the average product of labor in this model. Because the average product is equalized in the long run, we get the same positive correlation between the site quality and the group size as before. Better sites have higher populations, so in the long run neither group has any incentive to attack the other.

In this model, wars can still occur as in (b), but they require a shock to the productivities that causes one group to have an incentive to attack the other. Taking the group sizes as given, if nature or technology pushes up the productivity of site A by enough relative to group B, then B has an incentive to attack A. The same is true if the shock pushes down the productivity of site B down far enough.

Keep in mind though that the shock must be biased between the two sites. If climate or technology raises productivity by the same proportion at both sites, this doesn't affect the ratio of site qualities, and no war will occur. But it is not hard to imagine that a climate shock could have different effects on sites having different geographic features, or that a technology shock could provide proportionately larger benefits to one site than the other due to differences in their resource endowments.

The reason for result (c) is that after a war occurs, one group wins, and it spreads out over the territory of the two sites in a way that equalizes average products for the sites. There could be population growth or decline afterward for the region as a whole, but if the ratio of the productivities doesn't change, we continue to have equal AP, and there is no reason for one group to attack the other. A new war would require a new shock.

6. Empirical Implications

The main implications of the formal modeling are as follows.

Open access (free individual migration across sites) leads to peace.

Malthus leads to peace in the long run as long as relative productivities don't change.

Wars tend to be self-limiting in the sense that after you have one, peace is restored, at least until another shock occurs.

All three results arise because in each case there are forces that tend to equalize average products. Therefore better sites have higher populations, which tends to deter attacks.

Shocks can generate a temporary negative correlation between site qualities and group sizes, which can trigger a war when there is no individual mobility.

If you believe archaeological evidence indicates that warfare goes back a long time, you might emphasize the fact that there were large climate shocks in the Pleistocene.

However, our view of the evidence is that there was not much warfare in the Pleistocene. It seems to have become more common in the Holocene, especially with the development of sedentary foraging and agriculture.

Our explanation is that although there were a lot of climate shocks in the Pleistocene, there was also a lot of individual mobility among groups. People would normally marry outside their own group and could switch to another group through kinship connections. There were also Malthusian population dynamics. These two factors probably kept a lid on warfare despite the shocks. Once we had more sedentary societies with larger group sizes and a tendency for people to marry within their own groups, we had stronger group identities and it was less easy for an individual to move from one group to another. Even though we still had Malthusian population dynamics, a shock from climate or technology could now trigger warfare.

We also think our theory is consistent with the anthropological evidence from the SCCS discussed near the end of section 2 of these notes. I will leave it for you to consider why that might be true.

7. Conclusion

We made a lot of assumptions in setting up the model. Altering these assumptions would typically make warfare less likely.

Examples of some factors we ignored:

Even the winners in a war suffer injuries and deaths.
The winners may not get full control over the land of the losers.
Potential attackers may be risk averse.
Potential attackers have opportunity costs like lost food output when preparing for war.
Potential attackers may have kinship ties to the defenders.
Defenders may have advantages like local knowledge, inaccessible locations, or fences.

For all of these reasons, we were stacking the deck in favor of warfare. This makes it even more likely that war was rare among small egalitarian groups in prehistory.

We could add a number of things to the model to make it more complicated, such as:

Fancy utility functions, uncertainty about site qualities, property rights, allowing groups to determine their own size by admitting new members, considering alliances with other groups, investments to improve the quality of a site, local resource depletion problems, and warfare involving raiding rather than permanently taking control of land.

Two things we are especially interested in:

Why did we have 10,000 years of peace in the southern Levant (part of southwest Asia) despite a lot of shocks involving climate, technological change, and so on? One theory is that there was open access throughout this period, and free migration maintained peace. But it is also possible that institutions or culture restrained warfare. For example, local elites may have had ways of shifting commoners from one site to another in response to shocks, so the region was never very far away from equality of average products.

Also we clearly need a model of warfare for stratified societies, not just small egalitarian groups. There is a lot of evidence that stratification and warfare are correlated with each other, with greater inequality tending to be associated with more frequent warfare. We're working on that.

Lecture Notes on Mesopotamian City-States April 1, 2022

Based on chapter 9 from "Economic Prehistory: Six Transitions That Shaped the World"

Gregory K. Dow and Clyde G. Reed, Cambridge University Press, September 2022

The classic list of pristine states includes Mesopotamia, Egypt, the Indus Valley, northern China, Mesoamerica, and the Andes (there are also others, but these have been studied the most).

Mesopotamia is the earliest (about 5200 BP) and involved large city-states (Uruk had at least 25,000 people).

Background information on Mesopotamia (which corresponds to modern Iraq):

The Ubaid period (about 8000-6300 BP). Small agricultural villages (which became bigger over time). In the south, near Tigris and Euphrates rivers, mild stratification. Probably based on elite control over land that was high quality and easy to irrigate.

Elsewhere, probably many open sites where people could do foraging, farming, herding.

Rainfall was important for agriculture in the north, less important in the south.

The Uruk period (about 6300-5100 BP). Substantial population growth in the south. Precise timing of city growth is unclear, but we see Uruk as a full-fledged city-state by 5200 BP, with several smaller city-states in the same region.

Why are these considered to be states? Monumental architecture, four-tier settlement hierarchy, occupational specialization within the elite, colonization of areas in the north, etc.

There was a lot of manufacturing activity in the cities: textiles, pottery, metal working, and stone working. This involved mass production with extensive trade. Each of the cities was surrounded by an agricultural hinterland.

What do we think triggered the process of urbanization and state formation?

1. Climate became increasingly arid across the region starting around 7000-6000 BP.
2. Lower rainfall in the north pushed migrants toward the south.
3. It also lowered the standard of living for people getting their food in the commons.
4. This lowered the wage that had to be paid by elites in the south.
5. Lower wage led to more use of labor on irrigated agricultural land and more land rent.
6. Eventually, the wage became low enough that urban manufacturing become profitable.
7. Urban manufacturing was easier to tax than rural agriculture (trade-off with land rent).
8. Elites collected taxes for private consumption and to supply public goods they liked.

We have a formal economic model that captures these ideas. We also argue that once urban manufacturing began, learning by doing raised its productivity, leading to larger city sizes, etc. Suppose this is the story for Mesopotamia. Would a similar story apply to other pristine states?

In the case of Egypt, the same negative climate shift occurred in north Africa and the Nile Valley at around the same time. We think this caused environmental refugees to move toward the Nile, where some stratification already existed. This led to cities and manufacturing activities around the same time as in Mesopotamia.

The big difference is that Egypt went much more quickly from city-states to one big state for the entire Nile Valley (southern Mesopotamia had autonomous city-states for ≥ 1000 years before a regional conquest). Possibly it was easier to tax agriculture in Egypt, or tighter circumscription played a role.

Note that our environmental shock story is consistent with a long lag (2000 years) between the arrival of agriculture in Egypt and the formation of a pristine state. This is a problem for Allen but not for us.

Autonomous city-states developed in the Indus River valley around 4600 BP and manufacturing was important. Maybe due to a similar negative climate shift, although the timing was different. Some archaeologists suggest urbanization was triggered by lower rainfall, but this is disputed. It does not appear to be a case where warfare was important.

Northern China: early city-states arise around 3900 BP. Timing and location are controversial. Some people say this was triggered by climate shocks and some say it resulted from warfare.

Mesoamerica: again, city-states were important. Some clearly resulted from defensive locations in a context of warfare. Others perhaps due to gradual Malthusian population growth associated with improving agricultural tech, which led to falling commoner wages, stratification, and city-states. Environmental changes? Uncertain.

The Andes: the main examples of pristine city-states seem to be consistent with elite warfare.

We conclude that early states could have arisen through any of three distinct mechanisms:

1. Tech progress, rising pop, endogenous property rights, falling wages, urbanization
2. Elite warfare leading to geographical expansion, often with defensive urbanization
3. Environmental shifts, migration to stratified refuge sites, falling wages, urbanization

In all three mechanisms, we think early cities and early states were closely linked. Theoretically we could have one without the other, but they tended to emerge together. The reason might be:

(a) Any process leading to urbanization tends to stimulate manufacturing, which is easier to tax than agriculture.

(b) Taxation is a more robust fiscal foundation for a state than land rent.

Econ 452W

Greg Dow

April 2, 2020

Robert Allen, "Agriculture and the Origins of the State in Ancient Egypt,"

Explorations in Economic History, 1997

We are now moving to a new topic, the origins of the state. Here is a summary of what I would have said in a lecture on the article by Robert Allen (1997).

The first question is, "What is a state?" An important related question is, "How does a state differ from a chiefdom?" It is common among anthropologists and archaeologists to distinguish four types of society: bands, tribes, chiefdoms, and states. For example this is roughly how Johnson and Earle organize their book on the evolution of human societies, and Diamond uses this classification system in chapter 14 of Guns, Germs, and Steel. I'll come back to this later when discussing Diamond, but for now it is enough to know that the key difference involves group size (bands are the smallest and states are the largest).

To give a few examples: the mobile foraging societies we looked at in the first month of the course were organized into bands. The Yanomamo, the Tsembaga Maring, and the Enga would be classified as tribes. The northwest coast of North America would often be called small-scale chiefdoms, while Hawaii involved larger-scale chiefdoms and finally a state. Clear examples of states are ancient Egypt and the Incan Empire.

A chiefdom normally involves (a) the use of force to seize and hold power; (b) social and economic stratification into elites and commoners; and (c) hereditary social positions. So none of these things is unique to a state.

A political scientist would normally define a state as an organized group with an effective monopoly on the use of force within a geographic territory. An economist might define a state as an organized group with the power to collect taxes within a geographic territory. These definitions suggest that chiefs might not have a monopoly on the use of force, or they might not collect taxes, at least not in the usual sense of that word.

Johnson and Earle use an anthropology definition: a state normally has a division of labor within the elite: there are people specializing in warfare, taxation, public works, religion, etc. This contrasts with a chiefdom, where the elite usually consists of the chief and any closely related family members, but there is no specialization: the chief leads in warfare, performs religious rituals, negotiates trade deals, and so on. Johnson and Earle also say that a state is organized using an administrative hierarchy within the elite, rather than just being based upon kinship; and it often has a multi-ethnic or multi-cultural population.

So as you can see, there is no single definition of the state, and no consensus among social scientists about how you would know one when you see one. The concept is important but messy. Even so, there is wide agreement among archaeologists that some regions of the world had early states: southern Mesopotamia, Egypt, northern China, the Indus river valley, Mesoamerica, the Andes in south America, and so on.

Ancient Egypt is an interesting case. It was not a pristine center for agriculture (recall that agriculture diffused there from southwest Asia). However, it was a pristine state, in the sense that a state evolved in Egypt without influences from nearby pre-existing states. The state arose relatively rapidly after agriculture arrived (not a slow evolution through bands, tribes, and chiefdoms). Finally, the state was quite stable after it formed. Aside from some relatively brief periods of civil war or anarchy, the state remained intact for about 3000 years, until the Roman Empire took over.

I like the Allen article. It is clear, logical, has lots of economic reasoning, and there is no math to get in the way. However, I don't agree with everything and there are some issues that are debatable (which helps make it interesting).

Allen believes that in order for an elite to create a pristine state, it needs two things:

(a) The ability to extract a surplus from farmers.

(b) Geographical circumscription (which prevents farmers from running away to other easily available land).

Here are a few questions to keep in mind. Is agriculture a necessary condition for a state? This seems likely. Although the NW Coast had chiefdoms, it didn't get to the scale and complexity of a state. Is agriculture a sufficient condition for a state? The answer to this is clearly no, because many agricultural societies never developed states. And finally, how can we explain the timing and location of pristine states? What is the causality?

Allen reviews several theories of pristine state formation. I will run through them briefly.

1. The hydraulic theory (Steward, Wittfogel; 1940s and 50s). The idea is that the state was needed to manage irrigation systems. This seemed plausible because many early states arose in river valleys surrounded by semi-arid or desert regions. But at least in the case of Egypt, irrigation was local and small-scale. No reason to think a big state bureaucracy was needed. Archaeologists have come to similar conclusions about most other early states, so this theory is no longer popular.

2. Population growth. Combined with diminishing returns to labor, this lowers the standard of living and pushes people into developing more complex (and maybe more efficient) administrative structures. But the idea of exogenous population pressure doesn't make much sense. Why doesn't population eventually stabilize at an equilibrium level? Anyway, Allen says that Egypt was 'underpopulated' in the period immediately before the state emerged. Not sure exactly what he means by this, but clearly he is not impressed with population pressure arguments.

3. Trade. There was definitely trade between Egypt and southwest Asia (this is probably how agriculture arrived in Egypt), and there was trade along the Nile river valley. After the transition to a state, the state monopolized trade and it was an important revenue source. BUT: lots of places have trade and never develop a state, so this story seems vague and overly general.

4. The ecosystem approach. This story is based on two ideas; (a) the environment is important, and (b) it is complex (many variables). The conclusion reached is that managers are required in order to increase efficiency. This is a social integration theory because it says the state is good for everyone (the theory ignores conflicts between elites and commoners). But while the natural environment is obviously important, this approach is vague and doesn't yield sharp predictions.

5. Circumscription theory (this is what Allen likes).

   First, we start with a simple version that Allen borrows from Carneiro (1970). In this version, there is exogenous population growth. This leads to warfare, which leads to a state. However, a state only emerges if people can't run away because the region is surrounded by deserts, oceans, mountains, etc. In this case, a state can control all of the usable land and extract a surplus from farmers by force.

   [Note: for all of the usual reasons, you should be skeptical about stories based on exogenous population growth.]

   [Another note: there are many examples of warfare where we do not get a state. Clearly something more is necessary. If we added geographical circumscription, would that plus warfare be sufficient?]

   [A third note: a question you may want to think about is whether the Yanomano, the Tsembaga Maring, or the Enga were geographically circumscribed. If so, why didn't they have a state? If not, why didn't people run away from all the warfare?]

   Allen raises a number of related questions about Carneiro's theory. Why was pop growing? Was this due to climate or technology? Also, in the Egyptian case, he thinks population density was low when the state formed, and there was still a lot of available land, which is hard to reconcile with Carneiro's story.

Allen wants a more sophisticated version of circumscription theory that is not vulnerable to these objections. His exogenous variables are technology and geography. A key idea in his theory is *surplus*, so I will start there.

Allen distinguishes two types of surplus.

(a) *Production surplus* (measured in food units). This occurs when farmers produce more food than they consume, and the extra food is used to feed the elite.

(b) *Labor surplus* (measured in time units). This occurs when the total work time of the commoners exceeds the time they put into farming. The extra labor time is used for elite projects such as wars or building pyramids.

Note: you should be careful about the word 'surplus'. Sometimes people define surplus as the amount of food produced by farmers minus what is required for biological subsistence by the farmers. The idea of subsistence is often vaguely defined, and this approach doesn't really explain the actual food consumption of the farmers, which does not always stay constant over time. Allen's definition of production surplus in (a) doesn't have this problem because he is just comparing the output farmers actually produce minus the food they actually consume. In principle, it would be possible to measure this, although the data would not be easy to get.

Allen says a foraging economy did not generate either a production surplus or a labor surplus. I agree with this general statement, but it is important to recognize that foragers probably could have (a) collected more food than they consumed, in order to support an elite of some kind; or (b) reduced their leisure time and worked to build pyramids for an elite after they finished collecting food each day. What I am saying is that technology in most foraging societies was productive enough to make these things possible (recall our discussion early in the course about data indicating the foragers did not work that many hours per day on average). The point is that although it was technologically possible for foragers to create either kind of surplus, in reality they didn't. The question is why not?

I am emphasizing this point because people frequently say things like "foraging does not create a surplus, but agriculture does, and this is why agriculture leads to inequality (or a state, or whatever)". This makes it sound like a purely technological problem about food production. But we need to ask how chiefdoms and states were able to convert potential surpluses into actual surpluses, by decreasing leisure time for the commoners and getting them to hand over some of the food they produced. For some reason this did not occur in mobile foraging societies.

I think the missing piece of the puzzle is that elites need to use a technology of coercion to extract a surplus. This could either be the exclusion technology discussed in the Dow and Reed inequality paper, or the warfare technology discussed in the Dow, Mitchell, and Reed warfare paper (or a technology that is used to tax the commoners). For example, in the Dow and Reed inequality article, inequality arose because the elite was able to obtain land rent by excluding outsiders from valuable sites. Without this exclusion technology, in this model inequality would never have developed, no matter how productive the food technology became.

My point here is that you should not accept the simple idea that a better food production technology somehow magically creates a surplus, and the surplus creates a state. I would say that the state and the surplus arise simultaneously, in situations where an elite already exists and can use coercive methods to squeeze the commoners. It is probably true that a productive food technology is important, but perhaps only in the indirect sense that for

Malthusian reasons, this is what you need in order to get a high population density (as in the Dow and Reed inequality paper).

Now let's get back to Allen's article and see how he deals with these issues.

Allen emphasizes a difference in food technology between foragers and farmers: hunter-gatherer foods were perishable, while agricultural foods (grains like wheat and barley as well as domesticated animals) could be stored for longer periods than one annual cycle.

According to Allen, this created incentives for the elite to extract storable wealth in the form of food, which could be transported to other locations and used to feed specialists, rulers, etc. The result was a production surplus.

Another technological factor was that agricultural production was more seasonal than hunting and gathering. During some periods (like the floods in summer), the farmers weren't doing very much. This meant that the elite could pull them away from leisure without too much opportunity cost, and force them to build pyramids, serve in the army etc. The result was a labor surplus.

Notice that for both kinds of surplus, Allen is assuming that the elite has the power to coerce the commoners and confiscate their food output or their labor time, but he is not spelling out exactly how this was done. He just assumes that when agriculture arrived, there was a strong incentive for the elite to create a state, and they were able to do it.

Allen's story explains why the state arose soon after the arrival of agriculture. This was a big technological shift, and it is not surprising that it led relatively quickly to a big shift in political institutions.

What about the rest of Allen's story (population density, geographical circumscription)? Here are the main steps in his argument.

1. He says that due to low initial population density, land was not very scarce. Farmers may have cultivated more land than the absolute minimum for insurance reasons and for trade. [Note: these are good examples where a production surplus does not involve any exploitation by an elite. According to Allen's definitions, surplus does not always imply exploitation.]

2. The marginal product of labor in foraging was initially quite high, so agriculture had to improve a lot before it was adopted (the diffusion from southwest Asia did not occur immediately).

3. Climate shocks may have been relevant. There were unusually low floods just before initial agriculture (around 5200 BC). So maybe under these conditions, agriculture was a useful way to create storable surpluses to deal with the risks facing hunter-gatherers. The environmental disruptions continued during 4750-3500 BC when the Nile's floods were unusually high (however, he doesn't provide any details about this).

[Note: recent research indicates that the shift to more arid conditions in the Sahara began around 6000 BP, or around 4000 BC. A lot of archaeologists now believe that this drove a large migration of people into the Nile river valley, which may have been related to the formation of the state in Egypt around 3000 BC. So there is an alternative hypothesis to the one Allen presents, where a climate shock indirectly led to pristine state formation.]

4. If population density is high, land is scarce, and landlords can do well by controlling land. They use force to establish ownership, and the market does the rest by generating an equilibrium where land rent is high (if there is a land market) or where wages are low (if there is a labor market). This is similar to ideas in the Dow/Reed inequality paper.

But: if population density was initially low, as Allen claims, then land was abundant, so it wouldn't do the elite much good to control land (it has low value). What the elite or state really wants to do is control people (labor) directly, because this is the valuable resource. If the elite could do this, they could pay commoners less than what the wage would have been in a competitive labor market.

5. The problem with this strategy is that when land is abundant, workers can run away; they are hard to control. In fact, the early state in Upper Egypt (where population density was somewhat higher) had this problem. Farmers migrated away to Lower Egypt, where the population density was lower.

6. But due to the surrounding desert, there was only one way in which farmers could run: along the river valley. The solution for the elite was that the state in Upper Egypt had to conquer Lower Egypt. Once this occurred, geographical circumscription guaranteed that the farmers could not escape from elite control.

7. The state could then impose uniform policies everywhere, including

(a) Direct state control over labor allocation.
(b) Uniform taxation on land, which could not be avoided.
(c) The state was in charge of any settlement of new areas.

The result was not just that the commoners could be paid less than a competitive wage (because the state had a monopsony, it was the only demander for labor). Monopsony implies that you are still free not to supply labor. However, in this case the state had the ability to coerce labor directly. In my view, this was something close to slavery.

This is the Egyptian case. Allen suggests that other cases of pristine state formation may have been different. For example, the Sumerian case (located in southern Mesopotamia) was based upon the formation of cities, rising productivity associated with urbanization, increasing population densities, and so on. He thinks that in this region, people were not trying to escape from exploitation. Instead, they were attracted to cities. This led to the formation of city-states (probably the earliest states in the world). So early states could have developed in more than one way.

Econ 452W

Greg Dow

April 2, 2020

Allen Johnson and Timothy Earle (2000), "The Evolution of Human Societies"

Case study of the Incan Empire

This reading discusses the formation of the Incan Empire. Unlike ancient Egypt, this is not an example of pristine state formation. There were several earlier states in the Andes Mountains of South America. However, archaeologists know quite a bit about the Incan case, and it provides some insights into how states can arise. Note: some people write it as Inca while others write it as Inka. It doesn't matter which way you do it.

The Incan Empire was the largest political structure in the Americas before the arrival of Europeans. It ran from modern Colombia in the north to modern Chile in the south along the Andes mountains (although it also included coastal areas along the Pacific Ocean and rainforest areas east of the mountains). The empire had about 8-14 million people. This is big enough to count as a state by anyone's definition. The empire included a very wide range of cultural groups and ecosystems. It was formed rapidly starting around 1400 AD, and lasted until the Spanish arrived about 1520 AD. From your reading of *Guns, Germs, and Steel*, you will be familiar with Diamond's description of the Spanish conquest (see chapter 3 in GGS).

The first sedentary villages in the region developed around 800 BC (other archaeologists would probably tell the story differently, but I'll just rely on the J&E version). Around 1350 AD, these settlements starting growing rapidly in size, with some individual towns having thousands of people. Simultaneously there was more focus on defense (towns on hilltops, towns with fortifications, etc.). In this period chiefdoms often spanned multiple towns, and could include up to 15,000-20,000 people.

[Note: it would be very interesting to know where all this population growth came from. Migration? Or longer-run Malthusian factors like climate or technology? Unfortunately J&E don't give any clues about this.]

The Inca had to conquer many chiefdoms in order to put the empire together. How did they do it? I'll say more about this later, but there were two main factors.

1. They did not seek to drive people off their land as in the cases of the Yanomamo, the Tsembaga Maring, and the Central Enga. Instead, they engaged in conquest, which meant leaving the existing people in place and collecting taxes from them.

2. They left the existing chiefdoms more or less in place, but imposed a new layer of administrative hierarchy, so they turned the existing chiefs into state bureaucrats.

Environment and economy.

There were three general regions:

1. The coastal desert along the Pacific, which was crossed by many rivers from the mountains down to the ocean. This area tended to have high population density along the river valleys because it was good for irrigated agriculture and marine food resources. A number of earlier states rose and fell in this region.

2. The high sierra. This is the area of hills and valleys up in the Andes mountains. It tended to have a lower population density, with a variety of local groups and chiefdoms. Isolated villages were often surrounded by barren land. This region could be used for mixed farming (domesticated plants included maize, potatoes, and quinoa), with grazing for animals at higher elevations (llamas, alpacas). As mentioned above, this region had strong population growth in the period shortly before the formation of the empire.

3. Tropical rainforest. To the east, the Andes drop off rapidly into the Amazon rain forest. This region does not play much of a role in the story told by J&E.

In the high sierra, capital investments were important. This included irrigation systems, terracing of the land to make it flat enough for farming, draining the land so it would not flood, and so on. There were significant risks of crop failure. There was not much trade beyond local areas, maybe because there were large ecosystem variations within a small radius so most of the gains from trade were local. However, trade might also have been limited due to the insecurity created by warfare among chiefdoms. According to J&E, warfare was caused by population growth and competition over land (similar to their discussion of the Yanomamo, the Tsembaga Maring, and the Central Enga), although again they don't explain the reasons for the population growth.

Social organization (pre-Inca).

This seems to have resembled the local groups (clans) found in the Maring and Enga cases, along with some chiefdoms like in Hawaii, except smaller. The key social unit was called the *ayllu*, which was a kinship and territorial unit like a clan. These were self-sufficient communities with many households. Each *ayllu* was managed by a *curaca*, who was a small chief. Commoners had to work on his lands (apparently always a he), and he managed specialized resources like coca and mining. He probably also managed war and defense, settled disputes, allocated land, and ran ceremonies. This is consistent with the idea that a chiefdom has social stratification between elites and commoners, but does not have specialized roles within the elite.

What did the Inca do?

Politically they were very clever and used the following methods.

1. Unlike previous chiefdoms, they did not expel defeated groups from their land. Instead, they left the commoners in place and made them pay tribute to the state. This helped to finance the further expansion of the state, which could support a larger army. Commoners were also forced to supply labor for state projects.

2. The Inca turned the curaca into local representatives of the empire. Once the word got around that it wasn't that bad working for the Inca, this would have reduced the incentive for local chiefs to resist the empire. So probably the Inca only had to crush a few chiefs once in a while in order to convince the others to cooperate.

3. The Inca also transplanted some colonists into new regions where they had no traditional land claims. This made the colonists dependent on the empire and loyal to it, not to the locals.

4. The state claimed ownership of all land. The deal presented to commoners was "we give you land, you give us labor". Of course in reality the elite captured all the land rent.

5. There was a lot of food storage, both to support state personnel and to provide a degree of insurance against crop failures.

6. The state monopolized coca and mining industries to generate more revenue.

7. Local religions were absorbed into a flexible state religion. You were allowed to believe whatever you liked as long as you agreed that the ruler of the empire was divine.

How did this system differ from big chiefdoms, as in the Hawaiian case? Three things.

First, the system was too big to be based on kinship connections alone. There had to be a state bureaucracy. Second, there had to be specialization of roles within the elite such as warriors, tax collectors, accountants, public works managers, and so on. Third, the state made large public investments in irrigation, roads, canals, and mining.

What were the consequences of the empire? According to J&E, several things.

First, the Incan Empire ended warfare among local communities and chiefdoms. This was a major benefit. Second, the empire clarified property rights to land, so it could be allocated in an orderly way (this is the polite J&E way of describing it; I would say the empire grabbed all the land and monopolized all the land rents). Third, there was more long distance trade, and fourth, there was a better insurance system.

Whenever people discuss early states, there is always a question about whether the state made commoners better off or worse off. Or to put it another way: starting from no state, when a state develops, is that a Pareto improvement? Nobody doubts that the elite gains from having a state, so this is really a question about the welfare of the commoners.

I mentioned earlier that there are two general ways of explaining inequality: integration theory and conflict theory. The same two approaches also apply to explanations for the development of early states.

For *integration theory* the idea is that elites solve social problems in ways that benefit everyone. For example, the elite might manage insurance systems, organize community defense, invest in public works, or facilitate trade. In this point of view, one could argue that early states were a Pareto improvement compared to what was happening before.

For *conflict theory* the idea is that elites gain and maintain power through force. They act in their own self-interest. This may sometimes cause elites to do a few things that happen to benefit the commoners, but mostly the elites gain at the expense of the commoners and they create a state for that purpose. A conflict theorist would not expect an early state to be a Pareto improvement. Instead, she would expect commoners to become worse off.

In the case of the Incan Empire, J&E think commoners were better off with the state than they were before. They base this on evidence for a better diet among commoners, as well as a longer life expectancy for the commoners.

This could be true, but you should keep in mind that it is not necessarily true for all early states. For example, the early Egyptian state probably made the commoners worse off by controlling their labor and making it impossible for them to run away (see Allen, 1997).

Johnson and Earle have a theory of state formation. They say there are two necessary conditions:

(a) There must be a high population density, which creates a need for integrated control to solve social problems; and

(b) There must be opportunities for economic control by the elite, which permits stable financing of the state and supports the ruling class.

To me, point (a) sounds like integration theory and point (b) sounds like conflict theory. So it is hard to classify J&E as being one type of theorist or the other.

An interesting question is whether conditions (a) and (b) together would be sufficient for creation of an early state, or whether some additional conditions would also be necessary. J&E don't say.

Econ 452W

Greg Dow

April 3, 2020

Jared Diamond (1997), "Guns, Germs, and Steel"

Chapter 14, "From Egalitarianism to Kleptocracy"

This chapter gives JD's view on how early states developed. You should now have read the first fourteen chapters in "Guns, Germs, and Steel". On the final exam I will assume you have read all of these chapters, not just the ones I lectured on explicitly.

In chapter 14, JD uses a relatively standard classification system for societies: bands, tribes, chiefdoms, and states. For typical characteristics of each type of society, look at the table in pages 268-269 of Guns, Germs, and Steel, which provides a good overview.

In terms of population scale, bands usually have dozens of people, tribes have hundreds, chiefdoms have thousands, and states have more than 50,000. But be aware that these are arbitrary cutoff points, and what matters more are the institutions of the society.

In terms of institutions, bands and tribes are egalitarian, or approximately so. There are no inherited class distinctions (no elites or commoners). Relatively large tribes may have a "Big Man" who provides leadership and has good organizational skills, but this position is obtained through individual achievement, not by inheritance. The other members of the society can replace a Big Man if his performance is unsatisfactory.

Chiefdoms and states, on the other hand, do have inequality in the sense of inherited class positions. There are elites and commoners (at least; sometimes the class structure is more complex and involves more than two classes, or slavery, etc.). People are born into these groups and you cannot work your way up into a higher class through achievement. Thus inequality is institutionalized and persistent. The elites in chiefdoms and states generally obtain and maintain their power through the use of force.

The big question for chapter 14 is whether JD has a theory of how early states developed. If so, what is it? I think he does have a theory but it is complicated, with several parts.

First, JD surveys several previous theories:

1. <u>Aristotle</u> (ancient Greek philosopher): states are the natural condition of society. [Note: this is not much of a theory. Furthermore, it is empirically false. As we have seen, in prehistory there were many societies that did not have states.]

2. Rousseau (French social philosopher of the 1700s): states arise through a "social contract" among individuals, who see the state as providing benefits to everyone (this is a classic "integration theory" idea).

3. The hydraulic theory. We have seen this before (it is mentioned by Allen, 1997). This is the idea that early states were necessary in order to build and manage large irrigation systems. There are two empirical problems with it. First, the irrigation systems in early states were often local and small-scale, so they didn't require any large state bureaucracy. Second, when large-scale irrigation systems were built, this often happened substantially later than the formation of the state. So, more likely to have been an effect of the state, not the cause of the state.

4. Population density. There is an obvious correlation between population scale and the categories of band, tribe, chiefdom, and state. In fact, this is partly how they are defined. But keep in mind that there is a difference between population scale (the number of people included in some social group) and population density (the number people per unit of land). Theoretically, a social system could have a very large number of total people (very large scale) even if population density is quite low, as long as the system is geographically large enough. Aside from this point, population density could be an important factor in early state formation (Johnson and Earle think it is), but in the long run population is endogenous, so we need to explain what causes the rising population density.

JD's own argument assumes there is agriculture. He knows about the sedentary foraging societies of the Northwest Coast, but since only agricultural societies developed pristine states, he wants to focus on societies of this kind.

JD says there is a dynamic interaction where two things are happening simultaneously:

(a) High population causes social complexity.

(b) Social complexity causes high population.

The first causal channel in (a) involves the idea that agricultural technology generally has certain characteristics: seasonality, storage, and sedentism. In more or less the same way as Allen's article about early Egypt, JD thinks that seasonality makes it possible for elites to redirect the labor of commoners to activities other than agriculture; that storage makes it possible for elites to accumulate wealth; and that sedentism makes it more difficult for commoners to move somewhere else.

[Note: I find this confusing. Although JD is emphasizing the role of high population in point (a), the arguments he gives are based on characteristics of agricultural technology, not the effects of high population. Maybe what he has in mind is that improvements in technology lead to higher population density for Malthusian reasons, which then causes "complexity". Unfortunately, he doesn't spell out the causal relationships very clearly, and his concept of social complexity is quite vague.]

The second causal channel in (b) is based on the idea that social complexity in the form of public works projects, trade, and specialization makes it possible to support a larger population. Again he doesn't spell it out clearly, but I think this is based on a Malthusian idea that these sorts of activities raise productivity and therefore raise population density in the long run.

JD thinks the combination of (a) and (b) causes a society to have both rising population and rising social complexity over time. This is a bit similar to the way in which Kremer (1993) had an interaction between productivity and population that caused both variables to grow, except here JD is replacing 'productivity' by 'social complexity'.

At this stage in the argument, it is a little hard to say whether JD is an integration theorist or a conflict theorist. Point (a) sounds like conflict theory (elites exploit their dominant position over commoners), while point (b) sounds like integration theory (elites do things that raise productivity, therefore causing population to grow). However, as you will see below, there are other parts of JD's theory where conflict becomes much more important than integration.

The next step in the argument is a discussion about why large societies require central authority. He makes four points:

1. Conflicts between strangers are more common in larger societies. Because such conflicts are no longer restrained by kinship, a central authority has to keep order.

2. Communal decision-making is impractical or impossible with many agents.

3. There is an economic need for central allocation of goods.

4. There are spatial factors: high population density means that it is not practical to have many small autonomous groups. However, he doesn't really spell this out.

Point 3 seems strange to me as an economist. Hasn't he ever heard of markets? Markets allocate goods all the time without requiring a central authority, except possibly one who ensures order and guarantees property rights.

I think the key point is the first one. Large societies have greater internal conflict, so a central authority is required to maintain public order. If you are an integration theorist, you can interpret this as an elite that provides a public good (everyone is better off with less theft, less violence, reliable procedures for resolving disputes, and so on).

An obvious question here: if having a large society causes so many problems, why don't societies avoid these problems by remaining small? I think the answer JD would give is to go back to causal relationships (a) and (b) earlier, and say that those mechanisms make population grow, so eventually we will run into problems 1-4 above. Societies that find a way of solving these problems with survive and thrive, while others will fail or collapse.

One potentially big reason for having a central authority that JD does not include on his list is the need to avoid the overuse and depletion of vital natural resources. We will see, for example, that resource depletion was a huge problem for Easter Island, and eventually led to social collapse there. We have also seen discussions of local resource depletion in connection with warfare among the Yanomamo, the Maring, and the Enga. Preventing depletion of natural resources may require some kind of coercion by a central authority, and it is likely to be a bigger problem at higher population densities, especially when the resources are relatively fragile. For these reasons, I am surprised JD does not mention it.

In any case, suppose a central authority emerges for one or more of the reasons discussed above. JD emphasizes that centralized power creates an opportunity to exploit leadership positions for personal gain. This is what he means when he uses the word "kleptocracy" in the title of the chapter (this word literally means "rule by thieves"). The authorities may maintain order, but at the same time they may use their power to divert resources for themselves, their families, and their friends. This is the "conflict theory" part of his story.

[Note: JD doesn't clearly say whether the individual members of society understand that the central authority will abuse its position to some degree, but believe the benefits from having a central authority outweigh the costs of corruption; or whether they don't foresee the full costs from abuse and corruption until after it's is too late to do anything about it. In the former case you might think that having a state still provides net benefits to the commoners, while in the latter case you might not.]

{Also note: JD often talks as if the creation of central authority is something most people would want, because the authority is "needed" to solve an important social problem. He doesn't seem to consider the possibility that an elite simply seizes power through the use of force.]

Another part of JD's theory involves competition among societies. The better-organized societies have superior technology, higher populations, more military power, and so on. This enables them to crush their rivals and take away their resources. The central factor driving this part of JD's theory is warfare. As population density grows, warfare tends to shift from raiding (stealing wealth or kidnapping people) to displacement (pushing other people off their land) to conquest (getting rid of the rival elite, leaving commoners on the land, and taxing them). Larger societies that form through the amalgamation of smaller units must be able to solve the problems that come with larger size, or they will fail and lose out to more effective competitors.

So in this sense it would be fair to say that JD really is a conflict theorist. He emphasizes conflict within a society (central authorities are self-interested), as well as conflict across societies (warfare determines who are the winners and losers).

At this point I will stop describing JD's theory and make a few comments of my own.

I agree with JD that warfare may have played a large role in the formation of early states. We certainly saw how that could work in the case of the Incan Empire, and similar things happened in Hawaii, which some archaeologists argue had become a pristine state by the time Europeans arrived. There are numerous reputable archaeologists who think warfare among rival chiefdoms was the key mechanism leading to the creation of pristine states.

However, there are other theories. When Allen talks about ancient Egypt, he doesn't say much about warfare (except for the fact that Upper Egypt had to conquer Lower Egypt in order to prevent the commoners from running away). Allen's main exogenous variables are geography and technology, not warfare.

Allen also briefly mentions the city-states of southern Mesopotamia, which arose shortly before the first state in Egypt. The evidence for southern Mesopotamia indicates that the city-states did not arise through warfare. Rather, warfare developed later, after the cities had already existed for several centuries. I think the most likely story in this case is: (a) climate change led to reduced rainfall throughout the region; (b) this made it difficult for farmers in northern Mesopotamia to rely on rainfall-based agriculture; (c) this caused a large migration of people toward southern Mesopotamia where agriculture was based on irrigation using river water; (d) there were pre-existing elites in southern Mesopotamia who controlled the best irrigated land; (e) the negative climate shock and migration led to lower wages for commoners, which made it profitable for elites to expand manufacturing activities (textiles, metallurgy, pottery) in the cities; (f) the large scale of the cities led to the formation of states, in the sense that elites could easily collect taxes on manufacturing (where previously they had been mostly dependent on land rent from rural agriculture).

From an economic point of view, we have a state if an organized elite can collect taxes from the people who live in the geographic area controlled by the elite. This is normally easiest when a lot of people are packed into a small area with a high population density, and they are engaged in economic activities that are easy for the elites to monitor. For this reason, urbanization tended to be closely related to the formation of pristine states. But cities can form for various reasons (migration caused by climate change, refugees fleeing from warfare, economic benefits from urbanization, etc.).

I do tend to believe that elites were self-interested, and that when early states taxed the commoners they were doing it (a) to increase their personal consumption or (b) to finance projects beneficial to the elite (or both). I don't think early states were created in order to provide public goods for commoners, although occasionally elite activities may have had this effect (by ensuring public order, the construction of roads, and so on).

Early states were not anything like modern democracies. Today, in some countries, the majority of the population has a significant amount of influence over the political system (through freedom of speech, freedom to organize, regular elections, and so on). In some countries, there is also an independent judicial system that resolves conflicts and helps to maintain order. But it took many centuries (in fact millennia) to get from the institutions found in pristine states to the institutions in modern democracies. How this happened is a very interesting question, but not something we can address in this course.

Econ 452W

Greg Dow

April 5, 2020

Jared Diamond (2005), "Collapse"

Case Study of Easter Island

Note: this chapter is not from "Guns, Germs, and Steel". It is taken from a different book called "Collapse", which is about how societies in various times and places have failed to function properly in the face of challenges. Diamond's chapter gives useful background before we discuss the economic analysis of Easter Island by Brander and Taylor.

How does this topic fit into the rest of the course? People often talk as if societies have evolved in a straight line from foraging bands to tribes, chiefdoms, and states. But some societies (perhaps many) have not followed this path. They get stuck, they skip stages, they go backwards, etc.

We also want to avoid any assumption that movement from one of these "stages" to the next represents some kind of "progress". Keep in mind that chiefdoms and states often have a lot of warfare, inequality, oppression, and other bad things.

Easter Island is a case of a society that went completely off the rails into collapse. So it is an antidote to the notion that progress or increasing complexity is somehow inevitable (or that every society is Pareto efficient!).

The specific problem with Easter Island was resource depletion. This topic has come up from time to time in the course (for example, in the Johnson and Earle warfare readings). But I wanted to wrap up the course by talking about it directly.

Many people (including Jared Diamond) think there are important lessons from Easter Island for the modern world. We should evaluate this claim. Are there parallels? If so, what are they? Are there reasons to believe that modern society will not follow the path of Easter Island? And so on.

Let's start with a chronology of events from archaeology. Jared Diamond doesn't do this systematically, but I am relying on the dates given in his chapter. All dates are AD.

Early stage.

800-900 Initial settlement by people for eastern Polynesia using large canoes. Some writers suggest earlier dates, but JD thinks these are unlikely.

800-1300 Farmers remain in the lowlands close to the coast. This had several advantages, including fresh water, shellfish, and other fishing.

1300 Rock gardens are established further inland and at higher elevations. There are scattered elite houses in the interior.

1000-1600 Period for building *ahu* and *moai* (see explanation below). Peak years of construction were 1300-1600.

Environmental trouble.

1400-1500 Beginning of deforestation (probably complete by 1600). This led to soil erosion.

1500 Deep-sea food disappears from the diet. Land birds also disappear. Sea birds drop severely.

Social collapse.

1600-1680 Upland plantations abandoned.

1620 Last ahu and moai constructed.

≥ 1650 People are burning crop waste for fuel (instead of wood).

≥ 1700 Major population crash, house sites down 70% from peak in 1400-1600.

Outside contact.

1722 First known European contact (Dutch).
1770 More contact (Spanish).
1774 Even more contact (English).

1836 Smallpox epidemic.

1838-1868 Last statues (moai) torn down.

1862-63 Peruvian slave ships kidnap half the population.

1872 111 people left on Easter Island.

This is the history we want to explain. First, I provide more background information.

1. Easter Island is extremely isolated (in the eastern Pacific off the coast of Chile). It was a 17-day voyage by canoe from the closest inhabited Polynesian islands. Probably no repeated migrations.

2. It was definitely settled by Polynesians from further west. This is no longer a matter of debate (it was not settled by people from South America).

3. The island is small (66 square miles) and mostly low elevation (max 1670 feet above sea level), with gentle terrain.

4. The climate is subtropical (27 degrees south of the equator). Not as tropical as most other Polynesian islands. It can be windy and cold.

5. Good fertile soil (resulting from volcanic eruptions in the past).

6. Crops brought by the settlers include bananas, taro, sweet potato, sugar cane, and paper mulberry. They also had chickens, and unintentionally brought rats.

7. Several limitations of the island from the standpoint of natural resources:
   (a) too far south for coconuts
   (b) no coral reef for fishing
   (c) less fish diversity than most Polynesian islands
   (d) no land mammals
   (e) rainfall was 50 inches per year, low by Polynesian standards
   (f) limited supplies of fresh water

An interesting question is what motivated the original exploration and settlement. This was part of a wave of Polynesian expansion and it came toward the end of that process. Given how distant EI was from the rest of Polynesia, was there some other explanation, such as conflict or warfare? JD doesn't say, and probably no one really knows.

<u>Monumental architecture</u>. Easter Island is famous for having stone statues. There were large stone platforms called *ahu*, which were topped by large statues called *moai*. Such monuments had traditional roots in Polynesian culture, but were especially huge on EI.

Hundreds of statues and platforms were carved out of volcanic rock. This would have required a lot of labor, plus food to support the workers, plus timber, plus ropes (see the additional discussion of this production process below).

A puzzle: when the Europeans arrived, the population was very small, the island had no trees, and the people seemed to have poor technology. So how were the statues carved, moved, and erected? This question has led to a lot of ridiculous speculation, such as it was done by the Incans, the ancient Egyptians, or aliens from outer space.

The only reasonable answer (supported by a very large amount of evidence) is that
(a) Previously the population was much larger; and
(b) Previously Easter Island had many trees.
Under these conditions, the labor and raw materials required to construct the statues would have been available.

This immediately suggests that some kind of ecological and social disaster must have occurred. How did it happen? Before we get to that, here is more background info.

Population history. Initially the population was very low (well below carrying capacity, given the available resources and technology). It rose to a peak of about 15,000 people. This is based on evidence about housing sites, plus the known history around the time of contact, plus estimates of the effects from diseases, etc. The exact number is not known and the issue is controversial, with estimates ranging from 6000 to 30,000.

JD says the population had crashed to about 2000 by 1864. Note that this is just after a smallpox epidemic caused by contact with Europeans (if you have been reading Guns, Germs, and Steel, you will not be surprised by this). There is also archaeological data indicating a steep crash earlier, during 1600-1700, before European contact.

Social organization. At the time of peak population, there were about 12 clans having distinct territories. Assuming 15,000 is a reasonable estimate for total population, this means a little over 1200 people per clan on average. [Note: this is on the big side for what anthropologists would normally call a clan. It might reflect 3-4 clans clustered together and sharing a territory, or maybe small chiefdoms.]

Inequality. There were elites and commoners (this was widespread in Polynesia). The chiefs and other members of the elite had large houses immediately inland from the ahu and moai, which were along the coast. The commoners usually lived further inland, and had chicken houses, ovens, gardens, and garbage pits. The coastal locations were better, so the elite had the most desirable real estate.

The clans had wedged-shaped territories running from inland down to the coast. There was rivalry among clans (probably competition in building statues, and definitely later in the form of warfare). However, clans needed to trade with each other due to the uneven distribution of natural resources. Probably outsiders needed permission in order to enter the territory of another clan. No one knows whether there was any political structure for the island as a whole. The statues probably represented the high-ranking ancestors of the elite occupying a particular territory, and were probably related to ownership claims over the territory. Note that the statues look inland over the clan territory, not out to sea.

Why did Easter Island go so far in the direction of monumental architecture? JD offers several theories: (a) the island had uniquely good raw materials for carving stone; (b) it was isolated so there was nothing else to do; (c) the gentle terrain made it relatively easy to move heavy stone around; and (d) there were food surpluses. I think (a) and (c) make sense. Theory (b) seems like nonsense; if I were bored, I would rather sit around a fire and sing songs, not do hard labor building statues. Theory (d) doesn't make sense; why would Easter Island, with its relatively poor resources, have bigger food surpluses than other Polynesian islands?

How did they build, move, and set up the statues? Not a big mystery. It could be done using wooden tracks and hauling statues (and platforms) with ropes. This would require a group of 50-500 people. If a clan has about 1000-2000 people, it is feasible. JD cites estimates that these projects probably added about 25% to food requirements during the peak construction years.

Natural environment. When the first people arrived, EI was covered by a subtropical forest with tall trees. In fact, it had the biggest palm tree in the world, with a trunk diameter of 7 feet! A close relative of this tree in Chile is used for its sap (wine, honey, sugar); nuts (good food); fronds (to make houses, baskets, mats, and sails for boats); and the trunk (timber, transport, rafts, canoes).

Several other extinct trees also existed, including two other tall species that are used elsewhere to make canoes. Further trees provided raw materials for cloth, harpoons, carving, and firewood. Some had edible fruit.

In the early stage there were a lot of native land birds plus many nesting sea birds. This was one of the best breeding sites for sea birds in the Pacific, due to its isolation and the absence of predators (until humans showed up).

While the islanders still had deep-sea canoes and rafts, they ate dolphin, tuna, other fish, and maybe seals, sea turtles, and lizards.

BUT: once you lose the trees, you can't go fishing offshore. The land birds were wiped out by overhunting, deforestation, and predation by rats. The loss of trees also meant a loss of edible fruit. So the foraging opportunities disappeared.

Agricultural productivity began to fall due to soil erosion, desiccation (drying out of the soil), and loss of nutrients. This led to greater use of chicken houses, as people tried to find substitutes for their crops. There weren't many options left.

The eventual result was warfare, social collapse, and a population crash. It is a sad story.

I should mention that there is a minority point of view on all of this. Some people argue that Easter Island was settled later than JD believes, that a population crash didn't occur until after European contact, and that deforestation was caused by rats, not humans, or by some natural climate shock. One sometimes hears that the islanders would not have had any reason to destroy their own environment, so something else must have done it.

I think JD is closer to the truth on this. Yes, it is possible that there was some historically unknown case of European contact before 1722 (the Spanish were sailing back and forth across the Pacific in the 1500s). So in principle one could imagine that European germs were responsible for a big population crash at an earlier date, although there seems to be no evidence for this idea. It is also hard to see how earlier European contact can explain the massive deforestation of the island. As for climate stories, there have been numerous earlier climate shocks that did not destroy the island's ecosystem, and there is no specific evidence of a climate shock around the time that the deforestation occurred. So I think we have to accept that human beings are capable of destroying their environment, and this includes the people of Easter Island.

JD talks about some interesting research on the conditions that have made deforestation more severe on some Polynesian islands than others. The factors leading to more loss of trees include

dryness
colder temperatures (further from the equator)
older volcanic islands
no aerial ash fallout from other volcanic islands
large distances from the Central Asian dust plume
places without makatea (a nasty form of coral that is hard to walk on)
lower elevation
remoteness
small size of the island

These conditions involve climate, soil fertility, and geography. Easter Island had most of the factors on this list. So it was a very fragile environment. Once the trees were gone, it was impossible to build canoes, so there was no escape (Easter Island is an extreme case of geographical circumscription).

JD says that the similarities between Easter Island and the modern world are "chillingly obvious". Are they? How?

Before we get to this, we should try to understand the economic model of Easter Island constructed by Brander and Taylor. I'll send some notes on that article in a few days.

Econ 452W

Greg Dow

April 7, 2020

James Brander and Scott Taylor, "The Simple Economics of Easter Island"

American Economic Review, 1998

James Brander is a professor at the Sauder School of Business at the University of British Columbia. Scott Taylor is a professor of economics at the University of Calgary.

First I will describe their formal model. I can't discuss every feature of the model but I will survey the main points.

After that, I will talk about how the model could be used to explain the social collapse on Easter Island, and applications to other examples from prehistory. Finally, I return to the question raised by Jared Diamond: does Easter Island offer lessons for the modern world?

The model.

Let S(t) be the stock of a natural resource at time t. This could be interpreted in various ways (soil quality, land birds, etc.). I will think of it as the number of trees on the island.

BT use a differential equation to describe how the stock changes over time. This is

$dS/dt = rS(1 - S/K) - H$

The left hand side is the (absolute) rate of change in the stock with respect to time. On the right hand side, $r > 0$ is a positive constant, S is the current level of the stock, $K > 0$ is the carrying capacity, and H is the rate at which humans use the resource for food. If you ignore H, you will see that this is identical to the population growth equation used in the article by Richerson, Boyd, and Bettinger (2001) discussed earlier in the course.

To interpret this equation, suppose humans are absent ($H = 0$), and the initial stock S is at a low positive level (far below K). In this situation, the relative or percentage growth rate of the stock is r. For example, this may be 4% per year. As S rises, the fraction S/K gets closer to 1 and the growth rate declines. When $S = K$, we are at the carrying capacity, the growth rate is zero, and we have an equilibrium because $dS/dt = 0$. Human harvesting ($H > 0$) reduces the growth rate for the stock of trees at any given level of S.

The authors write the human population as L, which is also total labor supply. They use the standard assumption that each person has one unit of labor time.

There are two goods: food (H) and "other goods" (M). You can think of M as being manufactured or craft goods. For example, people might pick up pieces of driftwood on the beach and carve them into attractive artworks that can be sold to the other people on the island.

L_H is the total labor used to obtain food by chopping down trees.
L_M is the total labor used to produce other (manufactured) goods.

There is a constraint where $L_H + L_M = L$ (labor has to add up to the total supply).

The production function for food is $H = \alpha S L_H$ where $\alpha > 0$ is a constant describing the productivity of converting trees into food. They are multiplying the stock S by the labor input L_H so output depends both on the level of the natural resource (it is easier to obtain food when there are lots of trees) and the labor time people put into getting food. Notice that this function has a Cobb-Douglas form where the exponents are equal to one.

There are prices p_H for food output and p_M for manufactured output. There is also a wage rate w for labor. The individual islanders treat these are competitive prices (each person is a price taker for both goods as well as for labor time).

The authors assume the market for each good has free entry and exit in the long run, so there is zero profit in equilibrium. In the case of food, the zero profit condition implies

profit in the food market = $p_H(\alpha S L_H) - wL_H = 0$. This reduces to $p_H = w/\alpha S$.

The production function for the other goods is $M = L_M$. This is the simplest production function you will ever see. It says that the quantity of output is equal to the quantity of the labor input. This is why I was saying earlier that people can get the raw materials for free by walking on the beach.

Again we have a zero profit condition in equilibrium due to free entry and exit:

profit in the market for manufactured goods = $p_M M - wL_M = 0$, or simply $p_M = w$.

Note: the authors simplify notation by setting $p_M = 1$ (the price of manufactured goods is always equal to one). Then they drop the subscript H on the price of food so this price is written simply as p. This doesn't affect anything important in the model.

Next, consider preferences. The demand for goods comes from the utility function of a typical individual (everyone has identical preferences). The utility function is

$u = h^{\beta} m^{1-\beta}$ h is the consumption of food by an individual ($h = H/L$)
m is the consumption of manufactured goods by an individual ($m = M/L$)
$0 < \beta < 1$ where β is a fixed constant describing how much weight an individual consumer places on food relative to manufactured goods.

The utility function also has a Cobb-Douglas form. This utility function is maximized subject to the budget constraint

$ph + m = w$

where p is the price of food, h is the quantity of food an individual person consumes, the price of manufactured goods has been set equal to one, m is the quantity of manufactured goods an individual person consumes, and w is the individual's income (the wage they get from selling their one unit of time on the labor market).

I assume you all know how to use Lagrange multipliers to maximize utility subject to the budget constraint. If you don't, just solve the budget constraint for m, plug this into the utility function, and then maximize utility with respect to the single variable h, treating the prices and β as constants. This gives the demand functions

$h = \beta w/p$ and $m = (1-\beta)w$

These are standard demand functions for a Cobb-Douglas utility function (remembering that the price of m is equal to one, so you don't see this price in the denominator for m).

To get the aggregate demand for food, we multiply h by the number of people L:

$H = hL = \beta wL/p$ or $H = \alpha\beta LS$

The second of these equation is obtained by substituting $p = w/\alpha S$ from the zero profit condition for food (recall that we have dropped the H subscript from p_H).

We can substitute $H = \alpha\beta LS$ into the differential equation for dS/dt to obtain

$dS/dt = rS(1 - S/K) - \alpha\beta LS$

This shows how the rate of growth for trees depends upon two endogenous variables (the current stock of trees S and the current stock of people L), along with the constants r, K, α, and β.

Now the authors need a second differential equation to describe the human population. They use the following:

$dL/dt = L(b - d + \phi\alpha\beta S)$

where $b > 0$ is the birth rate, $d > 0$ is the death rate, and $\phi > 0$ is a positive constant that relates food to population growth. To see what is going on, notice that $\phi\alpha\beta S = \phi H/L = \phi h$ so the last term is the parentheses is just a positive constant times food per person.

This is the Malthusian part of their model: treating b and d as fixed, the equation says that as food per capita (h) goes up, the rate of population growth dL/dt also goes up.

They assume that b - d (birth rate minus death rate) is negative. This says that you need a positive amount of food in order for population to increase; if food per person h was zero, the population would decrease (seems like a reasonable assumption).

The rest of the model studies the interactions between the two equations for S(t) and L(t).

Steady states. We could get dS/dt = 0 by having S = 0 but this is trivial (no trees, so the growth rate for trees is zero). The only non-trivial way to get dS/dt = 0 is by having

$$r(1 - S/K) - \alpha\beta L = 0.$$

Similarly, we could get dL/dt - 0 by having L = 0 but this is trivial (no humans, so the growth rate for humans is zero). The only non-trivial way to get dL/dt = 0 is by having

$$b - d + \phi\alpha\beta S = 0.$$

The second of these equations only involves the stock of trees (not L), so we have

$$S^* = (d - b)/\phi\alpha\beta \qquad > 0$$

This is the equilibrium stock of trees. Plugging this into the other steady state condition, we can solve for the equilibrium human population:

$$L^* = (r/\alpha\beta)[1 - (d-b)/\phi\alpha\beta K]$$

So now we have solved for the equilibrium levels of the two endogenous variables (stock of trees and stock of humans), as functions of the exogenous parameters.

You can do comparative statics to see how the equilibrium depends on the parameters:

S* rises if d rises, b falls, or ϕ falls. These have fairly obvious interpretations: the stock of trees is higher if humans have a higher death rate, a lower birth rate, or reproduce less rapidly at any given level of food. S* falls if α rises (the harvesting technology becomes more productive) or β rises (humans have a stronger preference for chopping down trees compared to collecting driftwood on the beach).

L* rises if r rises (humans reproduce more quickly) or K rises (the environment has a higher carrying capacity for trees). The responses of L* to changes in the Greek letters are slightly more complicated and I won't go through them here.

These results are interesting, but what we really care about are the dynamic paths for S(t) and L(t). Brander and Taylor show that the steady state (L*, S*) is stable, so the system will converge to it from any starting point (L^0, S^0).

There are two ways in which this convergence may occur: monotonic and spiral. In the case of monotonic convergence, starting from (L^0, S^0) each of the variables L(t) and S(t) either always increases or always decreases as they approach (L*, S*). You can think of this as a 'direct' approach to the equilibrium point.

In the case of spiral convergence, the system circles around the equilibrium point while approaching it, where the circles become smaller and smaller. This case is illustrated in Figure 1 (see the end of this document).

You don't need to know why this is true but it turns out that we get spiral convergence if

$r(d-b)/\phi\alpha\beta K + 4(d - b - \phi\alpha\beta K) < 0$

Otherwise, we get monotonic convergence. A few observations: the first term is always positive because $d > b$. So the only way the left hand side can be negative is if the second term is negative. This requires $\phi\alpha\beta K$ to be big enough. As this expression becomes big, the first term approaches zero and the second term becomes both negative and big, so the requirement for spiral convergence will be satisfied.

This implies that spiral convergence is most likely when ϕ is large (population growth is highly responsive to food per person), α is large (the technology for chopping down trees is very effective), β is large (people have a strong preference for food relative to other goods), and K is large (the environment has a high carrying capacity for trees, so the tree population would be big in the absence of humans). Another factor contributing to spiral convergence is a low value of r (trees don't reproduce very rapidly), because this makes the first term small.

An application to Easter Island.

The dates given by Brander and Taylor do not match the dates given by Jared Diamond in his book "Collapse" (2005). BT assume initial settlement occurred around 400 AD while JD says 800-900. BT say there was noticeable forest reduction by 900 and the forest was gone by 1400. JD says the forest was gone by 1600. BT say the peak human population was about 10,000, while JD says it was 15,000. BT say the collapse began around 1500, while JD says the 1600s.

You have to get used to these kinds of disagreements if you are an economist who does research on prehistory. In general, I would place more weight on the JD data because his book was published in 2005 while the BT article was published in 1998, so JD had access to more recent archaeological research. But I would advise you not to worry much about the exact numerical dates and population levels. BT are making a general point about the qualitative dynamics of the situation. In particular, they are interested in the implications of spiral convergence. Their model is still useful even if they are a bit off on the timing.

BT simulate their model using numerical values for the parameters. Their original model used continuous time, so now they are switching over to discrete time where the length of a period is 10 years. They measure the natural resource in the same units as people (this is convenient and it doesn't affect anything), so they set the carrying capacity K = 10,000 at the same level as their estimate for the peak human population.

To get a numerical value for α, they assume that when S = K (the highest possible stock of the natural resource), the human population can reproduce itself using just 20% of the available labor time.

To get a numerical value for β, they assume that 40% of the labor force is used to obtain food, while the rest is used to produce the manufactured good.

They set r = 4% per decade (this is the growth rate of trees when S well below carrying capacity); b-d = -0.1 (the human population falls at 10% per decade with no trees); and ϕ = 4 (so the human population grows if the stock of trees is more than half of the carrying capacity K). They assume the initial human population is 40 (small but reasonable).

With these values, there is not much population growth for the first 300 years. But then growth accelerates rapidly and the resource stock S falls for the next 800 years. The peak human population of 10,000 occurs around 900 years after initial settlement. The stock of trees hits bottom about 250 years after the peak human population. This is illustrated in Figure 2 (again see the end of this document), using dates from the BT article.

The points A, B, and C in Figure 2 correspond to points A, B, and C in Figure 1. Point A shows the starting point at the time of initial settlement; point B shows the maximum for the human population; and point C shows the minimum for the resource stock. Note that the human population overshoots its long run equilibrium level and then it crashes due to spiral convergence. In the model (unlike the real world) the population would eventually start to recover, and the system would go through many cycles of decreasing size.

Why was Easter Island different from other Polynesian islands according to Brander and Taylor? They think the main problem was that the big palm tree (discussed by Diamond in his chapter) was very slow growing. It took about 40-60 years for this tree species to achieve maturity, compared to 7-10 years for large trees on other islands. In a footnote, they also say that EI was an outlier on rainfall and temperature. This is consistent with the arguments JD makes about the factors likely to cause deforestation.

They vary the parameter values in their simulations to see what happens. It turns out that a higher growth rate for trees prevents the overshooting of the human population. Instead the human population rises to a plateau and stays there while the tree population falls to a plateau and stays there. Thus we get something close to monotonic convergence.

Other applications. Brander and Taylor give other examples from prehistory where they think the population overshot the long run equilibrium, leading to resource depletion and a population crash. These include

1. The Mayan empire (located in Mesoamerica)
2. Empires in Mesopotamia (the issue here was severe loss of agricultural land due to irrigation methods that increased the salt content of the soil)
3. The Anasazi (a Native American society located in the modern southwest U.S.)

In general, they also think resource depletion has frequently led to warfare.

Institutional adaptations.

You may be wondering why the BT model leads to disastrous consequences even though they are assuming all markets are perfectly competitive. Didn't we learn somewhere that perfect competition leads to a Pareto efficient allocation of resources?

This puzzle can be resolved that recognizing that there is one big market failure in their model: there is no price for trees. The model has open access to trees, which serve as an important input for the production of food. Because there are no property rights to trees, and no price for using them, this input is treated as if it is free (zero price). So the use of trees is limited only by the harvesting technology. The model would look very different if people owned trees and users of this input had to pay for them. In that case increasing scarcity of trees would lead to a rising price and stronger incentives to limit harvesting.

BT discuss work by Elinor Ostrom (a Nobel prize winner in economics) on institutions that can be used to regulate common pool resources. The trees on Easter Island provide a great example of a CPR. Ostrom's research suggests that efficient institutions to manage CPRs are most likely to evolve when the following conditions are met:

(a) A good understanding of the problem
(b) Uniformity or similarity among the users of the resource
(c) People put a high value on the future relative to the present
(d) Enforcement costs are relatively low
(e) Initial trust or a sense of community is relatively high

But on Easter Island, these conditions were probably not met:

(a) There was probably little understanding of the problem in the early stages.
(b) There was substantial inequality among elites and commoners.
(c) People may not have put much value on the future because the trees grew slowly.
(d) Enforcement may have been difficult because the population was divided up into a number of clans, perhaps without any central authority for the island.
(e) Trust or a sense of community may have been low due to rivalries among clans

I would add two more points. First, institutions can take a long time to develop through trial and error or experimentation, even under relatively stable conditions. It is very hard to develop a good set of institutions to cope with one large population and resource cycle that unfolds over several centuries.

Second, other Polynesian islands tended not to have the same kind of disaster as Easter Island. The differing outcomes probably reflect differences in natural environments as well as differences in institutions.

Lessons for the modern world. Now let's return to Diamond's argument that there are important parallels between Easter Island and the modern world. Some similarities:

1. In both cases, the interactions among technology, population, and the natural environment can lead to problems. In particular, we need to think about non-linear dynamics involving the economy, population, and resources. Maybe the deforestation on Easter Island is like the problem of climate change today.

2. There is no guarantee that we will come up with good institutional solutions to such problems (ask yourself whether we are doing a good job of inventing new institutions at the global level to deal with climate change). Maybe the clans on Easter Island are like the nation-states of the modern world.

3. Both Easter Island and the modern world are geographically circumscribed. If we mess up the planet, moving to the Moon or Mars is not a practical solution.

So Diamond has a point. However, there are some ways in which the modern world is quite different from Easter Island.

1. Since the industrial revolution, we have experienced a demographic transition and the Malthusian model no longer applies. Today, when people get richer they tend to have fewer kids, not more kids. This may help to avoid a population overshoot.

2. Technological progress could solve some of our problems, and we have a much fancier set of technologies than the people of Easter Island. However, this is a two-edged sword. If we are thinking about climate change, developing cheaper renewable energy (solar, wind) is a good thing, because this encourages people to substitute away from fossil fuels. But developing cheaper ways to get fossil fuels out of the ground (fracking) makes the problem worse, by encouraging people to consume more of these fuels.

3. Although the planet as a whole is geographically circumscribed, people can move from one region of the world to another, and this may ease the pressure on places with more severe resource depletion problems.

Thus, while JD does have a point, I think one could argue that a combination of slowing population growth, progress with greener technology, and some institutional innovations at the global level might enable the modern world to do better than Easter Island did.

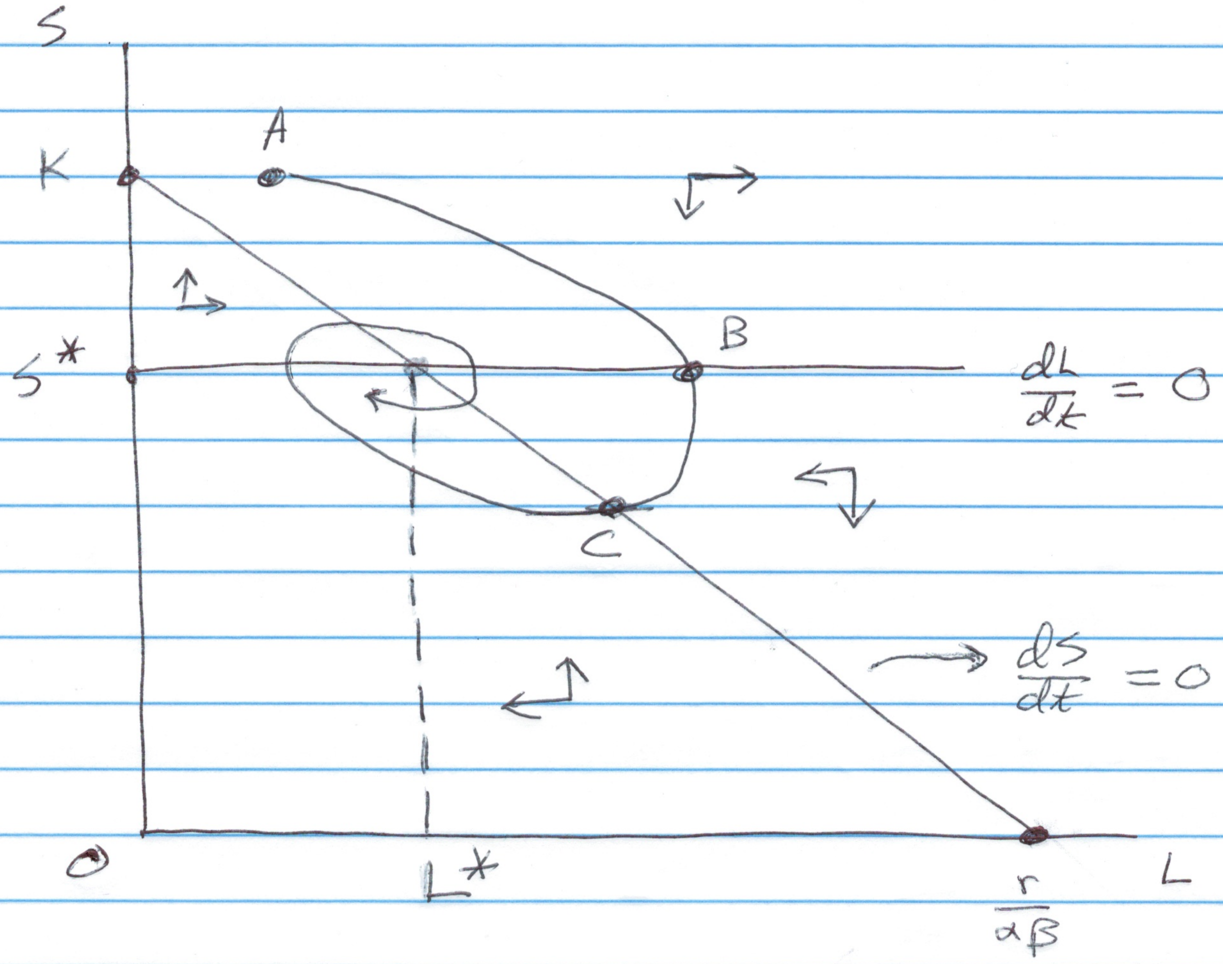


Figure 1

Spiral Convergence to Equilibrium (L^*, S^*)

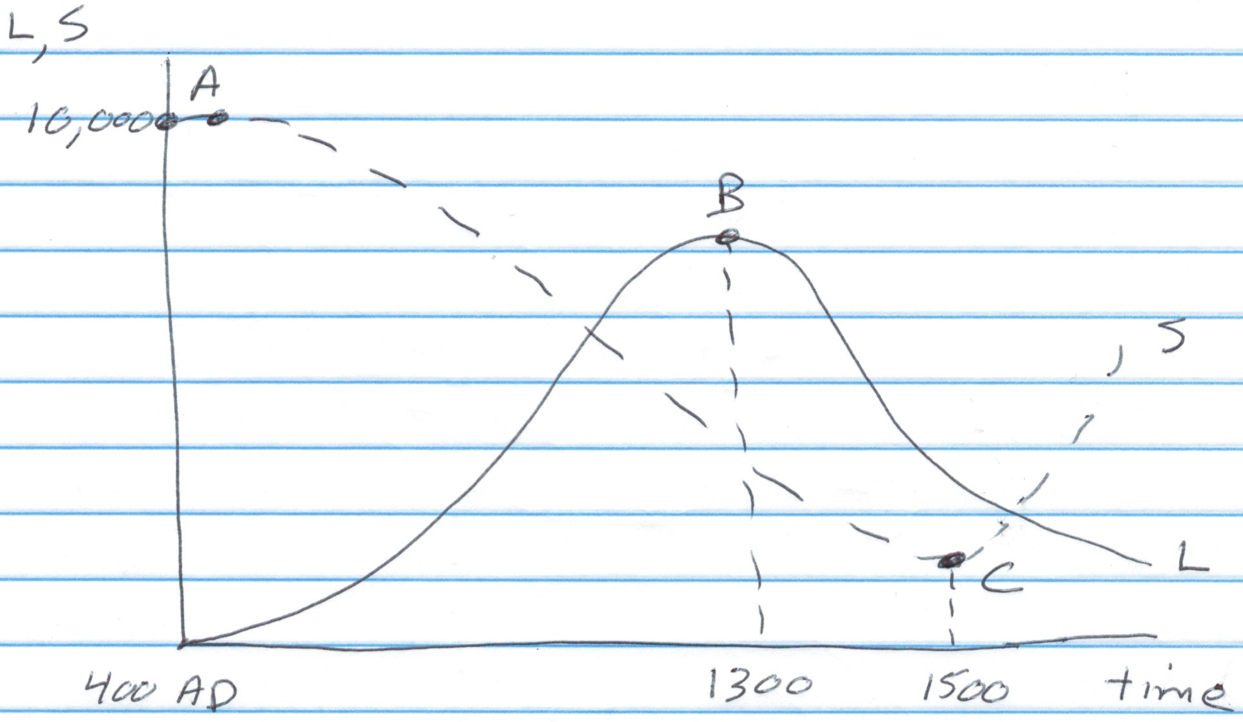


Figure 2

Simulated Human Population (L) and Resource Stock (S)

Note: dates are approximate