Title slide

This unit presents us with our first foray into economic modelling. Economists use models to explain certain empirical results; more specifically, start with an observation which motivates a question and develop a model to answer that question. WE will be formally introducing the use of models as a means to explain economics.

With every unit, we begin by looking at some empirical results. We will develop a question based on those observations. The next step is to develop a model which simplifies empirical complexity with the goal of finding a causal relationship that explains the underlying phenomena.

Last week we discussed the transition from stagnation to growth. We will return to this line of inquiry and develop a model which helps us understand what caused this transition. However, while the model we develop to explain transition to growth provides insight to causality underlying the observable phenomena, we will see that it fails at explaining why we were stuck in a flat world for so long.

This is a key point: economic models are context specific. Economic models are developed to answer a specific question. It is imperative that you understand the limitations of the models and diligently assess its applicability to a specific context.

A

The context for this unit

Last week we looked at a bunch of data which showed an observable, rapid increase in living standards approximately 200 years ago. Paralleling the rise in living standards was the technological revolution. These observations should make you question, why did the technological revolution start at that time? Why did it start in Britain?

If you were to respond, the capitalist revolution with the emerging dominance of private property, markets, and firms drove the rise in living standards. I would remain unconvinced. How did these institutions contribute to rising living standards?

It may be true that the capitalist revolution occurred at the same time as rising living standards, but correlation is not causation.

This unit

In unit 1 we crafted a response about the observable rising in living standards as due to technological progress. There are in fact many different explanations- historical, political/colonial, and economic.

For the first 400-500 years presented here, society was stuck in the Malthusian trap. Malthus posited that sustained increase in per capita income is impossible. According to Malthus, if a positive shock were to increase income, that would lead to increased population which, *ceteris paribus*, decreases living standards, decreasing the population. Ultimately, society returns to a subsistence equilibrium.

Eventually, society would break out of the Malthusian trap. Before we develop a model to help us understand how we could break free from the vicious circle described by Malthus, we will fist discuss the process of building economic models.

B

Why do we need models?

Recall that a key part of how we defined economics involved interactions between people acting across a variety of institutional settings: in the household, the firm, and with the environment. The fact of the matter is that this is a very complex reality generating the phenomena we seek o understand. Models, by design are an abstraction away from this complex reality. This simplification means that we will not obtain a full understanding of the phenomena under discussion: we can never provide a full explanation.

If we retain too much complexity, we lose clear insights that we would have been afforded if the model was well specified.

In fact, we have already seen a few models: these diagrammatic models of the economy were presented in Unit 1.

Building a model 1

One of the distinct advantages of this text over the more commonly adopted principles texts is the emphasis we place on the process of building and evaluating models. All too often economists remain in ignorant bliss regarding some of these difficult philosophical questions.

Because models are an abstraction away from a complex reality, one of the first challenges the modeler must confront is to determine what features of the economy should be included.

The simplification of omitting details is a feature, not a bug.

Building a model 2

Here you can see the 4 steps of building an economic model. This list describes the same process that I go through in my own research.

We made an observation about an empirical reality that animated a question we wish to answer.

The first step in answering this question, specifically in using a model to answer this question, is to determine the essential features of the economy that are pertinent to the phenomena under analysis. In a quantitative sense, which is a very common way of modeling in economics, this involves determining what variables are to be included in the model as well as which variables are endogenous, and which are exogenous. Endogenous variables have their value determined within the model; while exogenous variables have their values determined outside the model, often assumed by the model builder.

The second step is to describe the institutional structure: what are the rules which describe the interactions of the agents in our model with each other and with the other elements of the model. Again, in the quantitative sense, this step involves deriving the equations. While the use of mathematics is often abused in economics, describing interactions mathematically as a relationship between variables forces one to be very explicit in their treatment of the relationship, which can help to lead to the discovery of disagreement.

The third step is to find the equilibrium: that is to solve your model. This is an important step, albeit contentious, solving for the equilibrium allows us to introduce a change and discuss what happens. After solving the equilibrium- a condition which is self-perpetuating- we change introduce external force or add a shock as it is often referred to, and study what happens.

Briefly, the final two steps generate controversy because:

1) the economy is always is never in equilibrium and

2) introducing external forces often generates additional changes which would affect the result that follows from the shock.

What is a good model?

We will rely on four criteria to evaluate the models we build this semester. Remember these criteria and at the end of every unit ask yourself and your peers is this a good model. Is it clear: does the model help us understand something important? Does the model match the empirical reality: is the model consistent with evidence? Does it help us understand points of contention or perhaps lead to discovery of points of agreement? And the final question: does it inform our understanding of the empirical reality in a manner which allows us to improve the way the economy works?

Key concepts

The key assumption economists make to simplify complexity is *ceteris paribus* or all else constant. This is an assumption that we will make repeatedly, but rarely will it be made explicit. I refer to *ceteris paribus* as a key assumption because in economics we need to simplify the empirical complexity in order to identify causal relationships underlying phenomena of interest.

With every model we develop this semester, think about what is being held constant, and how if that assumption were relaxed the results would change. Be aware of the limitations of the model!

The second key concept that you are presented with here is the concept of an economic rent. This is a critical concept for understanding how economists model choice. An economic rent is a benefit received by the decision maker which takes into account the second best alternative or the reservation option. An economic rent is how much benefit the decision maker will receive for a choice after subtracting the benefit they would receive from the second-best alternative. For example, you need to choose between action A and action B. Action A yields a benefit of 10 units of something and the reservation option, action B, yields a benefit of 5 units of the same something. The economic rent of action A is 5 units.

The third concept is incentives. Incentives are the carrot and stick which motivate behavior. The carrot dangling in front of the horse motivates the horse to move forward. The stick to smack its butt also motivates the horse to move. One is a reward, the other a punishment.

The final concept is that of relative prices. Imagine its a Friday in pre-covid times and you are having a some friends over to celebrate the kick-[redacted] new job you got after graduating. You head to Bulldogs liquor to pick up a bottle of scotch. Upon entering you notice that they have your two favorite bottles of Macallan 18, both of which you love equally: the sherry and the triple; that is, you are indifferent between the two. Should you get the Sherry which costs $199 or the Triple? This is not enough information, to decide which bottle will yield the largest benefit, you need to know the costs of the Triple. You need to know the relative prices; relative prices help us compare alternatives.

I will conclude this slide by referencing a decision rule presented in the text. If an action yields you a rent, do it. If you are already doing an action that yields a rent, keep doing it.

C

Explaining the industrial revolution

In the reading you were presented with 5 alternative explanations about why the industrial revolution began in Britain in the 18th century.

The first explanation relies on relative prices of two factors of production, labor and capital/energy. This explanation posits that there was some sort of structural change which provided the incentive to adopt labor-saving capital-using technology.

The second explanation acknowledges the role of relative prices; it claims that input prices were the steering wheel, not the motor. This explanation states that it was the transformation of elite scientific knowledge into practical advice that animated this empirical result.

The final explanations draw on the role of the state and a cost-benefit analysis of stability vs. change.

Which of these competing explanations is right?

Part of the reason it is so difficult to explain why the industrial revolution happened when and where it did is because it only happened once; moreover, it cannot be recreated in an experiment. The best answer to the question is that all of the explanations contribute something to our understanding of this significant historical economic event. Scientific, demographic, political, geographic, and military factors all matter and not just the changes that were happening within Europe, but also the interactions occurring with the rest of the world.

Modelling technology

Technology in economics has nothing to do with the latest apple product you have in your pocket. Technology describes the process that converts inputs to outputs.

Here you can see 5 different technologies which all produce 100 meters of cloth. If we were using technology E and shifted to technology A or B, we would describe the shift as the adoption of a new labor saving – energy using technology: Technology A and B both use less labor than technology E does.

Can you think of any historical examples when society adopted labor saving technologies on a massive scale?

I hope you did not flounder too much in naming the Industrial revolution which has been central to our conversation.

Imagine you were the decision maker for the firm facing the choice of which technology you will adopt. Which one would you choose?

That's right, we don't have enough information, which of the available technologies minimizes cost depends on the relative prices of the factors of production.

Firms choice: inferior technologies

While we still do not know the relative prices, we can immediately exclude two of the available technologies. As long as prices are positive, a reasonable assumption, the firm would never choose Technology C or D. Technology C is dominated by technology A and technology D is dominated by

technology B. Technology A uses less of both labor and energy than technology C. Likewise, technology B uses less of both inputs than does technology D.

When we say an outcome is dominated, we should clarify that first of all we are discussing things we value and secondly hat there exists a win-win alternative where the firm can create more or the same output using fewer inputs.

Eliminating C and D still leaves us with three possible technologies. What we do know is that if labor was really cheap (that is cheap relative to energy), the firm would choose technology E. If labor was really expensive, the firm would choose technology A.

To be more precise we need more information.

Firms choice: minimizing costs

From this point forward, we will be assuming that firms seek to maximize their profits. The singular pursuit of profit, without regard for the community or environment, is what motivates firms to action. Maximizing profits is the same as minimizing costs.

The cost equation is presented here as well. The cost is equal to the sum of the products of the factor prices and quantities of those factors used in production.

Isocost lines

In the previous knowledge check the lines that you calculated the slope of are isocost lines. An isocost line represents all the combinations of inputs that give the same cost. The cost is constant along the isocost line.

There were a few different ways you could have found the slope of the line; the two easiest ways would be to find the endpoints by setting L and R to zero respectively and calculating rise over run. The easier way involves a little bit of algebra, start with the cost equation, and rearrange so that R, the variable representing the amount of coal, is on the left-hand side of the equation.

The image here shows 4 different isocost lines. For any given set of prices, there are infinitely many isocost lines. Remember, the isocost line represents the different combination of inputs that yields a constant cost. With this piece of information, we know that if we are on the isocost line H-J, every isocost line which is further from the origin, that further out than that line represents a higher cost. Now we can use the information on relative prices to compare the costs of different technologies.

The profit maximizing firm will select the technology on the lowest isocost line. The lower the isocost line the lower the costs.

It is the relative price that matters. In this example we set the wage at 10 and the price of coal at 20. If these prices doubled and the wage went to 20 and the price of coal to 40, the only thing that would change is that each isocost line presented would represent a higher cost, but the cost minimizing technology and the slopes of the isocost lines would remain the same.

Before advancing, take a minute and make sure you understand how we derive the isocost line from the cost equation. Follow the link to watch a video on how to solve for the isocost equation if you are unsure.

Change in relative prices

Lets apply this new found knowledge in attempt to understand why the industrial revolution happened in Britain.

Before the industrial revolution, labor was relatively cheap compared to capital/energy. Lets say the wage was equal to 10 and the price of energy was equal to 20. The slope of the isocost line is -1/2. We are using technology B and are on the isocost line J-H.

This is an equilibrium; firms are maximizing profits by minimizing costs. With these prices, technology A is on an isocost line which is further from the origin.

There was some structural transformation which we model by changing a parameter value: we add a shock. We change the value of the price of energy; let the price of energy drop from 20 to 5 while the wage stays constant. I am using an important assumption here— *ceteris paribus.* I assume only the price of energy changes.

Now, when we have a change in relative prices, the slope of the isocost line changes. The reduction in p, the price of energy, changes the slope of the isocost line to -2, it becomes much steeper. With the change in prices, technology B is now on an isocost line which is further from the origin than technology A.

The benefits of innovation

Here you are presented with the profit equation.

Switching to the new technology reduces costs. *Ceteris paribus,* holding revenue constant the new technology raises profits.

This is an example of an economic rent, specifically an innovation rent. The rent is equal to the benefit received, total profit using the new technology, taking into account the next best alternative, total profit using the old technology; the innovation rent is equal to the change in profit.

Creative destruction

Just to throw in a bit of history of economics because I love to nerd out on this stuff. This idea of innovation rents links to the concept of creative destruction developed by Schumpeter. This idea helps understand a process which contributes to the dynamism of capitalism…haha ism ism.

Technological change in industrial revolution

Nothing to say here, just a bit of economic history for all you geeks out there.

Why was Britain first?

To answer this question, we turn to history. We started down this path by asking why did the industrial revolution happen when it did and where it did?

Here you can see the relative prices in both England and France. Can you use the model we developed to answer: why Britain was first? Give it a shot before advancing to the next slide.

Shift to a lower cost technology

You saw how to use this model to understand why it happened in Britain in a previous slide.

The technology chosen depends on relative input prices. Are the predictions of our model correct? Is the outcome consistent with the empirical data?

At the time of the industrial revolution, the price of labor relative to capital was increasing and was higher in Britain. When the price of labor relative to capital increases, the slope of the isocost line becomes steeper.

You can see this in the image, you go from being on the isocost line through J-H to the isocost line through G-F.

D

Explaining the economy before the Ind revolution

We have spent a good deal of time developing a model to answer the question of why the industrial revolution happened at a certain time and place. Remember the models we develop are context specific.

If we want to understand the stagnation that lasted for centuries before the industrial revolution, we need a different model. For that we turn to Malthus.

Diminishing average product of labor.

This is an important concept.

The production function is one way that we model technology. It is an if-then statement: if you use this amount of inputs, given the current technology, then, this is your maximum output. It is a mathematical relationship between two quantities: the quantity of inputs and the maximum possible quantity of output.

The production function is concave by assumption. What this means is that as you increase the amount of inputs, farmers in this image, the maximum amount of output increases, but it increases at a decreasing rate. Alternatively, as you move along the line from left to right, it goes up, but it becomes flatter the further right you move.

The assumption we make to achieve this result is that we hold one of the inputs constant. As you increase farmers, *ceteris paribus…*there it is again the critical assumption and my favorite Latin phrase, you hold land constant.

For you math nerds, the first derivative of the production function is positive and the second is negative.

Malthus model

In point 2 you can see how *ceteris paribus* was critical in Malthus' subsistence equilibrium.

Malthus law

Follow through the causality of Malthus' model to understand why society lived in a flat world for so long.

Was Malthus correct?

Between 1280 and 1600, the evidence is consistent with Malthus' model. As population rises the wage decreases. But what about after 1600?

Revising Malthus law.

What Malthus failed to see happening around him, something which Adam Smith keenly observed decades before him, the changes in technology continued at a sufficient rate to offset the increased application of labor.

Thinking back to our production function, an increase in technology shifts the production function up.

Escaping the trap

To escape the Malthusian trap required the onset of the permanent technological revolution. This story of the technological revolution and the emergence of capitalism sets up two lines of inquiry that we will pursue over the coming weeks.

How much is produced?

How is it distributed?