

Economics, Law and Ethics
Part IB CST 75%, Part II CST 50%
2019-20

Alice Hutchings, Richard Clayton

with many thanks to Ross Anderson

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- Many thanks to Prof Ross Anderson who designed and previously lectured this course

Why teach this course?

- **Systems:** economics used in protocol design, congestion control, mechanisms like blockchain...
- **Theory:** the combinatorial auction is now seen as the archetypal complexity-theory problem
- **Professional:** over half of you will become entrepreneurs or go into consultancy, management
- **Law:** what can make you liable online?
- **Ethics:** how can you navigate the many grey areas?
- **Course accreditation:** ethics now mandatory for CS and economics for engineers

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- This course was put together a number of years ago by Ross Anderson.
- Bits and pieces from all over the place were brought together into one coherent story.
- Relevance for computer scientists:
 - E.g. economics is used in protocol design, congestion control, and cryptocurrencies.
 - Theory of auctions is needed to understanding routing networks.
 - Professional benefits – business, consultancy.
 - Law – understand what sort of things make you liable online e.g. GDPR - avoid being sued or going to jail.
 - Ethics – important for navigating the grey areas - law is 20 years behind innovations and companies that come out of that. What sort of behaviour is likely to be acceptable.
 - Ethics is mandatory for CS courses, and economics for engineers.

Aims and Objectives

- Aims: introduce you to basic concepts in economics, law and ethics
- Objectives: at the end, you should have a basic appreciation of economic and legal terminology and arguments; understand some of the applications of economic models to systems engineering and their interest to theoretical computer science; and understand the main constraints that markets, legislation and ethics place on firms dealing in information goods and services

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- Should be able to start wrestling with these concepts, as are perpetually moving target.

Outline

- Game theory: prisoners' dilemma, iterated games
- Classical economics with competitive markets
- Market failures – monopoly, asymmetric information, network effects, lock-in
- How information markets are different
- Auction theory and mechanism design
- Principles of law
- IT law (Richard Clayton, 28 November)
- Ethics – where the law hasn't made up its mind

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- Today - game theory.
- Then classical economics - supply and demand.
- How markets fail - monopoly, information asymmetry, network effects and lock-in drive the industry.
- Apply insights into microeconomic theory to explore how information markets are different to other types of markets.
- Auction theory - how to design good auctions, how ads are sold and the consequences, e.g. driving polarisation.
- Principles of law - civil, criminal, tort, etc., so get the jargon.
- Richard Clayton will talk specifically about IT law, and he has been involved in lobbying for the laws that we have to live by.
- Then ethics - where the law hasn't caught up with.

Resources

- Shapiro and Varian “Information Rules”
- Varian “Intermediate Microeconomics”
- Course website, plus as further reading:
 - Adam Smith, “The Wealth of Nations”
 - Richard Thaler, “Misbehaving”
 - JK Galbraith, “A History of Economics”
 - William Poundstone, “Prisoners’ Dilemma”
 - Steven Pinker, “The Better Angels of our Nature”
 - Nuffield Bioethics Council report on biodata

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- Economics is a field in which you have to do broad reading - breadth is really important. Number of possible books to go and read.
- Shapiro and Varian - pioneers of information economics. Many lessons from this book have been internalised by the industry.
- We’re not going into the mathematics - not going to state and prove theorems. If you like this, you can read Intermediate Microeconomics.
- Smith – The Wealth of Nations - kicked the whole study of economics off in the 18th century – he observed the start of the industrial revolution.
- Thaler - psychology and economics. Won Nobel in Economics in 2017.
- Galbraith - economic advisor to President Kennedy. Gives a more classical approach.
- Poundstone – game theory - provides background reading and examples with his book Prisoners Dilemma.
- Broader social context - Pinker - how we went from being people who lived in tribes who tried to kill neighbours all the time - homicide and tribal violence to the peaceful society we have today - with rights and ethics - evolution with a continued decrease in homicide rate.
- Nuffield - details of one textbook ethics case - what to do with health privacy - with cloud, genomics, can we do this privately and ethically any more.

Studying a humanities subject

- It's not like learning to prove theorems or program in Java, which gives a testable skill
- Wide reading is important – ideas become clearer when approached from several perspectives
- College libraries are a good place to start
- Dig into some subproblem that interests you
- Work out different viewpoints: how would a socialist / Keynesian / environmentalist / libertarian approach a problem of interest?
- Write proper essays! (Essay writing class in Lent)

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- Studying a humanities subject is not like learning java, where you practice until you get it right.

- Delve into a sub interest that you're interested in - work out the different viewpoints.

- Write proper essays - important skills - to marshal thoughts and have an essay with a beginning, middle and end.

Roadmap

- Economics as a subject is traditionally made up of macroeconomics, microeconomics and specialised topics
- 'Macro' is about the performance and structure of the global economy or a nation or region. It's about models of employment, inflation, growth, investment, trade, savings, credit, tax, GNP...
- We will touch on this only occasionally

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- Economics traditionally includes macroeconomics, microeconomics, and specialised topics.

- Macroeconomics - prices, interest rates, unemployment rates for a country or a region as a whole.

- This is what newspapers and politicians talk about, but not what we're looking at here.

Roadmap (2)

- Microeconomics or 'micro' is about how individuals and firms react to incentives, how market mechanisms establish prices, and the circumstances in which markets can fail
- Many topics of interest to computer scientists & engineers include game theory, the economics of information, the economics of dependability, and behavioural economics (economics + psychology)
- Our tools range from mathematical models to empirical social science

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- Focus on microeconomics - how individuals and firms respond to incentives, how markets fail, how monopolies arise, how competition dies - economics of information, dependability's, links in with psychology.

- Tools of microeconomics range from mathematical tools to empirical social science.

Cooperation or conflict

- One way of getting what you want is to make it, or make something else of value and trade for it – ‘Economics’
- Another way is to just take it, whether by force or via the ballot box – ‘Politics’
- Choices between cooperation and conflict are made at all sorts of levels all the time
- They can evolve in complex combinations
- The main tool we use to analyse them is game theory

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- Today's topic - people co-operate or they fight.
- If you want something you can't make yourself, you can make something else and you can trade for it. This is economics.
- War - take it from the guy next door.
- Politics- make yourself prime minister, take taxes and buy it that way.
- Choices between cooperation and conflict are made all the time, at all sorts of levels.
- Since the 1940s we've had a useful tool to analyse this - game theory.

Game theory

- The study of problems of cooperation and conflict among independent decision-makers
- We focus on games of strategy, rather than chance
- We abstract to players, choices, payoffs, strategies
- There are
 - games of perfect information (such as chess and go)
 - games of imperfect information (which are often more interesting to analyse)

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- Game theory explores problems of cooperation and conflict among independent decision makers.
- Games of strategy - not chance, focusing on the players, choices, payoffs and strategies.
- There are different types of games. Chess and go are games of perfect information.
- Games of imperfect information are more interesting to analyse - don't know the other side's intentions, need to figure out what they intend to do.

Strategic form

- Example: matching pennies. Alice and Bob throw H or T. If they're different, Alice gets Bob's penny; else he gets hers. The strategic form is

		Bob	
		H	T
Alice	H	-1, 1	1, -1
	T	1, -1	-1, 1

- This is an example of a zero-sum game: Alice's gain = Bob's loss

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- To analyse games, can tabularise the strategies.
- A simple example is matching pennies.
- Bob and Alice toss a coin. If they are different, Alice gets Bob's penny. If the coins are the same, Bob gets Alice's penny.
- This is an example of a game in strategic form. Calling heads or tails.
- This is a zero sum game - Alice's game is Bob's loss.

Dominant strategy equilibrium

- In the following game, Bob's better off playing left; similarly Alice is always better off playing bottom

		Bob	
		Left	Right
Alice	Top	1, 2	0, 1
	Bottom	2, 1	1, 0

- A strategy is an algorithm: input state, output play
- Here, each player's optimal play is a constant
- The is called a 'dominant strategy equilibrium'

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- This is an algorithm - write a program is the best possible outcome.
- This example Bob is better of playing left, regardless of what Alice plays (and vice versa).
- Bob's optimum strategy is to play left.

Nash equilibrium

- Consider this game:

		Bob	
		Left	Right
Alice	Top	2, 1	0, 0
	Bottom	0, 0	1, 2

- Each player's optimal strategy depends on what they think the other will do
- Two strategies are in Nash equilibrium when A's choice is optimal given B's, and vice versa
- Here there are two: top left and bottom right
- This game is sometimes called 'Battle of the sexes'

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- More complex case - Nash equilibrium.
- If Alice plays top, Bob had better play left.
- If Alice knows Bob is going to play right, she's better play bottom, as she gets 1 rather than 0.
- Each player's optimum strategy depends on what the other will do.
- Battle of the sexes - if one want to go to the pub and one wants to watch a movie - there is a battle of wills. Might take it in turns. If Bob goes to the pub every night, Alice might want to start looking for another partner.

Pure v mixed strategies

- With deterministic algorithms, some games have no Nash equilibrium

		Bob		
		scissors	paper	stone
Alice	scissors	0,0	1, -1	-1, 1
	paper	-1, 1	0,0	1, -1
	stone	1, -1	-1, 1	0,0

- Alice plays scissors → Bob will play stone → Alice will play paper ...
- Fix: randomised algorithm. Called a 'mixed' strategy; deterministic algorithms are called 'pure'

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- Rock paper scissors. Circular dominance – scissors cut paper, stone blunts scissors, and paper wraps stone.
- No constant strategy will win - if Alice always outputs paper, Bob will output scissors.
- Only output here is a random algorithm. Have cryptographically strong so Bob can't predict the outcome.

Prisoners' dilemma

- Two prisoners are arrested on suspicion of planning a robbery. The police tell them separately: if neither confesses, one year each for gun possession; if one confesses he goes free and the other gets 6 years; if both confess then each will get 3 years

Benjy

		confess	deny
Alfie	confess	-3, -3	0, -6
	deny	-6, 0	-1, -1

- (confess, confess) is the dominant strategy equilibrium
- It's obviously not optimal for the villains!
- Is this a problem? If so, what's the solution?

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- 2 prisoners are arrested on suspicion of planning a robbery. The police tell them separately: if neither confesses, one year each for gun possession; if one confesses he goes free and the other gets 6 years; if both confess then each will get 3 years.
- A and B confesses is the dominant strategy equilibrium. But this is not optimum for the villains. If they'd both kept quiet, they'd only get one year.

Prisoners' dilemma (2)

- You might answer 'serves them right'!
- But this can't apply to all instances of the dilemma
 - Defence spending
 - Fishing quotas
 - Free riders in file-sharing systems
 - Reducing carbon emissions
 - ...
- Tough but inescapable conclusion: if the game is truly as described, there is no escape. Both will cheat rather than cooperate, with bad outcome
- To fix it, you need to change the game somehow!

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- One possible answer is that it serves them right - what's the problem with them both going to jail for 3 years.
- But not just about prisoners:
 - Defence spending - If states are suspicious of each other more money goes on guns than health and welfare.
 - Fishing quotes - if areas are being over fished, how do you have means of restraint.
 - Free riders in file shearing systems - if people are greedy, they can get much more at the expense of others, leading to congestion in the network
 - Reducing carbon emissions - why should we do this if we can export our manufacturing to China.
- How to fix - change the game somehow.

The evolution of cooperation

- If PD played repeatedly, there's a fix!
- 'Tit-for tat': cooperate at round 1, then at round n do what the other guy did at n-1
- Simulation competitions run by Bob Axelrod played off many iterated-game strategies; tit-for-tat did consistently well
- In the presence of noise, tit-for-tat gets locked into (defect, defect). So: forgive the other guy occasionally
- People have realised in the last 30 years or so that strategy evolution explains a lot of behaviour

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- If the prisoners dilemma is played repeatedly - there is a fix.

- Tit for tat - if you do n, I do what you did at n-1.

- Bob Axelrod - iterated prisoners dilemma. Tit for tat did consistency well. Robust strategy. Do have to tweak a bit - can get locked into defect /defect. - so you have to forgive the other guy occasionally to go back to optimum strategy.

Price-fixing

- If it costs \$250 to fly someone LHR-JFK, do airlines compete and charge \$255 or collude and charge \$500?
- Competition laws forbid price-fixing cartels, but the same behaviour can arise implicitly
- Try charging \$500 and see what other airlines do. If they 'defect' by competing, play tit-for-tat
- If you're the regulator, how do you cope?

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- If running an ecommerce website - pricing strategy used will be key to how much money you make.
- If it costs an airline \$250 to fly someone LHR-JFK, do airlines compete and charge \$255 or collude and charge \$500?
- Laws against fixing prices – e.g. airlines have rigged fuel surcharge costs.
- Airlines try charging \$500 and see what the others do - cut prices in response to others - then look at losses and profits and put it back to \$500.
- So end up with the same kind of behaviour perfectly naturally.
- One of the issues that arise in our trade.

Stag hunt

- People can hunt rabbits on their own, but have to work together to hunt a stag. If your buddy runs off after a rabbit, the stag will escape

		Frank	
		chase hare	hunt stag
Bernard	chase hare	2, 2	5, 0
	hunt stag	0, 5	10, 10

- Difference from PD: (stag, stag) is now a Nash equilibrium
- You'll only chase a rabbit if you believe your buddy will defect
- Thus while PD is payoff-dominant, stag hunt is risk-dominant

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- People can hunt rabbits on their own, but have to work together to hunt a stag.
- If your buddy runs off after a rabbit, the stag will escape.
- Stag stag and hare hare are Nash equilibria.
- As risk dominant, and stags are worth more than hares, you only chase a hare if you believe your buddy would defect.

Volunteer's dilemma

- Multi-player chicken: if one person volunteers, everyone else benefits, but if no-one volunteers then everyone suffers a big loss

		Everyone else	
		someone acts	no-one acts
Me	act	benefit - cost	benefit - cost
	don't act	benefit	big loss

- The Arab Spring: "If everyone goes on the street and says 'the government is finished', it's finished. If you go on the street and say 'the government is finished', you're finished"
- Evolution of leadership: first move = fitness signal

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- Arab Spring - many people took the street to take down dictators.
- Different outcomes in different countries.
- The dilemma - if I act and everyone else acts, we get the benefit, but I may pay a small cost (e.g. get shot at). If I act and nobody acts the cost is a lot bigger, as I go to jail or worse. If nobody acts there is a big loss.
- Comes out in evolutionary history - who goes into the cave first and see if there's a sabre tooth tiger.

Chicken

- In 'Rebel without a cause', Jim (James Dean) and Buzz (Corey Allan) drive stolen cars at a canyon and try to jump out last to prove their manhood

	Jim	
	jump	drive on
Buzz	jump	2, 2
	drive on	3, 1
		0, 0

- Here, (1,3) and (3,1) are Nash equilibria
- Bertrand Russell suggested this as a model of nuclear confrontation in the Cold War
- But what about the iterated version?

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- 'Rebel without a cause', Jim and Buzz drive stolen cars at a canyon and try to jump out last to prove their manhood.
- Suggested as model for confrontation between states - e.g. nuclear confrontation in Cold War.

Game theory and evolution

- John Maynard Smith proposed the 'Hawk-dove' game as a simple model of animal behaviour. Consider a mixed population of aggressive and docile individuals:

	Hawk	Dove
Hawk	$(v-c)/2, (v-c)/2$	$v, 0$
Dove	$0, v$	$v/2, v/2$

- Food v at each round; doves share; hawks take food from doves; hawks fight (with risk of death c)
- If $v > c$, whole population becomes hawk (dominant strategy)
- What happens if $c > v$?

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- Iterated game of chicken is the Hawk dove game.
- Proposed by Maynard Smith.
- Suppose you have a population of individuals - some are aggressive and some are docile.
- Doves share food, hawks take food from doves, and hawks fight other hawks.
- Expectation that those with the temperament of a hawk will fight and there is a possibility that one dies.
- If the amount of food to be obtained is greater than the probability of death, everyone will be a hawk.

Game theory and evolution (2)

- If $c > v$, a small number of hawks will prosper as most interactions will be with doves. Equilibrium reached at hawk probability p setting hawk payoff = dove payoff

	Hawk	Dove
Hawk	$(v-c)/2, (v-c)/2$	$v, 0$
Dove	$0, v$	$v/2, v/2$

- I.e. $p(v-c)/2 + (1-p)v = (1-p)v/2$
 $\Leftrightarrow pv - pc + 2v - 2pv = v - pv$
 $\Leftrightarrow -pc = -v$
 $\Leftrightarrow p = v/c$

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- If the probability of death is greater than the utility of the food that can be obtained, a small number of hawks will prosper.
- Probability is most people they come into contact with will be doves.
- Equilibrium here refers to the point in which hawks and doves reach a stable level in a population.
- Models the probability that individuals in a species will be aggressive.

Broader implications

- Nash, Axelrod, Maynard Smith and others opened up many applications
- Politics: models of conflict, and of when religions are dominated by fundamentalists
- Criminologists: model the Mafia as alternative contract enforcement, and tattoos as signalling
- Computer science: how do you get AS operators to tell the truth about Internet routing? How do you get them to secure BGP? Will bitcoin converge, fork or collapse? ...

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- Game theory provides models of conflict, war between states, civil conflict, when religions are dominant by fundamentalists.
- Criminologists - model the mafia as alternative contract enforcement, and tattoos as signalling - trust if you cooperate and breaking your kneecaps during conflict.
- Computer science - how do you get AS operators to tell the truth about internet routers - How do you get them to secure BGP? Will cryptocurrencies converge, fork, or collapse.

Broader implications (2)

- In pre-state societies, if you see a man you don't recognise, you'd better kill him first (Diamond, "The World Until Yesterday")
- Now we live in largely peaceful societies (Pinker, "The Better Angels of our Nature")
- Evolutionary basis of morality: fairness from tit-for-tat, hierarchy from hawk-dove, maybe conservative / liberal preferences too (Haidt)
- Cooperation developed by states, religions, literature, markets, rights, TV ...

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- Wider implications in politics, history and anthropology.
- Before states, tribes and neighbour disputes - at war over hunting, grazing or fishing rights.
- Pinker's book - the murder rate went down with the increase in rights and ethics.
- If you have cooperation developed by states, religions, literature, markets, rights, and TV, then what happens when they go online?

Broader implications (3)

- If institutions that involve social cooperation are replaced by online mechanisms, what happens then?
- TV caused people to become more solitary when it replaced clubs, churches and pubs as the social focus (“Bowling Alone”)
- What if more of our cooperative social mechanisms are replaced by echo chambers?
- The spread of broadband was correlated with a rise in political polarisation...

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- Bowling Alone - study of what happened when TV came along.
- People were less sociable than their parents' generation.
- What happens when cooperative social mechanisms are replaced by echo chambers - right wing stay in right wing chatrooms, and likewise with left wing.

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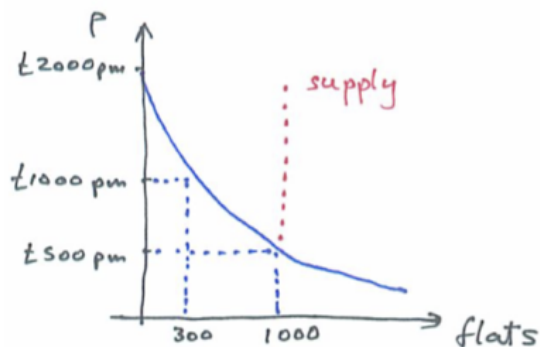
Prices and markets

- As an introduction to theories of prices, consumers and markets, consider an idealised market for flats in Cambridge
- Simplify to two types – one-bed flats in town, or house-shares in Cherry Hinton. People who can afford flats will rent them, and those who can't will cycle to distant house-shares instead
- Assume that there are 1000 flats to rent, and that people vary in their ability / willingness to pay

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- Theories of prices and markets
- Simple model of rental apartments in Cambridge.
- Assume there are two choices, a one bedroom flat in town, or house shares in Cherry Hinton.
- People who can afford flats will rent them, and those who can't will cycle to distant house shares instead.
- 1000 flats to rent, and people vary in their ability or willingness to pay.

Accommodation market

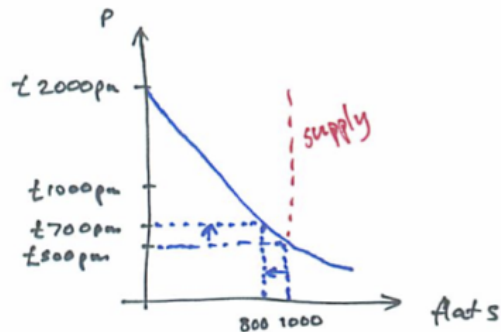


- So there might be 1 person prepared to pay £2000, 300 prepared to pay £1000, 1000 prepared to pay £500...
- With 1000 flats to let, the market equilibrium price p^* is where the supply and demand curves cross, i.e. £500

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- This is what the demand curve looks like – a few wealthy students are prepared to pay £2000/month, others are prepared to pay £1000/month, and so on.
- Assuming there is no collusion, no market rigging, then the equilibrium price is where the supply and demand curves cross, so £500/month.

Monopoly



- If the market is rigged, the cartel might restrict supply – 800 flats at £700 pm can earn more than 1000 at £500 pm
- This is inefficient! (there are empty flats which people would pay to rent)
- How can we formalise this?

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- Suppose the market starts being rigged.
- E.g. private cartel wants to rig the rents.
- If the rents could be increased, so you rent 800 flats at £700/month, you can earn 12% more.
- However, 200 flats are left empty, despite people being prepared to pay for them.

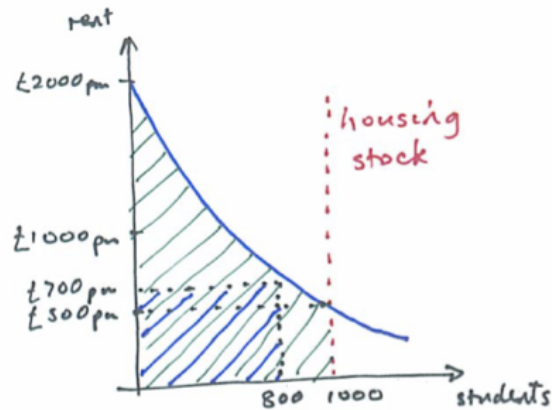
Efficiency

- A monopolist might leave some flats empty despite people being prepared to pay for them
- Definitions
 - A *Pareto improvement* is a way to make some people better off without making anyone worse off
 - A *Pareto efficient allocation* is such that no Pareto improvement is possible
- This is weak: pure monarchy and pure communism are both Pareto efficient!
- Anyway, is there any way for the monopolist to find a Pareto efficient allocation?

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- Inefficient to leave some flats empty despite people being prepared to pay for them.
- Italian economist Vilfredo Pareto: concepts of Pareto improvements and Pareto efficiency.
- A Pareto improvement is a way to make some people better off without making anyone worse off.
- A Pareto efficient allocation is such that no Pareto improvement is possible.
- Pareto efficiency is a weak concept - if you have pure monarchy that is Pareto efficient - cannot give anybody anything without giving the king less stuff.
- Says nothing about equity or justice.
- But is there some way for the monopolist to find a Pareto efficient allocation?

Discriminating monopolist

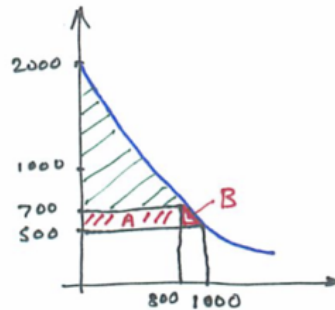


- If you know what everyone can pay, charge them just that!
- This arrangement is Pareto efficient!
- The monopolist captures all the consumer surplus ...

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- If the monopolist is all knowing and powerful - e.g. Google - can change the rent according to what people can afford.
- This arrangement is Pareto efficient.
- The monopolist has 'captured all the consumer surplus'.
- E.g. why there are so many different prices for Microsoft Windows.
- Can do this by ensuring that not all the flats are exactly the same - people feel that they are paying more for a better flat.

Consumer surplus



- Consumer surplus is the total amount people saved on their reservation price
- Ordinary monopoly: green area left to consumers
- The monopolist diminished surplus by A and B
- The discriminating monopolist gets the lot!

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- Consumer surplus is the total amount people saved on their reservation price.
- Here, the green area is left to consumers.
- If the remaining flats are rented at £500 pounds a month, the monopolist has diminished the surplus by A and B.
- The discriminating monopolist, who charges £2,000 pounds for those that can afford it, etc, gets the lot!

Monopoly and technology

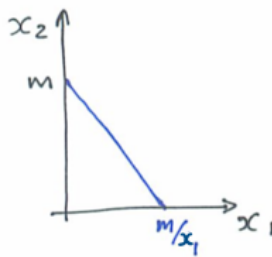
- Monopolies are common in the information goods and services industries
- We'll study why in some detail later
- For now, monopolists have an incentive to price discriminate, to mop up all the available surplus
- Hence the many prices of Windows!
- But it's not just tech. Think airline tickets, cars, and even food.
- So what factors determine the structure of markets?

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- Monopolies are common in the information goods and services industries.
- Monopolists have an incentive to price discriminate - to mop up the surplus.
- This is common in industries with low marginal costs, such as airlines.
- Fixed price to fly an airplane – but every additional seat filled above this is revenue.

Basic consumer theory

- Examines mechanisms of choice
- Consumers choose 'best' bundle of goods they can afford
- Most of the time, two goods are enough – say books versus everything else
- Assuming a budget constraint m , $p_1x_1 + p_2x_2 \leq m$
- This gives a line on which choices must lie

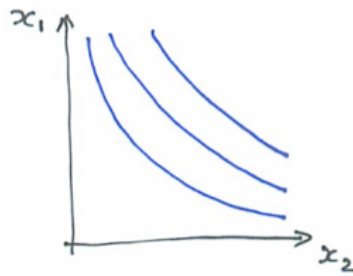


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- Jargon and ideas of basic consumer theory.
- The economic theory of the consumer is very simple.
- Mechanisms of choice is the assumption that people choose the best bundle of goods they can afford.
- Most of the time, we consider the consumption bundle as two goods.
- For example, books (x_1), and then generalise everything else the consumer is choosing to spend their money on (x_2).
- P_1 is the cost of each book, while P_2 is the cost of X_2 .

Preferences

- We draw 'indifference curves' or 'isoquants' joining mutually indifferent points – that is, where the consumer prefers bundle (x_1, x_2) equally to (y_1, y_2)
- We assume they're well behaved – the curves don't cross. I.e. if (x_1, x_2) is preferred when (y_1, y_2) is affordable, then when (y_1, y_2) is preferred, (x_1, x_2) is not affordable (the 'weak axiom of revealed preference')

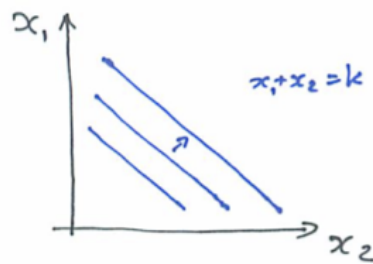


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- We can express preferences using 'indifference curves' or 'isoquants'.
- Assume for modelling purposes the curves don't cross.
- If x_1, x_2 is preferred when y_1, y_2 is affordable, then when y_1, y_2 is preferred, x_1, x_2 is not affordable.
- This is the weak axiom of revealed preference.
- For most cases that the curves are convex.

Perfect Substitutes

- Sometimes I just don't care at all whether I have good 1 or good 2
- E.g.: Tesco's sugar or Sainsbury's sugar
- Such goods are called perfect substitutes

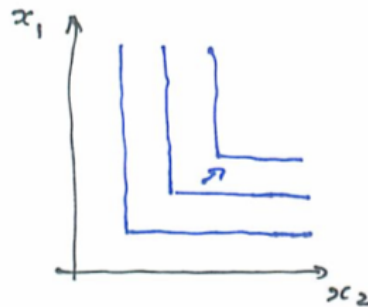


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- Here lines are straight.
- E.g. sugar from Tesco or from Sainsbury's.
- These goods are called perfect substitutes.

Perfect Complements

- Sometimes I want exactly the same quantity of good 1 and good 2
- E.g. left shoes and right shoes
- Such goods are called perfect complements

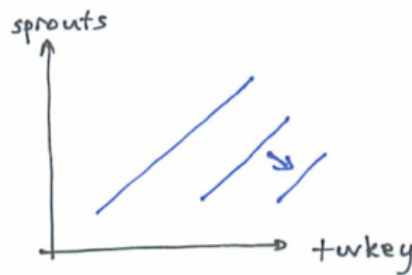


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- On the other extreme, are perfect complements.
- We want the same quantity of good 1 and good 2.
- E.g. same number of left and right shoes.
- The indifference curve for perfect complements are L-shaped.

Bads

- There are some goods I'd rather avoid!
- But sometimes I have to consume some of a bad in order to enjoy some of a good



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- Some goods you want to avoid.
- There may be a trade-off between goods you like and goods you don't like.
- You may be willing to eat some sprouts in order to enjoy turkey.
- Here the isoquants slope the other way-the direction of increasing preference is down and to the right.

Marginal rate of substitution

- The tangent to an isoquant gives the marginal rate of substitution (MRS)
- This is the exchange rate at which the consumer will trade the two: $MRS = \Delta x_1 / \Delta x_2$
- Convex curves: you're more likely to trade the good if you have more of it

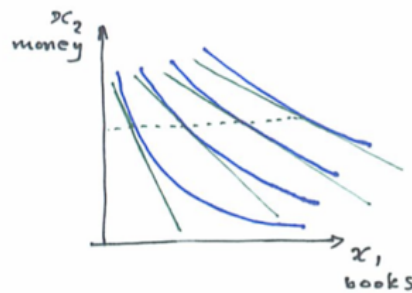


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- The tangent to the isoquant is the marginal rate of substitution- the exchange rate at which the consumer will trade the two goods.
- The MRS shows how much of a change in good 1 you will accept for a change in good 2.
- The curves are convex as how much you're likely to trade will depend on how much of the goods you have.

Diminishing MRS

- The more you have of x_1 relative to x_2 , the more likely you are to trade x_1 for x_2 , in the strictly convex case
- I.e. you become less willing to pay for 'one more'

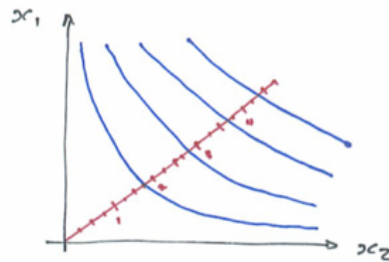


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- The MRS tends to diminish as wealth increases.
- The more you have of one good, the more willing you are to give some of it up in exchange for the other good.
- If you have lots of books but not much money, you become less willing to pay for just one more.

Utility

- Often indifference curves can be parametrised
- Marginal utility $MU_1 = dU/dx_1$
- Then $MRS = -MU_1/MU_2$
- Utility functions can be useful for describing consumer choices
- They can often be inferred from shopping behaviour, and answer questions about the value of better / faster / ...

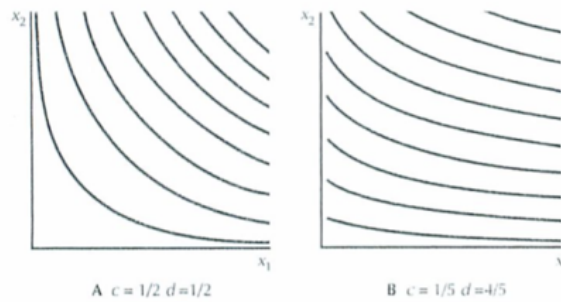


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- Utility: term to describe preferences, so how much value you get out of a good or service.
- Often utility curves can be parametrised, e.g. when optimising a commerce website.
- The utility function assigns a number to every possible consumption bundle such that more preferred bundles get assigned larger numbers than less preferred bundles.
- If you draw a ruler out from the origin you can measure the utility of different bundles to the consumer.
- If you have a number of the utility – this can be modelled.
- E-commerce sites - infer from the shopper's behaviour what their utility is - how much more will people pay for a better or faster machine - or a machine with more RAM.

Cobb-Douglas utility

- Commonly used: $U(x_1, x_2) = x_1^c x_2^d$
- If the utility is believed to depend on a number of observed factors, take logarithms and look for a fit



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- The Cobb-Douglas utility is how this is commonly done in practice.
- If the utility is believed to depend on a number of observed factors, take logarithms and look for a fit.

The marginalist revolution

- Until 1871, no-one had a good theory of supply and demand. Why are essentials like water cheap, while diamonds are expensive?
- Solution: the value of the last and least wanted addition to your consumption of a good sets its value to you (Karl Menger, Stanley Jevons, 1871)
- Shifted thinking from costs of production to demand, and led to 'classical synthesis' of Marshall and others – interlocking models of consumption, production, labour, finance etc in a world of free competition

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- Why do things like diamonds cost a lot of money, but water, which everyone needs come out of the tap?
- Karl Menger and Stanley Jevons: the value of the last and least wanted addition to your consumption of a good sets its value to you.
- Shifted thinking from costs of production to demand.
- Led to classical synthesis – interlocking models of consumption, production, labour, finance, etc in a world of free competition.

Concrete example

- Suppose a local coal market in 1840 had three typical suppliers / customers

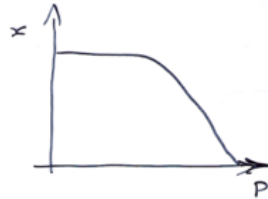
Sea coal gathering 8s	Blacksmiths 15s
Small deep mine 5s	Households 8s
Open-cast mine 2s	Export 3s

- The market price determines who produces and who consumes
- It's determined by the marginal transaction
- It fluctuates with demand (weather) and can evolve in the long term with tech, investment...

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- Suppose a local coal market in 1840 had three typical suppliers and customers.
- The highest cost is sea coal gathering. There is a deep mine –still expensive. The open cast mine is relatively easy.
- On the demand side - blacksmiths cannot do their work without coal. Households can do without heat – you can put a coat on. Export is everything that is left over, sent to London for 3/s tonne.
- In the summer expect that the marginal producer will be the open cast mine and the market will be export.
- In winter it depends on whether the supply can meet demand.
- If not, people are going to have to go on the beach and pick up the coal. So prices will go up.
- Price of coal will fluctuate between winter and summer.

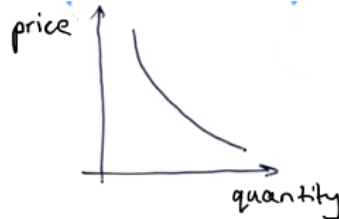
Demand



- Assuming functions well-behaved, we can get a consumer's demand from their utility or vice versa
- Market demand is the sum of demand over consumers
- In general a price change will have a substitution effect (if beer goes up, drink more wine) and an income effect (if rent goes up, you're poorer)
- At the level of this course, we can ignore this... ⁴⁶

- Assuming functions are well behaved, you can get a consumer's demand from their utility, and vice versa.
- Various things to look out for - substitution effect - if wine goes up, people will drink beer instead.
- Income effects – if rent goes up, you have less to spend on other things.

Elasticity

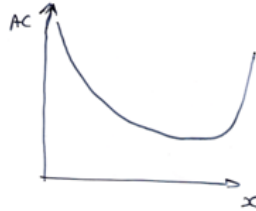


- Given a market demand curve, elasticity measures the effect on demand of a small change in price
- Formally, $\varepsilon(p) = (\Delta q/q)/(\Delta p/p) = p\Delta q/q\Delta p$
- Elasticity = 1 means there are substitutes
- Revenue $R = pq$, so
$$\Delta R/\Delta p = q + p \Delta q/\Delta p$$
$$= q (1 + \varepsilon(p)) = q (1 - |\varepsilon(p)|)$$
- Key fact: price increases boost revenue iff $|\varepsilon(p)| < 1$

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- Elasticity measures the effect on demand of a small change in price.
- If the cost of coal goes up, when do people start putting on coats instead?
- How much does quantity stretch for a given amount of price change?
- The price elasticity of demand is the percent change in quantity divided by the percent change in price.
- When elasticity equals 1, it means there are substitutes.
- If someone is a monopolist - put up the price until the elasticity nears 1.

Supply

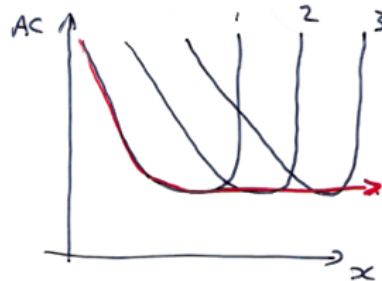


- Firms typically have fixed costs and variable costs, so the average cost of goods initially falls with output
- The variable costs typically rise at some point (overtime etc) and eventually rise sharply due to capacity constraints
- Thus the supply curve typically takes the above convex shape, at least in the short run (static analysis)

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- As seen in the previous example –suppliers have constraints.
- It can suddenly become more expensive - if don't have capacity in the open cut mine, open the deep mine.
- Cars – you might start by making a small amount - if you start making more cars, the price goes down.
- There is a point when the costs go up as you reach capacity constraints – paying overtime, require more factories, etc.
- The supply curve typically takes a convex shape.

Cost evolution

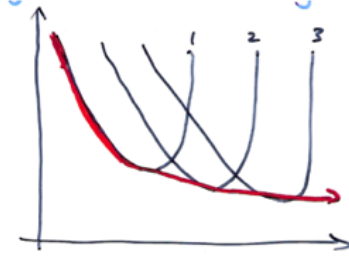


- In the long run, firms can fix capacity constraints by building more factories
- This gives nearly constant fixed costs and thus constant returns to scale as the firm / industry expands

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- In the long run, firms can fix capacity constraints, such as by building more factories.
- This cost evolution gives nearly constant fixed costs and thus constant returns to scale as the firm and industry expands.

Effects of technology

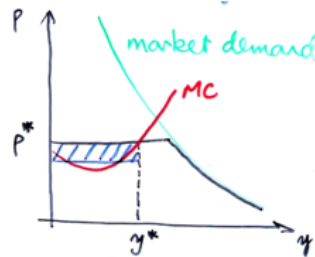


- In a traditional industry, technology can improve the process; larger / newer factories may be better
- Some industries have natural limits (not everyone wants to drive a Ford)
- In information goods and services industries, marginal costs may never rise – so firms like Microsoft enjoy ever-increasing returns to scale

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- Our industry is different – typically low marginal costs.
- Can go up from a million to a billion users with relatively little extra effort.
- Cost is not zero - need to make sure tech scales.
- Ever increasing returns to scale can crush competition.
- Once established - costs a lot for someone else compete with you.
- Technology can also automate and improve the processes.

Firm supply

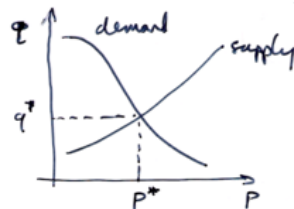


- In a competitive market, firms are price takers
- The demand curve faced by each firm is in black – at any price above p^* , demand is zero, while at any price below p^* , the firm would face all the demand
- The firm's profit is maximised when it sets output so that its marginal cost equals the price p^*

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- How supply and demand meets in normal industries.
- In a competitive market, firms are price takers.
- A consumer would not pay a higher price if the same good is cheaper elsewhere.
- Green line shows supply and demand - averaged over millions of consumers.
- Average cost curve in red.
- Costs go up once you reach capacity.
- If many firms in the market - then choose price p^* .
- If charge less, lose money as face more demand than have capacity to deliver and therefore costs increase.
- The firm's profit is maximised when it sells output so that its marginal cost - the cost per extra item – equals the price p^* .

Putting it all together



- In the classical synthesis, prices are set where supply and demand curves intersect in competitive markets
- Key: p^* will be the marginal cost of the marginal supplier
- Similar models apply in markets for labour etc
- Intrinsic advantages of non-marginal suppliers (e.g. easily mined coal, good farmland) get built into rental values
- By 100 years ago, people thought they understood the 'invisible hand' and just had to guard against monopoly

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- In the classical synthesis, prices are set where supply and demand curves intersect in competitive markets.
- This is the big insight that explains many of the strange and perverse behaviours in this industry.
- P^* and q^* are set by the intersection.
- P^* is the marginal cost of the marginal supplier.
- What happens if you are the landowner who owns the open cast mine? You know cost fluctuates between summer and winter.
- If costs between x and y depending on the season, sell at y , and the difference is profit with no extra effort.
- If you have easily mined coal - that gives you a rental value. Economic rent is the benefit received from non-produced inputs.
- E.g. farm land around Cambridge - pay about £10,000/acre - make about £2,000/acre from selling wheat, and around £2,000/acre in subsidies.
- The subsidies are a rental income which affect the value of farmland.
- 100 years ago - people thought they understood the invisible hand - thought they just had to guard against monopoly.
- Now you have all seeing, all knowing, non-marginal suppliers – which leads us to ask what is the market's view of the kind of rents you can charge in the future?

Equilibrium

- Studying supply and demand for one good is 'partial equilibrium analysis'. 'General equilibrium analysis' adds in labour, capital etc
- First theorem of welfare economics: market equilibrium is Pareto optimal
- Second theorem: any Pareto optimal allocation can be achieved by market forces provided preferences are convex
- Arrow and DeBreu, 1948. Technical conditions include rational actors, property rights, complete information, no transaction costs ... (more later)

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- Studying supply and demand for one good is partial equilibrium analysis.
- Extending to a model of macroeconomic behaviour – to include labour, capital, and so on, is general equilibrium analysis.
- Arrow and DeBreu - two theorems of welfare economics.
- The first theorem is that market equilibrium is Pareto optimal.
- The second is that any Pareto optimal allocation can be achieved by market forces provided preferences are convex.
- Conditions for the welfare theorems to apply – actors should be rational – there should be complete property rights – there should be complete information, no transaction costs (e.g. no stamp duty), and so on.
- These conditions are often broken in practice.

Efficiency, welfare and justice

- Efficiency does not imply justice! Giving the king all the money is Pareto efficient
- Different theories of justice are consistent with different welfare functions
 - $W = \sum U_i$ is classical utilitarian welfare
 - $W = \min U_i$ is Rawlsian welfare – that of the most miserable citizen
- Pigou: diminishing marginal utility of money means that transferring £1 from a rich man to a poor one will generally increase welfare
- But – there's a methodological problem!

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- Efficiency is often used by politicians to argue that market outcomes are the best practice.
- But we don't have perfect markets, and Pareto efficiency does not imply justice.
- Different theories of justice are consistent with different welfare functions.
- Classical utility welfare - greatest good for the greatest number – add up the individual utilities and use the resulting number as a kind of social utility.
- Rawls - should not be using the sum of U_i but care about the welfare of the most miserable citizen – therefore should be considering the lowest U_i , not the summed U_i .
- Economists have been arguing for years what W should be for the ideal world.
- Money like everything else has a diminishing marginal utility.
- Methodological problem - composing utilities into welfare is hard.

Efficiency, welfare and justice (2)

- Composing utilities into welfare is hard!

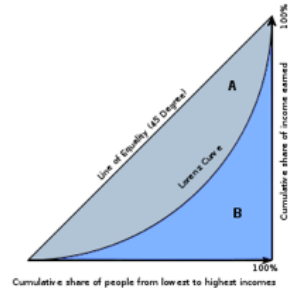
	A	B	C
First	X	Y	Z
Second	Y	Z	X
Third	Z	X	Y

- Arrow's impossibility theorem says there is no perfect way to aggregate personal choices into social welfare that's consistent with democracy

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- Arrow's impossibility theorem: no perfect way to aggregate personal choices into social welfare that's consistent with democracy.
- Exec summary, if Alice, Bob and Charlie have to choose between XYZ –
- The preferences are circular – so how to break them?
- When more than one preference in an election - tactical solutions work best.
- All sorts of schemes for voting - constant battles about changing voting rules in order to lead to certain outcomes.
- Can measuring the outcomes/correlates of different welfare functions.

Income distribution

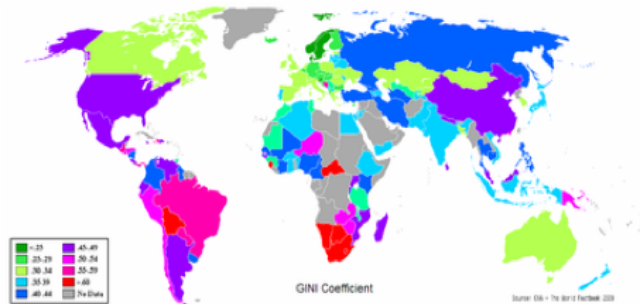


- The Gini coefficient is used to measure inequality
- $Gini = A/(A+B)$ in the above graph where B is the cumulative income distribution
- Gini = 0: communism; Gini = 1: the king has the lot

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- Increasing inequality.
- If have cumulative distribution where everyone had same income distribution, there would be straight line of equality, but more likely to be a Lorenz curve where B is the cumulative income.
- The more skewed the Lorenz curve, the greater the inequality in income distribution.
- The Gini coefficient is using the area A—the area between the Lorenz curve and the line of equality, divided by the area A plus B.
- If the Gini coefficient is 0, everyone has the same income.
- If the Gini coefficient is 1, the king has the lot.

Income distribution (2)



- Generally speaking, Gini falls with development
- Ranges from 0.247 in Denmark to .707 in Namibia
- Conflict theory explanation: over time, the poor fight harder for welfare than the rich resist them
- Democracy cuts both ways though: e.g. farm subsidy that gives each farmer £20000 but costs each nonfarmer £200 ⁵⁷

- Most developed countries have a Gini co-efficient in the range of .3 to .34, but some countries are very unequal.
- Certain things are correlated with the Gini coefficient - e.g. rate of violent crime.
- Some countries have become more equal over time - mainly those that are democratic.
- In the interest of big businesses to have an educated work force - might lobby for more equal distribution of wealth.
- Democracy is strongly correlated with equality and it can come both ways – If your software company succeeds you might spend £10,000 on a farm near Cambridge – income from agricultural subsidies.
- Farmers have a powerful and well connected lobby - go to Whitehall to ensure subsidies continue. Yet taxpayers don't do the same as the relative cost of the subsidy is low.
- Concentrated interests prevail over distributed interests.

Economics, Law and Ethics
Part IB CST 75%, Part II CST 50%
2019-20

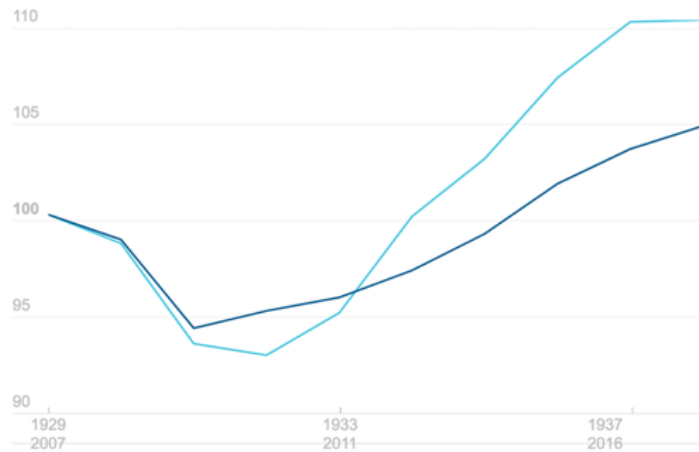
Alice Hutchings, Richard Clayton

with many thanks to Ross Anderson

The Business Cycle

GDP per 20- to 64-year-old. Index, 100 = level in pre-recession year

■ 1929-1938 ■ 2007-2016



Guardian graphic | Source: House of Commons Library, Bank of England, Central Statistics Office, ONS

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- Quick look at macro economics.
- Global financial crisis has dominated world political debate in the past 10 years.
- Banks collapsed and were bought out by the government –national debt doubled.
- Dip in GDP for 20 to 64 year olds – the light blue line is the 1929 recession - lasted about the same amount of time and led to WWII.
- This time –line is not quite as deep, but recovery hasn't been as thorough.
- This is simplified, and ignores that there are now a lot more pensioners.

The business cycle (2)

- The business cycle was a puzzle for classical economists. Why the pattern of boom and bust?
- Say's law: supply and demand are equal
- Mill and Ricardo argued that demand for goods + savings = supply of goods + investment, and savings = investment, so demand = supply
- 1930s: Keynes' more sophisticated model of 'liquidity preference'. People want a certain level of savings – maybe 3 months' salary. In a recession, liquidity preference rises
- Many other dynamic effects, different timescales...

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- It had been assumed that supply and demand can never go out of kilter. So why the pattern of boom and bust?
- Mill and Ricardo argued for a more nuanced model: demand for goods plus savings equalled the supply of goods plus investment. Savings equals investment, so demand equals supply
- According to this, you have to think of the market for money as well as the market for goods.
- Keynes came up with the more sophisticated model of liquidity preference: How much savings people want as a function of confidence.
- When the economy goes bad people cut back on spending and start saving.
- In a recession, liquidity preference rises.

The business cycle (3)

- Credit actually introduces instability
- In a boom, people and firms borrow assets that appreciate faster than the interest they pay
- A bank that takes in £100 in deposits might lend out £94; so £6 of capital underwrites £94 of lending – a multiplier of $94/6 = 15.7$
- In a recession many things happen at once:
 - Some loans go bad, eating into capital
 - The bank's share price falls, further eating capital
 - The regulator raises capital requirements from 6% to 8%
 - The government competes for the available loans
- So the money supply could contract sharply
- This time round, governments fixed that (quantitative easing)

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- The kind of transactions that happen in an economy are on a huge range of timescales.
- In some markets there are inherent instabilities - in a boom people try to borrow money.
- If you borrow when the market is rising and sell later - the assets appreciate faster than the interest you pay.
- Banks are limited by reserve ratio - a bank that takes in £100 in deposits is only allowed to lend out £94. That £94 goes into the economy and gets lent out again - it is a multiplier.
- When the market goes the bank has to call in loans.
- The regulator raises capital requirement to curtail credit – so banks need more in reserve.
- As the economy goes into reverse, people lose their jobs, and tax revenue falls.
- Government needs to compete for available loans to pay suppliers, etc.
- Last time around, the government fixed that - effectively the Bank of England printed money and lent it to the government.

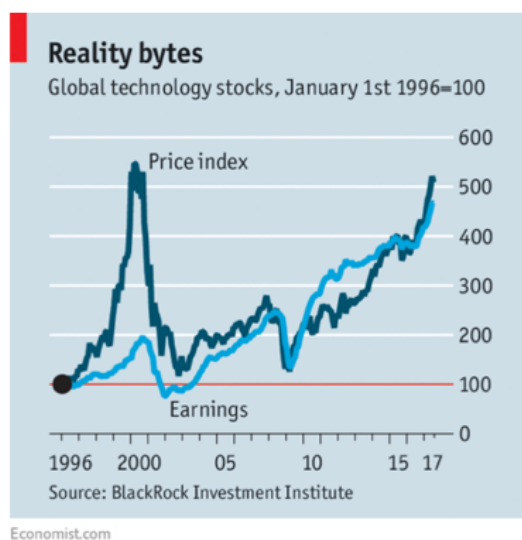
Recession and tech

- Great Recession kicked off by US mortgage crisis of 2007 which led to collapse of money markets
- Recessions may be fed by bubbles bursting but are often tied up with technology change
- Railways 1840s, electricity 1880s, cars 1920s, tech now – boom creates capacity, bust slashes prices
- We've killed whole industries (telephone switchgear), taken over others (bookselling), marginalized others (local newspapers, music publishers) and are disrupting most of the rest
- Schumpeter: 'creative destruction'

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- Recessions are tied up with technological change.
- In the 1830s and 1840s there were booms as people built the railways.
- When people figured out how to do electricity at scale – huge innovation.
- When cars came along - mass production lead to a big boom in the 1920s.
- As new tech comes along, old tech becomes obsolete.
- Nowadays, telephone switching has died, and Huawei and Cisco are making the money.
- Book sellers - Amazon sells over half of the world's books - implications for booksellers/bookshops/authors.
- Newspapers - a third of what was being printed previously.
- Schumpeter - described this as 'creative destruction' - fire gets rid of obsolete industries.

Recession and tech (2)



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- Recession and tech have interacted.
- 1990s - dot com bubble.
- The Internet arrived in mainstream economies.
- Huge bubble of confidence - people wanted to fund tech industry.
- Many companies went bust, but some, like Google, were phenomenal investments.
- Banks realised they'd gone to far - so a bust. But earnings have continued to rise.
- Dip in 2008 when the GFC hit. But now the tech stocks are about where they were at the height of the bubble.

Trade

- Adam Smith “Wealth of Nations” (1776):
‘If a foreign country can supply us with a commodity cheaper than we ourselves can make it, better buy it off them with some part of the produce of our own industry, employed in a way in which we have some advantage’
- Ricardo, 1817: it’s comparative advantage that matters

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- Trade has engaged British politics for hundreds of years.
- Adam Smith stated “if a foreign company can supply us with a commodity cheaper than we ourselves can make it, better buy it of them with some part of the produce of our own industry, employed in a way in which we have some advantage.’
- Radical idea at the time.
- Back then governments took the view that the role of policy was to maximise exports, minimise imports and in this way increase wealth.

Trade (2)

- Ricardo considered the following costs:

	wheat	wine
England	15	30
Portugal	10	15

- Portugal has an absolute advantage at producing both
- But England has a comparative advantage in wheat – each unit costs 1/2 unit of wine versus Portugal's cost of 2/3 a unit of wine

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- Ricardo noted it was comparative advantage that matters.
- Consider England and Portugal – It costs more to grow food and wine in England because Portugal is sunnier.
- Portugal has an advantage for producing both wheat and wine. But if we import then our farmers go bankrupt.
- England has a comparative advantage of wheat. Each unit costs half a unit of wine versus Portugal's cost of two-thirds a unit of wine.

Trade (3)

- Suppose England has 270 units of labour, Portugal 180

	wheat	wine		wheat	wine
E	8	5	E	18	0
P	9	6	P	0	12
Total	17	11	Total	18	12

- Mill: welfare gains from trade come from cheap imports
- Heckscher-Olin model: capital v labour (outsourcing)
- Under perfect competition, free trade optimal; almost all economists agree it's also a pragmatic optimum; but there can still be losers. English vintners?

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- If English has 270 units of labour - e.g. person hours per month - and Portugal has 180.
- If produce units of wheat and wine according the table on the left, then there are 17 units of wheat, and 11 units of wine.
- If each specialise where they have the comparative advantage - then each are better off.
- Overall, there are 18 units of wheat being produced, and 12 of wine.
- This argument gained force over time – In the 1840s there was a huge row about the corn laws.
- This doesn't just apply to goods - also capital and labour, e.g. EU single market allows for free movement for people and goods and services.
- Everyone overall ends up better off - strong consensus for economists is that free trade is a pragmatic optimum, but there can still losers, such as English vintners.

Growth

- Adam Smith: output = $f(\text{land, labour, capital})$; so growth means land improvement / colonisation, education / specialisation, capital accumulation
- Keynes: it's all about capital formation
- Neoclassical school (Solow, Swann...): it's all about technology and population growth
- Modern view (Becker, Romer): mostly know-how
- Chad Jones: US growth 1950–93 due 50% to worldwide R&D, 30% better education, 20% to population growth in idea-producing countries
- Prescription: spend four times as much on R&D!

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- The tech industry is also tied up with growth
- Research is sponsored due to the assumption that this leads to development and employment and increases in taxes, etc.
- The 18th century - output is a function of land, labour and capital. Growth means colonisation, improving the land, improving labour, increasing work force, and educating people.
- The Keynesian idea is it's about how much capital you have.
- State invested in technology, owned British Telecom, British Airways, etc.
- The Neoclassical school was about all-out tech and population growth.
- The Modern view - knowledge is the driver of long-term economic growth.
- Data indicates half of the growth is due to R&D, 30% is due to better education, 20% is due to population growth in idea-producing countries.
- Economic consensus is the world should be spending about four times as much on R&D as we are at the moment.
- Why don't we spend enough?

Tragedy of the commons

- 100 peasants each graze a sheep on the common
- If one peasant adds one more, he gets 100% more, while the others get 1% less
- Overgrazing, overfishing ...
- Welfare theorems assume complete property rights, atomistic principals and full information
- Where this fails, private cost \neq social cost
- Observed forever, documented by 1830s, used to justify enclosure movement, inspired Malthus

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- Interesting question of public goods - tragedy of the commons.
- 100 people each graze a sheep on the common. If one adds one more, they get 100% more, while the other sheep get 1% less grass to eat.
- Others start to cheat as well - get another sheep and soon there is desolate land and a lot of starving sheep.
- This is what we're seeing with overgrazing, overfishing, etc.
- Classical view of economics - welfare theorems assume complete property rights.
- Where you have a common resource you don't actually have property rights.
- Each farmer cannot enforce the number of sheep on the commons.
- Example of a more general problem of externalities.

Externalities

- Externalities are goods / bads people care about, but not traded: typically side-effects
- Consumption externalities include smoking in restaurants, domestic heating emitting CO₂
- Production externalities include a steelworks polluting a fishery downstream, or emitting CO₂
- Positive externalities include education (1 more year = 2% crime reduction), file formats,...
- In the presence of externalities, competitive equilibria are unlikely to be Pareto efficient
- Can in theory fix with property rights (Coase) but this is hard with many players, or delays

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- Externalities - goods or bad that people care about that are typically side effects.
- 10 years ago people could smoke in restaurants, so people who didn't smoke didn't go to restaurants.
- Eventually regulation stopped this, but the tobacco industry lobbied against it.
- Externalities can also be positive - e.g. if people are educated, tends to reduce crime so a benefit to the entire society.
- File formats –debates about open or private file formats for genetics research.
- If you have externalities then competitive equilibria are unlikely to be Pareto efficient - in theory can fix this with property rights - but hard to do when there are many players or delays.
- The problem with raising sheep was fixed when aristocrats took over ownership of the commons and dictated how many sheep could be grazed on it - and subsistence farmers went to get jobs in factories.

Public goods

- A public good is non-rivalrous and non-excludable
- Example: scientific knowledge. The producer can appropriate a small part of the benefit (e.g. PhD thesis); the rest spills over to all
- Example of a public bad: CO₂ emissions. Again, everyone gets to 'consume' the same amount
- Strong temptation for people to free-ride!
- If production is decided communally, there are potential 'impossibility theorem' issues
- Alternatives? Prizes / taxes? Cap-and-trade? ...

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- Public goods are an extreme case of raising sheep on the common.
- Some types of goods where you can't exclude people - e.g. scientific knowledge.
- Free software, open access papers are in the public domain and as many people can consume the goods as they wish.
- Benefits of research are available to everyone to use and build on.
- CO₂ emissions are an example of a public bad – the average time in the atmosphere is 6 weeks - the temptation is to free ride.
- Similarly, you can read scientific discoveries without contributing and doing your own research.
- Fix this by handing out money by means of grants and awards.
- In science – the amount of money spent depends on how big the industry is to capture the benefits.
- America is spending more on science because they have Google, Facebook, etc.

Club goods

- Traditional communities can simply limit scale
- E.g. fishermen in Turkey: 40 fishermen gather in tea-house, arrange rota, signed by mayor
- Self-enforcing: if you find another boat in a good spot when it's your turn, chase them
- Elinor Ostrom studied many examples to work out the conditions under which this is sustainable
- Internet routing used to work this way!
- But what happens when the club breaks down?

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- What can you do to deal with this?
- Arrange things so public goods are limited to certain memberships. If the membership is small enough to organise things socially, then can limit scale.
- E.g. Turkish fishermen – 40 different fishing boats but some fishing sites are better than others - over time they arranged to get together once a year –
- Map out where the fishing grounds are - agree who could fish where on a certain day – the mayor signs it off .
- Anyone fishing where they shouldn't be could be chased off with the support of the community.
- Internet routing used to work this way – met twice a year at RIPE. Now bringing to break down because of consolidation.

Enter politics ...

- Buchanan: 'Politics is a structure of complex exchange among individuals, a structure within which persons seek to secure collectively their own privately defined objectives that cannot be efficiently secured through simple market exchanges.'
- But politics has costs too!

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- This leads to politics.
- James Buchanan - studied politics from an economic viewpoint.
- But politics has its own costs.

Monopoly rents

- Absent barriers to entry, firms will enter a market until excess profits competed away
- Economists define a rent as an excess, undeserved income resulting from barriers to competition
- 'Rent-seeking' drives much of politics

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- Monopoly rents.
- In the absence of barriers to entry - firms enter the market until excess profits are eaten away.
- Rent is an excess, undeserved income resulting from barriers to competition.
- In tech, the objective is often to try to create a rent - income from a website or application.
- Uber doesn't make money from driving cabs, but from its app.
- Rent seeking drives politics—lobbying to increase agricultural subsidies leads to increased value of farmland, but not to farmhands being paid more.

Monopoly rents

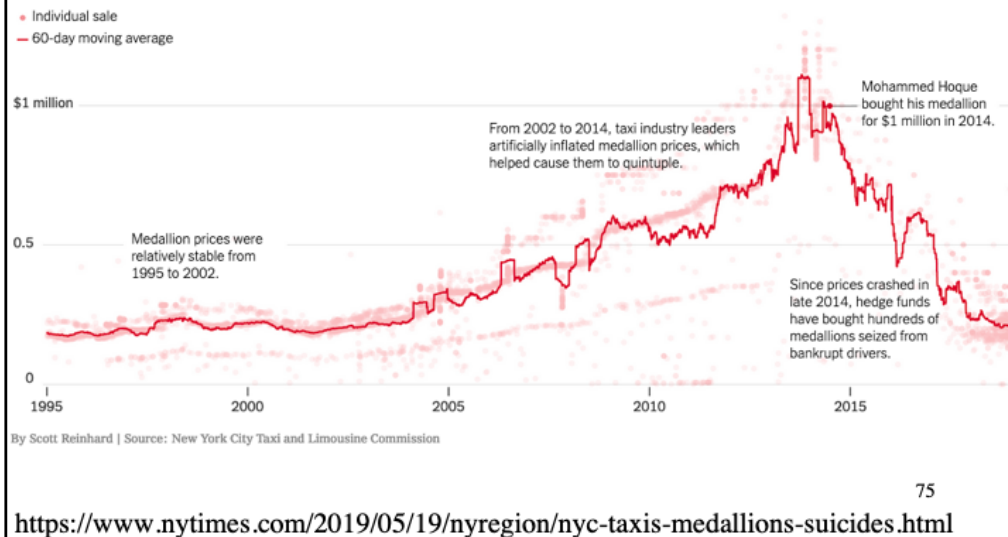
- What if we regulate prices?
 - In 1986, New York taxi licenses cost \$100,000 yet drivers earned \$8 an hour
 - License owner makes \$17k p.a. net – 17% ROI
 - Politicians put up fares, supposedly to help drivers
 - Extra \$10,000 p.a. just added \$60K to the value of a license, so helped the owners instead!

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- What if we regulate prices?
- In New York in 1986, taxi licences cost \$100,000, yet drivers earn \$8 an hour.
- The licence owner makes \$17,000 a year, a 17% return on investment.
- The Mayor put up fares to get taxi drivers to vote for him - the value of a taxi licence went up.
- The extra \$10,000 per annum from increased fares added to \$60,000 to the value of a licence, and the taxi drivers kept making \$8/hour.
- Taxi licence owners who are sophisticated will lobby for the taxi fares to be put up because they can then sell on their taxi licence later.

Monopoly rents

How the Price of a New York City Taxi Medallion Has Changed



- From 2002, the taxi industry increased the price of taxi licences, from \$200,000 to over \$1M.
- Licence owners began selling their licences, including to the drivers who worked for them.
- The New York Times describes how drivers were misled into thinking they were paying much less for their licence than they actually had.
- They took on risky loans on debts they could not afford, under terms they did not understand.
- Powerful licence owners created a bubble, sold on their licences, and then the bubble burst.
- Similar conditions to the 2008 GFC.
- When the bubble burst, the drivers went bankrupt.

Competition and information

- The marginal cost of producing information is zero, so that's the market clearing price!
- Example – machine-readable phone books
 - 1986 – Nynex charge \$10,000 per disk
 - ProCD had the phone book retyped in Peking and started selling for \$300
 - ABI joined in
- Now it's a few bucks for a CD, or free online
- Hence Free Software Foundation slogan: 'information wants to be free'
- So how can you make money out of selling information – software, books, music, ...?

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- Last lecture - diagram showing where a competitive market will clear at the marginal cost of production.
- When you have information, the marginal cost of producing that information is zero.
- It doesn't cost more to create one more copy of a Wikipedia page.
- For example, machine readable phone books – in 1986 these cost \$10,000 per disk. Now can get it online for free.
- Became a cultural thing - e.g. Free Software Foundation's slogan, 'information want to be free'
- So how do you get money from selling information – whether it be books, software, or music....?

Lock-in

- Often, buying a product commits you to buying more of it, or spending money on one or more of:
 - durable complementary assets, such as apps for a computer or phone, tunes for your iPod
 - skills, e.g. fluency with Win/Mac/Linux or Office
 - services, e.g. network service for a PC or mobile phone, directory service for a PVR
- Same applies to services – facilities management firms make it hard to switch to their competitors
- Not new (fewer people change their bankers than their spouses) but has very pronounced effects in information goods markets

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- Lock-in is the way in which people in our trade make money.
- If you buy a product you're either committed to buying more on it, or spending money on it.
- Can create lock-in through skills – employees in an office may use Windows - once they have made the investment in learning something, it costs time and effort and bother to change.
- Lock-in through services. If you have a mobile phone – you need a calling plan.
- Drives investment in the Internet of Things - smart devices are being sold on the basis that they will check price of electricity or check what goods you need to buy.
- It's really about connecting your fridge to the tech company so they know how to sell you stuff.
- If you're working for a tech firm running government systems, the contract may be up for renewal every 7 years. You want to ensure that it's difficult and expensive for others to steal the customer.
- This is not new. People are more likely to change their spouses than bankers
- Banks get their customers while they're young, as children.
- Since the marginal cost of information is zero, then lock-in is one of the key tools used.

Lock-in (2)

- **'Fundamental theorem' (Shapiro, Varian); the net present value of your customer base is the total cost of switching**
 - Suppose you're an ISP and it costs £25 to set up a new customer
 - Suppose it costs a customer £50 of hassle to switch
 - If your new business model makes the customer worth £100, offer them £60 cashback to switch
 - They're £10 ahead, you're £15 ahead
- **So the value of Microsoft is what it would cost people to switch to Google Docs and Linux ...**

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- Shapiro and Varian - Fundamental Theorem – the net present value of your customer base is the total cost of switching.
- If you're an ISP, and it costs \$25 to set up a new customer.
- Let's say it costs a customer £50 worth of hassle to switch.
- If your new business model makes the customer worth £100, offer them £60 cashback to switch.
- They're £10 ahead, and you're £15 ahead.
- So, the value of Microsoft is what it would cost people to switch to Google Docs or Linux.

Lock-in (3)

- The incumbent will strive to maximise switching costs, competitors to minimise them
 - file format wars
 - loyalty programs
 - phone number portability
- Incumbents promote complementary goods and services that increase lockin – from tied printer cartridges to G Suite and Facebook Connect
- Asymmetric switching costs – a phone network has to supply a phone to win a customer, but to keep one can offer extra minutes which cost it nothing

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- Suppose have 100 employees and you've given them all Microsoft Office and Windows - how much will it cost for people to switch to Google Docs and Linux? The cost of having to retrain everyone may be about £20k. This is the argument that dictates the value of Microsoft - the cost to switch to open source.
- Phone number portability has been a big deal in the last 15 years. Your phone number used to be tied to the supplier - if you wanted to change provider you had change phone numbers. In the end regulators made a rule that you had to take your phone number when you swapped.
- Lock-in also promotes complementary goods and services - e.g. Xerox had the idea to electronically tie print cartridges to the printer themselves. Subsidise the cost of printers - individuals tend to look at the sticker price, not the running cost.
- Big service firms build the entire ecosystem - Google doesn't just provide a search engine, also G-Suite, calendar, gmail, etc. When you use the whole package, everything works a bit better.
- Switching costs are intrinsically asymmetric. If you are a new phone network, to get customers you need to give them phones, so the customer acquisition cost is several hundred pounds. If you are an incumbent and get asked by a customer to switch the number, you offer bonuses to stay - the retention costs is virtually zero.
- Lock-in is a huge deal in the industry - increase your own lock in or decrease competitors lock in.

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with many thanks to Ross Anderson

Network externalities

- Many networks become more valuable to each user the more people use them
- Metcalfe's law: the value of a network is proportional to the square of the number of users
- It's actually more complex than this (local effects are stronger) but still more than linear
- Overall effect: past some threshold, network use takes off rapidly (and creates lock-in)
 - Telephone – late 19th century
 - Fax – 1985–88
 - Email – 1995–99

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- Networks become more valuable the more people use them.
- When Bell created the first telephone, all he could call was his assistant in the next room.
- But the real value is when you could actually have people talk to each other.
- When some people have a phone everyone else wants one and it takes off.
- According to Metcalfe's Law, the value of a network is proportional to the square of the number of users.
- When you have x people in a network, the value of the network is x squared.
- A tenfold increase in the size of a network leads to roughly a hundredfold increase in its value.
- It is a little more complex than this as local effects are stronger.
- In the late 19th century - suddenly there were enough people with phones who wanted to use them.
- In the 1980s everyone who was a serious business needed to communicate by fax.
- Same thing with email in 1995.

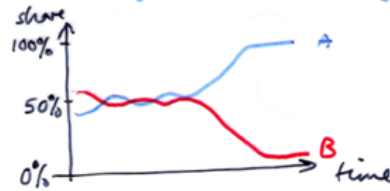
Network externalities (2)

- As well as 'real networks' like fax and email there are 'virtual networks' such as PCs and software
 - Most people used to buy PCs rather than Macs because of software
 - Back in 1985 companies started to write software for PCs first and Macs second, as they thought the PC was winning
 - So it won – people bought PCs for the software
- It works for bads as well as for goods: malware writers target Windows although Mac (and Linux) are also vulnerable

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- As real networks like fax and email there are virtual networks like PCs and software.
- Two sided market, because if you go and buy a PC you're in the market to buy software for it, but you're no longer in the market for software for Macs or Unix.
- When social networks came along there were 30 or 40 that were competing, but then Facebook broke through and got dominance.
- Network effects are also relevant for bads as well as goods. At first approximation - malware is for Windows.

Network externalities (3)



- So markets with network effects can 'tip'
- It's particularly common with two-sided markets
- Other examples:
 - Rail gauges in the 19th century
 - Colour TV standards in the 1950s
 - VHS v Betamax, Blu-Ray vs HD-DVD, ...
 - Paypal v other online payment startups 15 years ago
 - Facebook v Myspace, Bebo, Friendster, ... 10 years ago

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- When you have two sided markets and network effects, the market will tip.
- Eventually one competitor will be marginalised.
- E.g. railway track gauges in the 19th century.
- When railroads began to be built, tracks of varying widths were employed. \
- Arbitrary early choices had long lasting impacts.
- Over considerable time, a standard gauge was developed to allow for interconnections, so the same engines and locomotives could use the same tracks.
- There have been a number of fights over video cassettes and then disk formats.
- 15 years ago number of people providing payment services via email, PayPal was the one that emerged.

Strategic issues

- Each of these factors – high fixed costs plus low marginal costs, significant switching costs due to technical lock-in, and network externalities – tends to lead to a dominant-firm market model
- Given all three, monopoly is even more likely
- Hence the race for market share whenever a new product or service market opens
- Hence the 1990s Microsoft philosophy ‘ship it Tuesday and get it right by version 3’
- Business driver: is your customer acquisition cost (CAC) still less than your lifetime value (LTV)?

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- Three factors that make a dominant-firm market model more likely.

1. High fixed costs and low marginal costs

2. Significant switching costs due to technical lock in and

3. Network externalities.

- Explains frenzy and hype surrounding new products and services.

- VCs and entrepreneurs race to be at the starting line because if you're not in it you can't win it.

- In the 1990s, IBM took a staid approach. Make sure you engineer properly and test everything and get it right, always ship quality products.

- Microsoft on the other hand took a different approach- ship it Tuesday and get it right by Version 3.

- From the point of view of business - customer acquisition cost and lifetime value of the customer.

- You can put a capital cost on that depending on what the current interest rate is.

- If each customer is worth £200 and the interest rate is 10%, then the value of the customer is £220.

- If the lifetime value is £15,000, go to marketing department and ask if can buy new customers for less than that.

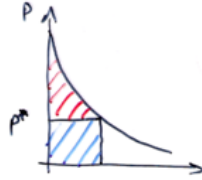
Strategic issues (2)

- **Ethics:** how bad are monopolies?
- **Policy:** do you hope that the incumbents become obsolete, or do you regulate?
- **EU law:** a fairly-won monopoly is OK but using dominance in one field to get it in another is illegal
- **US:** monopoly used to be measured by consumer surplus (which doesn't work for Google, Facebook, Amazon, Wikipedia...)

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- This leads to an ethical question - how bad are monopolies?
- The classical view is that it is a bad thing.
- But need to start thinking about other costs.
- The other cost is that innovation is hard.
- According to EU laws - monopoly is ok, but if you're using your dominance in one field to get dominance in another field, that's not ok.
- For example, Google can create new products, but if they use their dominance in the market for search results to direct people towards those products they can get in trouble.
- The US takes a much more free market approach - individuals can bring lawsuits against their competitors.
- One of the big policy issues here is how you measure monopoly.
- The naive approach is to approach monopoly through consumer surplus, but Wikipedia does not make profits.
- There is no legal remedy for the bookshops that close as a result of Amazon.

Price discrimination



- Recall: an efficient monopolist sells to each customer at her reservation price – ‘selling to value’
- Pigou’s three degrees of price discrimination:
 1. Personalised pricing (e.g. haggling, loyalty cards ...)
 2. Versioning (e.g. first / business / economy class)
 3. Group pricing (e.g. student and OAP discounts)
- Around forever – but getting more powerful and pervasive
- Tech simultaneously increases the motive and the means (and drives the erosion of privacy)

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- The efficient monopolist sells to the customer at their reservation price - selling to value.
- This is price discrimination.
- Traditionally there are three ways to price discriminate.
 1. With customised or personalised pricing, there is a special price just for you.
 2. With Versioning there are different prices for different levels of comfort. For example, airlines offer first, business and economy class tickets.
 3. Group pricing is based on purchaser types, e.g. student discounts, or old age pensioner discounts.
- The most efficiently you can tailor your price discrimination, the more surplus you have.
- Technology increases the motive and the means to price discriminate, because companies have more information about you and your preferences and what you have bought in the past.
- This drives the erosion of privacy.

Price discrimination (2)

- Versioning can include 'pricing for sharing', e.g. scientific journals charge libraries more than private readers
- Disney DVDs are cheaper than titles people rent
- Versioning can include marketing – e.g. magazines cheap for students but expensive for business
- Much of the promised efficiency gain from e-commerce was based on hope of more effective price discrimination
- But discrimination is often unpopular!

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- Price discrimination comes in all forms.
- You can price things for sharing - so scientific journals charge university libraries more than individuals.
- Versioning includes marketing.
- Students can get cheap subscriptions to the Economist and NY Times.
- The idea is that you get addicted, and when you're in a big company you continue to buy the product, and the business will pay a higher cost.
- Discrimination is unpopular, which is one of the things that's pushing back on it.

Cruel, mean or lavish ...

It is not because of the few thousand francs which would have to be spent to put a roof over the third-class seats that some company or other has open carriages with wooden benches. What that company is trying to do is prevent the passengers who can pay the second class fare from travelling third class; it hits the poor, not because it wants to hurt them, but to frighten the rich. And it is again for the same reason that the companies, having proved almost cruel to the third-class passengers and mean to the second-class ones, become lavish in dealing with first-class passengers. Having refused the poor what is necessary, they give the rich what is superfluous. (Jules Dupuit, 1849)

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This is not new – a French economist noted this in 1849

Bundling

- One way to conceal discrimination in 'bundling': selling a number of products together, as with Microsoft Office
- Suppose Alice and Bob have the following reservation prices for Word and Excel

	Word	Excel
Alice	£50	£75
Bob	£75	£50

- With separate pricing, MS would charge £50 per product and get £100 per customer, or £75 and get £75
- By selling them together, it gets £125
- Can sell different bundles, e.g. annual sub with Office 365₈₉

- Number of ways of hiding price discrimination, including bundling, deals, packages and cash backs.

- Bundling - suppose Alice and Bob have the following reservation prices. Alice is an accountant, and is willing to pay £75 for Excel, but only £50 for Word. Bob is an author, so he's willing to pay £75 for Word, but only £50 for Excel.

- If Microsoft is selling the products separately, can sell for £50 per product and get £100 per customer, or £75 and get £75.

- However, by selling them together they can get 125 pounds.

Asymmetric information

- Akerlof won the Nobel for the 'market for lemons'
 - 100 used cars for sale – 50 good cars worth \$2000, 50 lemons worth \$1000
 - Buyers can't tell difference – so price \$1000
- One fix is for sellers to offer a warranty – this is cheaper for owners of good cars, so can act as a 'signal' for the hidden information
- Why is a Cambridge degree valuable? It's hard for employers to tell smart diligent employees from interview, so many use education as a signal
- Signaling theory is important for recommender systems – Google, eBay, Grameen

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- Akerlof - asymmetric information
- If you have 100 used cars - 50 which never break down, and 50 which are forever breaking down. If half are worth £2000 and half worth £1000, and the buyer doesn't know which is which, you might think they would sell at £1,500. However those with the good cars would not sell at this price, so only the bad cars end up on the market. This is why new cars drop so dramatically in value once they're off the lot.
- You can offer a warranty - this is cheaper for owners of good cars - so can be a 'signal' for hidden information.
- Also explains why Cambridge degrees are so valuable. If you're an employer, you don't know who will be good at writing software. But if you hire a Cambridge graduate you know they were good enough and bright enough at the age of 18.
- This is an example of signalling. Many online businesses run recommender systems of one kind or another.
- E.g. Amazon, Trip Advisor, eBay, Uber. Grameen is a bank in Bangladesh that lends money to poor people. It relies on social trust as money is distributed based on recommendations in the village.
- Recommendation systems are increasingly used in business to business systems, taking over what used to happen with quality control.

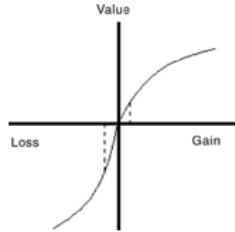
Asymmetric information (2)

- Do Volvo drivers have more accidents because:
 - Bad drivers buy a Volvo to survive accidents better
 - Volvo drivers compensate for safety by driving faster?
- The first effect is 'adverse selection' and the second 'moral hazard': examples of 'hidden information' versus 'hidden action'
- Lemons market: adverse selection
- Insurance markets can also be trashed by moral hazard; hence excess, no-claims bonus, ...
- Moral hazard can also lead to surveillance, such as insurance company black boxes monitoring drivers

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- Why do Volvo drivers have more accidents? Is it because
 1. If you're a bad driver you buy a Volvo because you'll survive if you have a crash, or
 2. Volvo drivers compensate for safety by driving faster
- The first effect is adverse selection and the second is moral hazard.
- These are examples of hidden information and hidden action.
- Important for insurance markets - people who are unwell will buy health insurance but those that are fit and healthy invest in pensions.
- If people make bets have more information than you have, then you lose out.
- Technology is used for surveillance – e.g. lower cost insurance if you have a black box that surveils your actions.

Bounded rationality



- Recall Prospect Theory from 1a SSE: people offered £10 or a 50% chance of £20 usually prefer the former; if offered a loss of £10 or a 50% chance of a loss of £20 they usually prefer the latter!
- And recall the Asian disease problem – framing actions as ‘saving’ can make them more attractive
- The misperception of risk is a big deal: it’s how terrorism works (and a lot of other political marketing)
- ‘Behavioural economics’ studies all this stuff

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- Recall prospect theory from 1A Software and Security Engineering.
- If people are offered £10 or a 50% chance of £20, they usually prefer the former.
- If offered a loss of £10, or a 50% chance of a loss of £20 they usually prefer the latter.
- You may also recall the Asian disease problem. If you’re selling a vaccine your success will depend on whether it’s been presented as a gain or a loss.
- Misperception of risk is a big deal - how political marketing and terrorism works.

Bounded rationality (2)

- Herb Simon coined 'bounded rationality' in the 1950s along with 'satisfice'
- People try to make just-good-enough decisions
- A satisficer will work hard until his lifestyle goals are met, then slack off.
- Most of us are satisficers, and VCs don't like this!
- Another common rationality bound is 'hyperbolic discounting': people disregard far-future events (most people have inadequate pensions)
- The endowment effect: people generally demand a higher price for something they already own

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- Simon coined 'bounded rationality' along with the concept of 'satisficer'.
- If you're a satisficer you will slack off once your goals are reached.
- Hyperbolic discounting – people disregard events that are likely to occur in the future. This is why most people have inadequate pensions.
- Endowment effects - people's maximum willingness to pay to acquire an object is typically lower than the least amount they are willing to accept to give up that same object when they own it.

Cultural biases

- Some biases we acquired from evolution are modulated by culture
- Caliskan noted that machine translation from gender-neutral Turkish text gave male doctors, but female nurses
- She ran experiments and found all MT systems were sexist, racist, homophobic ... inhaling prejudice with their training data
- See paper, linked from web page

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- Cultural bias is the way with which individuals make consistently biased decisions.
- Irrational, but propagated through culture, such as language.
- Caliskan noticed that machine translation in Turkish, which does not specify gender, found that Doctors were he's and nurses were she's.
- She ran experiments and found that machine translation systems were sexist, racist, etc due to training data prejudices.
- How do you capture implicit biases ingrained in culture?

The power of defaults

- Most people just go with the flow. So:
- Marketing: firms make people opt out of getting spam / buying extra insurance ...
- Libertarian paternalism: governments make people opt out of some policy options, from pensions (US, UK) to organ donation (Spain) to use of medical records in research (most countries)
- Recall from SSE: why do people worry too much about terrorism, but not enough about IT security?

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- Most people are lazy, go with the flow and accept the product as it comes out of the box.
- In the UK, in the past if you wanted a pension you had to sign up for it. The law was changed it's opt-out if you don't want one. Now most people have provisions for their own age.
- In Spain organ donation is permitted by default, while in Britain you have to opt in (this will be changing next year to an opt out system).
- Relates to the use of medical records for research - to what extent is it ethical to opt out of sharing data, rather than requiring people to opt out?
- In Iceland 15 years ago high court decided that people had to opt in for medical research.
- People worry more about terrorism than security because more worried you are the more likely you will be to vote for the government rather than the opposition.

Agency effects

- Classical economics sees institutions as rational
- But decisions are made by individual managers, who optimise their own utility too
- ‘New institutional economics’: study managers’ behaviour. Should you give them stock options to align their interests with shareholders?
- ‘Public-choice economics’: apply this incentive analysis to civil servants and elected politicians (“Yes, Minister”). What’s the cost of democracy?
- Why do public-sector IT projects fail more often?

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- Classical economics sees institutions as rational.
- But many decisions are made by managers who are maximising their own utility too.
- How do you incentivise managers? Give them stock options to align their interests with those of the company?
- Public choice economics applies incentive analysis to civil servants and elected politicians.
- Why do public sector IT projects fail more often than private sector projects? About a third of all big IT projects fail, but in the public sector only about a third will succeed.
- Comes down to the way that ministers and civil servants behave and pass the buck.

Transaction costs

- Trades are not free! Time & effort; commissions; search; bargaining; policing and enforcement
- Ronald Coase (1937): why do some sectors have large companies, and others small ones? External transaction costs higher than internal ones
- Jensen-Mockling (1976): agency costs within firms also matter hugely
- Oliver Williamson (1980s-90s): incomplete contracts: frequency, specificity, uncertainty, limited rationality, opportunistic behavior
- So should tech make firms smaller on average?

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- Classical economics assumes that trades are free, but they aren't.
- Coase noted external transitional costs are higher than internal ones. If you have an industry where organising production is difficult because of quality control, then it makes sense to produce goods internally, where you can control manufacturing.
- Jensen-Mockling later noted that agency costs within firms also matter - so makes sense to subcontract some components.
- Oliver Williamson – contracts between firms are often incomplete. Not possible to have a contract that specifies the legal consequences of every possible state of the world. There is limited rationality, opportunistic behaviour, and information asymmetry.
- Transaction costs are an issue that may occasionally be seen.

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with many thanks to Ross Anderson

Auctions

- Around for millennia; standard way of selling livestock, fine art, mineral rights, bonds...
- Many other sales from corporate takeovers to house sales are also really auctions
- Auctions are a big success of the Internet, from eBay to Google
- Some unpleasant side-effects
- Rapidly growing interest in theoretical computer science: auction resources in distributed systems
- Many issues of asymmetric info, signaling, strategic play... – plus some solid theory!

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- Auctions have been around forever, mineral rights, bonds, paintings, house sales.
- From eBay to Google, many firms exist due to auctions.
- Interest to theoretical computer science - use auctions to distribute routes across distributed systems.
- All of the previous issues we've discussed come together in auction theory.

Types of auction

- English, or ascending-bid: start at reserve price and raise till a winner is left (art, antiques)
- Dutch, or descending-bid: start high and cut till somebody bids (flowers)
- First-price sealed-bid auction: one bid per bidder (government contracts)
- Second-price sealed-bid auction, or Vickrey auction: highest bidder wins and pays second-highest bid (postage stamps)
- All-pay auction: everyone pays at every round until one remaining bidder gets the goods (war, litigation, winner-takes-all market race)

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- Types of auctions

- English - e.g. Sothebys - hammer falls. Start at reserve and raise in increments until one winner left.
- Descending bid auction - Dutch - start high and then decrease.
- First price sealed bid auction - e.g. government auctions - opened in the presence of witnesses.
- Second price sealed bid auction - this is how you buy postage stamps. You allow people to bid, similar to English auction but the winner pays second highest bid.
- All pay auction – everyone pays at every round until one remaining bidder gets the goods. This is what happens in war, or during litigation

The Aalsmeer flower auction





Sealed-bid auction

- Email bid (without showing anyone else!) to:
ah793@cam.ac.uk

What could have gone wrong?

- How could those auctions have been gamed or rigged?

Strategic equivalence

- A Dutch auction and a first-price sealed-bid auction give the same result: the highest bidder gets the goods at his reservation price
- They are 'strategically equivalent'
- Ditto the English auction and the second-price sealed-bid auction (modulo the bid increment)
- But the two pairs are not strategically equivalent!
 - in a second-price auction it's best to bid truthfully
 - in a Dutch / first-price auction, you should bid low if you think your valuation is much higher than everybody else's

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- The Dutch and first price sealed give the same result. Ditto the English auction and second price sealed bid auction -
- But two pairs not strategically equivalent.
- Second price auction it's best to bid truthfully.
- Dutch/first price auction - bid low if you think the valuation is actually much higher.
- For a second price auction you should bid high if you think your valuation is higher than everyone else's, but not for Dutch auction.
- For a Dutch auction you should call out as soon as a price that is below your private value is reached.

Revenue equivalence

- This is weaker – not ‘who will win’ but ‘how much money on average’
- According to the revenue equivalence theorem, you get the same revenue from any well-behaved auction under ideal conditions
- These include risk-neutral bidders, no collusion, Pareto efficiency (highest value bidder gets goods), reserve price, independent valuations, ...
- Then bidders adjust their strategies and the English, Dutch and all-pay auction yield the same
- So when you design an auction, you must focus on any ways the conditions aren’t ideal

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- Revenue equivalence - not about who will win - but amount on average.
- Revenue equivalence theorem: this should be the same from any well behaved auction.
- Ideal conditions include risk neutral bidders, no collusion, Pareto efficiency (so the highest value bidder gets the goods), having a reserve price, and independent valuations.
- If these ideal conditions are met, the bidders adjust their strategies so that all auctions should give the same revenue.

What goes wrong (1)

- In a 'private-value auction', each bidder's value v_i is exogenous (think: sculpture). In a second-price auction, everything you buy is a bargain
- In a 'public-value auction', each item has a true price which bidders estimate at $v + \varepsilon_i$ (think mineral leases; spectrum auctions). The buyer is the sucker who overestimated the most!
- This is called 'the winner's curse'
- Many real auctions lie somewhere between these two extremes

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- Two types of auction in terms of valuation - private value auction - every bidder's value is entirely independent and comes from outside.
- If you buy art - the value is the amount of pleasure you obtain from it.
- Public value auction - there is an intrinsic value –e.g. mineral leases - there is an amount of oil there - each bidder has an estimation +/- error.
- The winner is the sucker who overestimated the most – the winner's curse.
- Real life - many lie somewhere between these extremes.
- Even with art there is social consensus that Picasso is good and collectable, so value is more than just pleasure.

What goes wrong (2)

- Bidding rings – bidders collude to buy low, have a private auction later, split the proceeds
- First-price auctions are harder to rig; with second-price, New Zealand bids of \$7m and \$5000
- Entry detection / deterrence: an early (1991) ITV franchise auction required bidders to draw up a detailed programming plan. In Midlands & Central Scotland, industry knew there was no competition; bids under 1p per head (vs £9–16 elsewhere)
- Predation: ‘we’ll top any other bid’ in takeovers
- Sniping and other boundary effects

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- Bidding rings – bidders collude to buy low and sell later at a higher price.
- First price auctions are harder to rig - here you need everyone to collude.
- With second price auctions, you could place a very high bid if you expect everyone else will bid low, knowing you will pay the second highest amount.
- In a New Zealand mobile licence auction the winner bid \$7m, but only paid \$5,000—the amount of the second highest bid.
- Attempts to deter people from entering low quality bids can also backfire. TV rights are typically auctioned for seven years at a time
- Early 1990s, TV authorities required a full program plan - what the programs would be, how much sport, news, etc. to ensure unsuitable bids did not win the auction.
- No competition in the Midlands and Central Scotland, so bids were low (1p/head, compared to £9-16 per head elsewhere).
- So placing barriers to enter the auction can affect what people are willing to pay.
- Predation – where you make it clear that you’ll top any other bid.
- Sniping - put in a bid right at the last minute before anyone else can top it.

What goes wrong (3)

- Risk aversion: if you prefer a certain profit of £1 to a 50% chance of £2, you'll bid higher at a first-price auction
- Signaling games: show aggression by a price hike
- E.g. in simultaneous auctions, as in the USA, signal "we want SF, LA, SD and if you compete with us there we'll push prices up in your patch")
- Budget constraints: if bidders are cash-limited, all-pay auctions are more profitable
- Externalities between bidders – e.g. arms sales

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- According to the revenue equivalence theorem, all auctions should have the same outcome if held under ideal conditions, including that bidders are risk neutral.
- But, as we learnt in the last lecture, rationality is bounded.
- Most people are risk adverse - if that's you you'll bid higher at a first price auction.
- Auctions can also go wrong when bidders play signalling games.
- Last lecture: you can signal qualities such as offering a guarantee to indicate that you are not selling a bad car.
- In auctions you can signal aggression by showing a price hike.
- Budget constraints - because revenue equivalence theorem only works if people have unlimited money –if bidders are cash limited, all pay auctions are more profitable.
- Externalities – e.g. the sale of arms during wars- you can profit by selling guns to both sides.

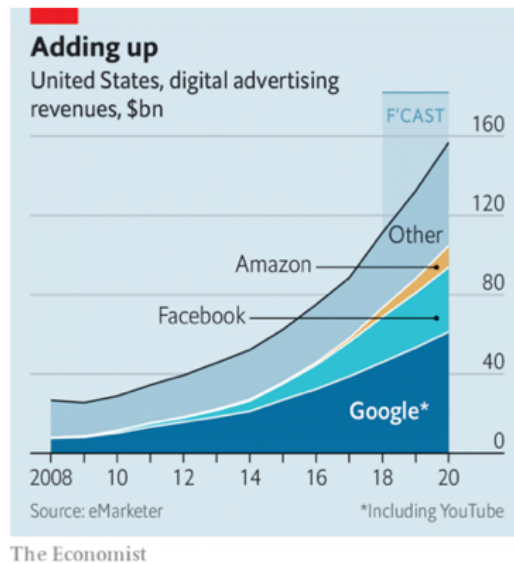
Combinatorial auctions

- Externalities lead to preferences for particular bundles of goods: landing slots at airports, spectrum, mineral rights...
- Bid ($\$x$ for $A+B+C$) or ($\$y$ for $A+D+E$) or...
- Critical app for CS: routing in presence of congestion (bid for AB and BC , or AD and DC ...)
- The allocation problem is NP-complete; practical algorithms work up to a few thousand objects
- Also: how can we make the auction strategy-proof (i.e. truth-telling is the best strategy)?
- New field of 'algorithmic mechanism design'

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- If you're trying to arrange an air route between London and Seattle to compete with BA you need a take off and landing slot in both cities an appropriate number of hours apart.
- So only interested buying goods if you have matched goods.
- Same thing for routing on the internet - if you want to deal with congestion and route from A to C, then you can bid for Ab and BC , or AD and DC ...
- The allocation problem is NP-complete yet practical algorithms work up for a few thousand objects.
- People who understand this are in great demand.
- How can you make the auction strategy proof? Make it a second price auction. People then have the incentive to tell the truth about their valuation.
- Gaming it is risky, as if others do the same you may be paying way more than it's worth, and suffer the winner's curse.
- Truth telling is the best strategy.

Ad auctions



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- Digital advertising revenues in the USA.
- Google makes about a third of the money - coming on for \$60B year.
- Another third goes to Facebook and Amazon, and the rest goes to everyone else.

Ad auctions (2)

- Pioneered by Google
- Basic idea: second-price auction mechanism but tweaked to optimise platform revenue
- Bidders bid prices p_i , platform estimates ad quality e_i , and then ad rank $a_i = p_i \cdot e_i$
- Ad quality $e_i = \text{relevance} \cdot \text{clickthrough rate}$
- So how do we work out who wins the auction and how much they pay?

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- Ad auctions is how Google made their money.
- Basic idea - second price auction mechanism tweaked to optimise platform revenue.
- Bidders bid prices p_i , the platform then estimates ad quality e_i , and then ad rank is p_i times e_i .
- Ad quality is based on relevance and clickthrough rate.
- How do we work out who wins the auction and how much they pay?

Ad auctions (3)

Advertiser	Quality Score	Bid	Ad Rank	Rank	CPC
Jerry	4	\$2.00	8	1	\$1.50
Elaine	2	\$3.00	6	2	\$2.00
George	1	\$4.00	4	3	\$3.00
Kramer	3	\$1.00	3	4	\$0.70

- Here George bids \$4 and Jerry \$2 but Jerry wins the auction because of higher ad quality – the platform expects he'll get four times the clicks
- Jerry pays a cost per click of only \$1.50 (bid times competitor ad rank / own ad rank)

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- Google model
- If you have four players bidding for the first ad position - Jerry, Elaine, George, and Kramer, and they have quality score of 4, 2, 1, 3
- Jerry bids \$2, but his ad is 8 times more likely to be clicked.
- Award the ad to Jerry. For every click on Jerry's ad, he pays \$1.50.
- This price is calculated by dividing Jerry's competitor's ad rank – 6 -- by Jerry's Ad Rank, which is 8, and then multiplying that result by Jerry's bid of \$2, to get \$1.50
- Tweaked version of a second price auction. Each advertiser is actually paying less than they originally bid. But as their bid does affect their ad rank, they have an incentive to tell the truth about their valuation.

Ethical aspects of ad auctions

- Translated to social media, ad ‘quality’ can easily segue into ‘virality’
- Then if your ads are good clickbait, and your followers follow them, you pay less
- See Martinez ‘How Trump conquered Facebook – without Russian ads’ (web page)
- Many sites tend to serve ever more provocative and extreme content...

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- What’s quality?
- If this is the likelihood that someone will click on their ad – actually a measure of virality.
- Pay less to disseminate clickbait.
- Donald Trump paid significantly less money per ad than Clinton.
- Barak Obama was paying less than McCain.
- See Martinez - ‘How Trump conquered Facebook’
- This is the mechanism by which sites use more and more provocative material and leads to clickbait and extreme content.
- Tricky issues. Optimal solutions can lead to undesirable side effects.

Economics, Law and Ethics
Part IB CST 75%, Part II CST 50%
2019-20

Alice Hutchings, Richard Clayton

with many thanks to Ross Anderson

Introduction to Law

- Two lectures
- This lecture:
 - how can you end up being liable for things you do online (contract vs tort)
 - how do you make the agreements you want to, and enforce them
 - when you need advice, and the context in which to understand it
- Next (Richard Clayton): IT-specific laws

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- Introduction to Law - two lectures
- The first is about how you can end up liable for things you do online. Two basic areas of law - contract versus tort.
- You need to be aware of how to make the agreements for the things you want to, and how you enforce them.
- You should also know when you need advice, and the context in which to understand it.
- Next week - Richard Clayton - IT specific laws.

What is law?

- We can't get all we want by private action because of externalities etc
- Politics: "a structure within which persons seek to secure collectively their own privately defined objectives that cannot be efficiently secured through simple market exchanges" (Buchanan)
- The main mechanism is law

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- We can't get all we want by private action - by buying and selling in the market place - there's all kinds of ways by which things fail - eg. externalities, pollution, monopolisation effects, etc.
- Buchanan: "Politics is a structure within which persons seek to secure collectively their own privately defined objectives that cannot be efficiently secured through simple market exchanges".
- The main mechanism for this is law,

What is law (2)?

- Many origins and flavours (state vs religion, common vs Roman vs Napoleon ...) but two main divisions: criminal and civil
- Criminal: Alice harms Bob seriously, so the state prosecutes Alice
- Civil: Alice harms Bob, or breaks a contract with Bob, so Bob sues Alice
- Significant overlap

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- Many origins and flavours - at this level of detail we're interested in criminal and civil law.
- Criminal law - Alice stabs or defrauds Bob - state prosecutes Alice. Alice might get sent to jail.
- Civil law - Alice harms Bob or breaks a contract, so Bob sues Alice
- Overlap - if assault and police too busy/don't want to take action - can still take to court. E.g. OJ Simpson.
- Sometimes the difference between the two is a matter of degree. E.g. copyright infringement.

Criminal law

- In general a crime requires
 - A guilty act (actus reus)
 - A guilty mind (mens rea) – so legal advice or going to the ethics committee may shield you!
But some offences are ‘strict liability’
- Prosecution must prove the case beyond reasonable doubt
- CPS guidelines matter (e.g. ‘hacking tools’) and agreements (e.g. with the IWF)

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- Criminal law.- requires two things - criminal act—actus reus-- and guilty mind—mens rea.
- So need intent as well as the act.
- When doing research that skirts the law, e.g. botnets, malware, required to go to the ethics committee – to showthere’s no mens rea.
- Some offences are strict liability - e.g. child sex abuse images - no excuse.
- Also, prosecution must prove beyond reasonable doubt.
- CPS guidelines - if you use Wireshark - this is an offence - it’s a hacking tool. But bonafide security researchers are to be presumed innocent.
- Also agreements - e.g. Internet Watch Foundation - have a letter from the CPS.

Civil law

- Contract – making the agreements you want
- Tort – avoiding infringement of the rights of others, and giving adequate notice to others of your rights that you may want to enforce
- Regulation – specific things you need to do to enforce your rights or avoid penalties
- International – choice of law and venue
- Arbitration, costs etc

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- Areas of civil law include contract law, tort, regulation, international law, and arbitration.

Contract

- A contract consists of offer and acceptance by competent persons for a lawful purpose involving consideration
- Can be made in writing, orally, by conduct
- We make dozens of informal contracts every day; but an online business will usually want to formalise its standard terms and conditions (you may want advice here!)

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- A contract consists of an offer and acceptance by competent persons for a lawful purpose involving consideration.
- Requires competence - so your 9yo sibling can't be considered competent - must be at least 10 in the UK, other ages elsewhere.
- Needs to involve consideration - something going each way - If Alice is giving Bob something, but Bob gives nothing in return, then it's not a contract.
- Informal contracts – don't even need to exchange words.
- Purchasing a banana for 50p is a contract.
- Usually want standard terms and conditions on your website - and this is one of the areas where you should seek advice.

Contract (2)

- When a shop offers goods in the window this isn't the offer but an 'invitation to treat'. The customer makes the offer for the good and the shopkeeper accepts
- When offering goods online it's wise to make this clear, in case you run out of stock
- Linking clearly to terms and conditions is in general enough (as with a railway ticket)

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- When you have specials, you are not making an offer, but an 'invitation to treat'.
- The contract begins when the customer goes into the shop and offers to buy it.
- This ensures that if you run out of stock, then you won't get sued.
- Linking to terms and conditions is general enough.
- E.g. railway tickets can't contain all terms and conditions, so have a notice in the station spelling out what the terms are, and ticket states subject to general terms and conditions.

Contract (3)

- Many national laws require some contracts to be in writing (real estate; insurance; guarantees; in the USA, goods over \$500)
- Many jurisdictions have electronic signature laws; in general electronic writing is fine as the essence of signature is intent
- The US E-SIGN Act of 2000 made clickwrap licenses explicitly enforceable

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- Many laws require contracts to be in writing - e.g. buying a house has forms for the purpose, insurance guarantees, in the US there should be written contracts for all goods over \$500.
- This doesn't mean you should FedEx paper backwards and forwards - under English law the essence of a signature is intent - so typing your name at the bottom of an email is considered a signature.
- In America - President Clinton signed the E-SIGN Act as one of his last acts in office - make clickwrap licences legally enforceable.

Limits

- Consumer Rights Act 2015 extends previous legislation to software (you're now liable for malware you give your customers)
- Retailer has one chance to repair or replace (at customer's choice) else refund
- Can't enforce unfair contracts against retail customers
- Can't exclude liability for death or injury (a separate EU rule, applying to all products)

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- Consumer Rights Act 2015 - subsumes various European regulations - extends legislation to software - you are liable for any malware you give to your customers.
- If you sell goods and services they should be fit for service.
- If you sell something that breaks and the customer complains, then you should repair or replace else refund - even if your contract said this wouldn't happen as this is unfair.
- Cannot exclude liability for death or injury - applies to all products.
- E.g. if a motor vehicle breaks and results in death the driver can sue you, even if it was excluded in the contract.
- Does not apply to services - if you provide a satnav, and this directs someone to an inappropriate place, the satnav maker can be sued.
- But if Google Maps took you down that route they can't be sued. This is a loophole in the law.

Globalisation

- It can be tiresome for a firm in England to be sued by a customer in Australia
- Make clear whose law is to apply, and separately where cases should be heard
- Enforcement of foreign judgments is not straightforward (the USA is almost rogue)
- One fix is to specify arbitration of disputes

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- Globalisation - in the news a lot - practically if you're running a website here in the UK and you get sued by a customer in Australia then it's inconvenient to get on a plane to a small claims court in Sydney.
- So make it clear in your T&C whose laws applies and where disputes should be heard (not necessarily the same place).
- E.g. if a firm has most of its customers in Asia may make the court one in Singapore.
- Enforcement of foreign judgements is not straightforward and US is rogue - have to sue all over again in the US.
- US judgements also tend not to be recognised by courts in Europe.
- The usual fix is to specify arbitration of disputes - arbitration is basically private civil law.

Arbitration

- A contract can specify binding dispute resolution by an arbitrator
- It can also specify applicable law and set other parameters such as limits on costs
- The Convention on the Recognition and Enforcement of Foreign Arbitral Awards makes awards enforceable everywhere, even in the USA

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- Might specify disputes will be settled by arbitration, to be heard in London.
- International treaty to recognitive arbitration awards enforcement everywhere, even in US.
- Have rules to reduce costs, to have arguments to be made in writing rather than orally - to cut down expensive solicitors time.
- This is how law gets optimised and privatised and is used to settle disputes between companies.

Costs

- US system – each side pays its own costs. Can be expensive for some firms
- UK system – loser generally pays the winner's costs. May make it uneconomic for most customers to sue you, but a dispute with a rich one can be ruinous
- UK rules on costs are bad for consumer protection, and for free speech (later)

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- In America if you sue somebody - regardless of who wins - each side pays its own costs. Can still be out of pocket if you win.
- It can be expensive for firms if they are sued by lots of parties - so may end up settling for more than is ideal.
- In Britain - also broken, but in different ways - rule is the loser pays the winner's costs.
- If the dispute is a small one can go through a small claims court - but as soon as over the 5K threshold then things change.
- If you have to defeat your customer it could go to £100,000 to defend - and if you win the customer loses his house.
- Much of the dynamic is a strategic game of threat of cost orders, and less about the merits of the case.
- This is why it's not just enough to take legal advice when you get sued - need to have a strategy and be aware of the real risks of the threat of a ruinous dispute.
- This is one of the reasons people get sued for libel - e.g. Thiel suing Gawker - got cost order and closed website down.

Tort

- Tort is the second main way you can become liable online, after contract
- A tort (in Scotland called a delict) is a wrong which unfairly causes someone else to suffer loss or harm
- Examples are negligence (whether in product liability or in giving advice), defamation and copyright infringement

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- If you are concerned about issues of contract you can control costs by specifying arbitration.
- But it's not just breach of contract that can get you sued - there's also tort - old French word - wrong that unfairly causes someone else to suffer loss or harm - also called delict in Scotland.
- Examples - negligence - if you're a consultant you can be negligent if you give careless advice - also defamation and copyright infringement.

Negligence

- Arises if you break the duty of care owed by a reasonable person and cause harm directly
- Usual yardstick is the standard of the industry. Some exceptions apply
- Liability often tied up with insurance rules; e.g. car crashes, medical malpractice
- NB: if your software harms a non-customer or a child, you didn't disclaim liability to her as she didn't make a contract with you

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- Negligence is the biggie - a large number of cases in the civil courts are due to negligence - arises if you break the duty of care owned by a reasonable person and cause harm directly
- If you cause a car crash then you are liable for other cars that crash into you. But not indirect harm - eg. If you cause a two hour traffic jam - as too hard to measure outcomes.
- Usual yardstick - standard of the industry - e.g. if all the banks think it is sufficient that customers authenticate themselves using a password - when some banks start using 2FA, then that becomes the standard of the industry and the bank then becomes negligent if they give their customers passwords that are then guessed.
- You may have a good solution to a problem, but banks are unwilling to break ranks and change the standards.
- Insurance rules - often tied up with liability - defines negligence in terms of car crashes, medical malpractice, etc. Can change over time, but largely stable.
- Need to be aware of what happens at the edges - e.g. if your software harms a non-customer or child or elderly person suffering from dementia - the contract is not with them, so negligence claim rather than a breach of contract.

Defamation

- Libel (if spoken, slander) is a tort, and the UK is a popular venue for forum shoppers
- Direct defamation; innuendo; linking
- Burden of proof on defendant in UK
- Also the UK system of costs shifting – loser pays winner's costs
- Defamation Act 2013 excludes trivial claims, creates public interest defence, and makes claimants pursue the author first

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- Defamation - has been a big deal in the UK - courts are one of the most attractive in the world for opponents who want to sue their opponents and bankrupt them for costs.
- Can be libel - or if spoken, slander.
- If the defence is that what you said is true, then the burden of proof is against you. Need witnesses that it is true.
- The big thing in Britain is that the burden of proof is on defendant - also people tend to get very expensive law firms - if you apologise now it will cost £100k but if you go to court it will cost you a million.
- Defamation Act 2013 excludes trivial claims, and creates a public interest defence - if you're a journalist you can claim public interest if you say that someone is a dictator, etc. Also makes claimants pursue the author first - rather than the newspaper or the newspaper's distributors.

Patents

- Mechanism to tackle the underprovision of R&D from externality in research
- Protects an invention which must be
 - Novel (“prior art” disallows)
 - Useful (no perpetual motion machines)
 - Non-obvious (to “someone skilled in the art”)
- Typical duration – 20 years
- Traditionally only physical inventions; can’t protect ‘the theories above, or the facts beneath’
- But the economic case is weak, except possibly in pharmaceuticals; to IT firms, patents are a nuisance

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- Patents - mechanism to tackle under provision in R&D - strong externalities - once you publish research it becomes part of the scientific knowledge - so why should people do good research when they don’t get the good outcomes from it.
- Protects inventions that are novel (no prior reference in the literature) - useful (e.g. no perpetual motion machines as these don’t work) - non-obvious (to someone skilled in the art) - although patents are often issued against pretty much anything.
- Only granted if applied, and pay the fees - might be several hundred pounds in the UK. But often want patents in many countries - eg. US, China is developing intellectual property laws.
- Patent lawyers are becoming ingenious and aggressive and patent offices are often issued against anything applied for, as they get income from the fees.
- One patent that made real money in the trade is public key encryption - eg. Diffie Helman - RSA being sold for many millions of dollars.
- Do patents work economically? Important in the pharmaceutical industry - but to people in our trade they are basically a nuisance. If you work for MS there will be tens of thousands of patents that people think are infringing and have to spend on lawyers to beat them back.

Patents (2)

- Software patents in theory not allowed in Europe: EPC Art 52 “The following shall not be regarded as inventions ... rules and methods for performing mental acts, playing games or doing business, and programs for computers”
- Don't you believe it! The courts keep stretching it
- In general, innovation in CS is incremental: a large program can use thousands of ideas, while a blockbuster drug is a single patentable molecule
- So far only four CS patents earned serious money
- Microsoft has just open-sourced its collection!

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- Software patents in theory not allowed - but disregarded by the courts.
- The problem in science is that innovation tends to be incremental - e.g. Linux is not one idea, but thousands of lines of code - unlike blockbuster drug that is a single molecule.
- Tend to be used for access for other people's stuff - if you work for MS or IBM then you're required to patent things - if someone comes along and accuses you of infringing their patents, then you look at your patents and point out they're infringing 17 of your own.

Trademarks

- Marks capable of distinguishing your goods or services from others (e.g. 'IBM')
- May be registered (®) or not (™) – registering can make litigation easier
- Registered trademark owners usually win domain name disputes
- Can sue infringers, but have to show a misrepresentation that damages your business
- Pitfalls – some companies are very aggressive about registration and enforcement (McDonalds)

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- Trademarks - something that is a mark, string, symbol that is capable of distinguishing goods and services from others - e.g. IBM, MS, Apple, etc.
- If you use a term it can be a non-registered trademark (TM) - registering useful as makes litigation easier - stops competitors from registering trade marks, domain names, etc.
- Can sue infringers- but have to show how that misrepresentation damages your business.
- E.g. McDonalds used to sue anyone in Scotland who was involved in catering and had 'Mc' in their name - they became very unpopular as too aggressive.

Copyright

- Since Statute of Anne (1709–10), copyright has protected your literary works – extending from novels and drama to art, music
- Is the main protection for the software you write
- No need to register – but asserting copyright (“© RJ Anderson 2018”) can make litigation easier
- Duration – has steadily increased and is now author’s lifetime + 70 years (was 50 years for sound recording rights, now 70)
- Protects against copying etc; but “fair use” and “fair dealing” get-outs for criticism, parody...
- Moral rights remain yours even if copyright sold

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- Copyright is a big deal if you’re in the business of writing software. This protects the code that you write.
- Started in 1709 by the Statute of Anne - before then the Crown would give a monopoly to a business to write books of a particular type - e.g. Cambridge could write bibles and Oxford could write dictionaries - and a firm in London got the monopoly to write law books. People got annoyed at this and developed a new system - if you produced a new piece of work then got copyright.
- Cambridge University Library - copyright library - has a right to a copy of everything published in England for future generations - another 4 similar libraries.
- How can you get copyright? As soon as you sit down and start writing something. But can be useful to assert copyright to make it easier if litigation later on.
- In the Computer Lab typically put in the public domain - for the members of the team, people who come on later, for others who want to use the software. For each module you write put the name date, and the type of licence.
- Duration has steadily increased - author’s lifetime plus 70 years - cynics say that it keeps extending for as long as it takes for Mickey Mouse to stay in copyright.
- Protects others from copying your material - if you use Micky Mouse, Disney’s lawyers will get onto you, and if you do it commercially you might even get prosecuted. If you put Mickey Mouse in a clip - then may fall under fair use, fair dealing for criticism or parody.
- Moral right - right to be identified - or not identified - as the author of particular work.

Copyright (2)

- There are many orphan works – books, pictures etc whose owners aren't known
- Stalled Google Books project – see web page!
- How do you avoid software becoming a similar 'anti-commons' of competing claims?
- Stallman – GPL; BSD license
- Creative Commons gives a general framework for sharing (attribution, commercial use, share-and-share alike, ...)
- Collecting societies vs YouTube etc

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- Many orphan works - books, pictures, etc.
- Stalled Google Books project - couldn't get a court decision or legislation as to how to deal with paying royalties to authors who could not be traced.
- YouTube was different - managed to get agreement with the industry as to how royalties would be shared.
- How to avoid 'anti-commons' of competing claims - Stallman GPL - if anyone uses they also have to release any additions - become tainted with 'freeness' and has to be free forever.
- We normally use BSD - as companies can then use the code as they see fit.
- More generally Creative Commons gives a general framework - attribution, commercial use, share and share alike, etc.

Other 'IPRs'

- **Specialist rights**
 - Database rights (EU only)
 - US Semiconductor Chip Protection Act
 - Plant breeder's rights
 - Design rights
- **Rights based on contract**
 - Materials transfer agreements
 - Confidential information; NDAs
- **Limits – e.g. an employer can't restrict knowledge that's become part of the 'tools of your trade'**

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- Other intellectual property rights – e.g. database rights, US Semiconductor Chip Protection Act, Plant breeder's rights, design rights - don't matter unless a specialised industry.
- Rights based on contract - one of most interest to the IT business is confidential information - in business signing NDAs all the time - e.g. if you intern at Google you might be asked to sign an NDA that lasts for the rest of your life. If ends up in the public domain, must have been breached by someone.
- There are limits that are worth knowing - they are not allowed to restrict knowledge that becomes the tools of your trade. If you go and work at Google and become really good at something can take your skills elsewhere, even though you may have to keep quiet about particular products.

DRM

- Copyright owners panicked at printing, audiocassette, videocassette ... and the Internet
- Huge push to introduce DRM over last 20 years
- But it shifted power to Apple, Google, Amazon from old-style record companies
- US law made it illegal to mess with DRM mechanisms even when used for technical lock-in
- Lexmark v SCC case allowed reverse engineering for compatibility
- October 2018: US Copyright Office said it's also OK for repair, but selling tools is illegal
- Open-source tools a grey area still...

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- Digital rights management - copyright owners have panicked along the way.
- There are still firms - e.g. music industry in particular - who push for stronger digital rights management.
- This shifted power to the platforms.
- US Digital Millennium and Copyright Act - illegal to mess with DRM mechanisms, even for technical lock in - but then Lexmark v SCC (cryptanalysis and extracted keys from Lexmark printers) . SCC - allowed people to copy keys for compatibility - Lexmark sued them - court decided that SCC is entitled to hire the smartest cryptanalysts they can.
- October 2018 - tractor owners found that John Deere had put software in tractors that would make tractors stop working if did not take to their authorised repairers - breaking this was found to be legal.

Strategy

- 'IPR' often a combination (biochip h/w patent + software copyright + MTA on reagents ...)
- IT industry strategy: patent portfolios mostly defensive, used to get access by cross-licensing
- Compound models, e.g. GPL the linux version, sell the Windows version, charge for support...
- Startups: VCs like to see some IP (mantra is 'global sustainable competitive advantage')
- Incumbents worry about lock-in: network effects, two-sided markets, distribution moats, control of platforms and interfaces. Challengers can be more creative, but must try to think ahead!

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- Strategy - if you're setting up a biotech company you might have a biochip with patents and software copyright.
- In the software business you might have a free version available and charge for support.
- Venture capitalists like to see some IP - for global sustainable competitive advantage
 - need to convince that the market value will be other than zero so that they invest in your business.

Economics, Law and Ethics
Part IB CST 75%, Part II CST 50%
2019-20

Alice Hutchings, Richard Clayton

with many thanks to Ross Anderson

Ethics

- In our field, laws are often ten years behind, and even then often don't fit reality very well
- Practical ethics: in what circumstances should we restrain our actions more than the law requires?
- Analogy: medical ethics (used to) require doctors to observe stricter confidentiality than either the law of confidence or data protection law required
- The philosophy of ethics asks "What are true moral values?" and "Why?"

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- Specific laws in our field – are often 10 years behind. Where does this leave you if running a business?
- Practical ethics - in what circumstances should we constrain our actions more than the law requires?
- Sometimes this is a club good - e.g. research requires ethics approval before publishing papers.
- From the point of view of a business - last thing you want is that the business plan appears on the front page of the Guardian the day before your IPO and everyone recoils in horror.
- What sort of analogies can be drawn? One example is medical ethics - historically doctors observe a code of medical ethics - more constraining than data protection laws. How navigate our way?
- Going back to Ancient Greece - philosophy of ethics - what are our true ethical values and why?

Philosophies of ethics

- Authority theories mostly derive from religion. But God usually talks via scriptures or a priesthood; so how do you resolve disputes?
- Intuitionist theories say we can tell what's good and bad, like we can tell something is green. But again, our intuitions can differ, and how do you resolve disputes?
- Egoist theories say we act rationally in our own self-interest. We've seen the limits on that...

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- Philosophies of ethics start with authority theories - religion, etc. Within these you see subfields, e.g. Sunni v. Christianity v. Catholicism. How do you go about resolving disputes? See enormous sectarian conflicts around the world on various issues.
- To get perspective, look back in history. Early 19th century - big debate was slavery. Conservative Christians would say slavery is the will of god as there are various scriptures in the bible. Same kind of thing in the Koran. Someone who said should free all the slaves was wicked.
- Liberals said this was a load of tosh, and they eventually won the argument. When it was eventually abolished by Grey - gave compensation to the slave owners rather than the slaves. Even after ending slavery there were conservatives who hit back against this. Weren't going to let imperialists take away their slaves - group broken away from the Ottoman Empire - if take away slaves must be a heretic.
- The second bunch of theories are intuitionist theories - can tell what's good and bad through intuition. But intuition is embedded in historic and social context. It's a standard thing in linguistics that the boundaries between different colours depends on language - e.g. blue and green differs between Gaelic speaking Scotsmen and English speakers. How to resolve disputes?
- Next bunch of theories - people act rationally in their own self interest. But there are limits to this - e.g. prisoners dilemma. Can escape that trap, but still see all the problems with monopolies etc... And slavery would be rational in the slave owner's self interest.

Philosophies of ethics (2)

- Consequentialist theories include Hume, Bentham and Mill's utilitarianism: maximise $W = \sum U_i$ (or, 'greatest happiness of the greatest number')
- But how do you work out consequences in detail?
- Social choice: it's hard to define W in a way that's consistent with democracy
- Cheney's 'ticking bomb' justification for torture
- Modern debate: act vs rule utilitarianism

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- Next theories were consequentialist - Hume - famous atheist. Their view was that you are seeking the greatest happiness for the greatest number. But the problem here is how to work out the consequences in detail? Difficult to define W in a way that is consistent with democracy.
- But also ticking bomb argument - after 9/11 terrorist attacks - the US administration - particularly Dick Cheney who was effectively in charge of the intelligence apparatus - wanted to suppress the ban on torture. Argument for ticking bomb was run on the news again and again. If only the terrorist knows the unlock code, then surely it's ok to pull out their fingernails until they confess. How do you answer the ticking bomb argument? Surely it's ok to pull out his fingernails to save lives?
- Eventually settled - films about torture got out of control. This contributed to the development of the Islamic State.
- This is an example of where things can go wrong.
- Modern debate - Act v. Rule utilitarianism - should follow the rules in all cases rather than a one-off justification in rare cases.

Philosophies of ethics (3)

- John Rawls 'Theory of Justice': we should make moral decisions about a society behind a "veil of ignorance" of whether we'll be born high or low
- Deduces: we should maximise $W = \min U_i$
- Same problems as before with bounded rationality
- What if a small minority is badly off?
- Would you rather be reincarnated in the USA or (say) Portugal – poorer but with better welfare?
- Randomised algorithms, anyone?

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- John Rawls - theory of justice - we should make moral decisions about a society behind a veil of ignorance - given our ignorance as to whether we'll be reincarnated in a palace or a hovel - how we should act.

Philosophies of ethics (4)

- Aristotle: consequentialist theories are 'for beasts': you'd be happier if you were stupid
- People should act in accordance with nature and duty: they will do good and be happy
- It's not just the consequences of actions that make them right or wrong, but the motives of the actors
- The many flavours include Kantian theory of duty: act only on maxims that you'd like to be universal and treat people as ends not means

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- Philosophies of ethics - Aristotle - consequentialist theories are for beasts - if you were trying to maximise happiness you would be happier if you were stupid.
- People should act in accordance with nature and duty - not just the consequences, but the motives of the actors.
- There is variation in nature just as you have variation in religious beliefs - duty can be socially conditioned. Aristotelian ethics can result in two groups thinking it is ethical to go to war with each other.

Current debates include:

- Evolutionary psychology (monkeys do tit-for-tat; Machiavellian brain hypothesis, the moral roots of ethics in the way our brains have evolved)
- Neuroethics (from moral development of children to consciousness as an epiphenomenon ...)
- Experimental ethics: e.g. whether you'd divert a runaway trolley to save two people but kill one
- What is nature, versus nurture / culture?
- See Haidt video on the web page

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- Current debates - evolutionary psychology - monkeys do tit for tat, as do some other animals, as it's a natural thing to evolve. Treat people as they've treated you in the past. Machiavellian brain - developed intelligence not to use tools better, but use animals as tools. Created tools, started living in larger social groups, needed to develop greater brains to deal with social interactions.
- Moral roots of ethics - Jonathan Haidt has done much of the research on this - 5 or 6 primary colours of ethics - inbuilt ethical reflexes. Fairness, care for others (these two are primary dominant in liberal disposition), authority, hierarchy and sanctity (dominant in those with a conservative disposition).
- Neuroethics - moral development of children to consciousness as an epiphenomenon - putting children in MRI machines and watching how their brains light up for various tasks. Often decide to do something before you realise that you have decided. Boundary between what is conscious and unconscious action - what is a reflex. Is morality a function that enables people to carry out unconscious actions.
- The third line of enquiry - experimental ethics - suppose you're standing by points in a train line - the train has come off the line and will kill a couple of people standing by. Can throw the points and divert the train so it kills one person instead, do nothing and kill two people, or by conscious action kill one instead? Do as experiments - turns out the average person may need to kill about 3 people to save one.
- Broader questions at nature versus nurture or culture? What extent is morality social, how can we measure prejudices that people suppress? Are people lying? People lie all the time, particularly about morality and ethics.

Live policy debates

- **Censorship**
 - All countries have some (e.g. child porn). But then along come Hollywood, libel lawyers, and now the push to get Facebook etc to be censors
- **Export control**
 - Is it ethical for GCHQ to allow DPI equipment exports to Iran / Syria?
- **Surveillance**
 - From Ed Snowden to the ACM ethics code

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- Live policy debates - censorship - all countries have some censorship.
- Cybercrime Convention makes it universal that countries criminalise sexual images of people under the age of 18.
- But once you have some universal prohibitions create mechanisms to suppress content, and then along comes the lawyers claiming copyright infringements.
- Push now is to get FB, Google, etc. to be censors for 'fake news' stories? Are we comfortable with them being censors? Should this not be for the courts?
- Export control - is something that government departments have done in the past to regulate sales - extended this to include cryptographic software - means exist to prevent the export of software. Military list of software that should be treated like rifles. Is bulk surveillance equipment ok to sell to countries on the bad countries list - e.g. Iran or Syria?
- Surveillance - 2013 Snowden revealed what the NSA was up to - bulk surveillance and ramifications for other countries. Previously didn't realise that they had the expertise to index everything well - given the nature of public sector IT. But it seems the NSA did have expertise.

Live policy debates (2)

- **Privacy**
 - Economic analysis alone is insufficient as privacy is very context-dependent. Data protection regulation changed with GDPR
 - Privacy often a touchstone issue in ethics
- **Freedom of Information**
 - Like privacy laws, FOI laws push back on the ‘natural’ flow of data from the weak to the strong. We have rights not just to data but to the basis of decisions that affect us

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- Current debates on end-to-end security and adding GCHQ as a silent listener to the calls of people of interest.
- Privacy - is very context-dependent. CMU research - 3 groups of students - created a privacy questionnaire - how far people go through before they balk and refuse to go through any further. One was a control group - who got a privacy score. First treatment group was given a good privacy assurance - won't keep details of you - encrypted etc. Disclosed less, as privacy made more salient. 3rd group - howbadareyou.com - website with a devil with horns - filled out everything.
- Privacy and freedom information laws have been developed to push back on the flow of data from the weak to the strong - FOI - entitled to collect information about the strong. Before the most recent US president were able to see the president's tax returns. We can FOI documents from Whitehall.

Privacy

- 2014 report on Big Data by the US President's Council of Advisers on Science and technology
- Spread of gesture, speech and video interfaces will lead to cameras, microphones everywhere
- Can't stop data collectors; can't regulate processors (they claim); so have to regulate uses
- Problem: US privacy law regulates only a few uses (such as video rentals) and is weak even there

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- How do these work in practice?
- 4 years ago interesting fork in the road - if you go and read the report on big data by PCAST - President's brain trust - Obama asked them to figure out what the future would hold with big data and how American would cope with privacy issues. Now that we have sensors everywhere - microphones, cameras, etc - and all done in the cloud as more efficient to process. Can't stop data collectors as there's too many of them. Can't regulate the data processors - didn't say why - so have to regulate uses. Laws like video rental laws in the US.

Privacy (2)

- Google v González, European Court of Justice, 13 May 2014
- Search on Mr González returned reference to a lawsuit against him in 1998
- Google said, that's not our problem.
- ECJ: Oh yes it is! He can ask either the newspaper or Google to take old stuff down

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- That very same week there was the Google Spain judgement - Gonzalez - he was a lawyer that had had a court decision against him in 1998 which was no longer relevant but whenever people googled him they can to an article saying he'd been bankrupt and this affected his ability to do further business.

- Google was furious about this - don't people understand how the internet works - we can't be the world's censor.
- Google had to start hiring thousands of people to start dealing with takedown requests.
- Many requests that are made are abusive. If a MP was fined for smoking dope when a student - don't want to make that hidden as he's now involved in politics - but yes if expired under statute of limitations.
- No algorithmic way for dealing with requests. Fork in the road - US and EU law.

Health privacy

- David Cameron said in 2011 that NHS records would by default be made available for research (the 'transparency' agenda ...)
- Don't worry: our records would be anonymised, and we'd have an opt out
- Opt-out is needed because of European privacy law (I v Finland, ECHR, 2010)
- But anonymisation doesn't really work for rich linked data (e.g. 'atrial fibrillation, Hammersmith, Mar 19 2003')

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- Another example is health privacy - number of tussles over the years - most recently conservative government NHS records would by default be made available for research. Don't worry, records would be anonymised and there would be an opt out.
- But anonymisation doesn't really work for rich linked data - if get hold of database - all hospital treatments are in there. If search for atrial fibrillation, etc - then will pick out Tony Blair's records. Not sufficient to hold in a publicly accessible database with an encrypted NHS identifier, as can link other ways.

Health privacy (2)

- The Hospital Episode Statistics (HES) database has a record of every finished consultant episode going back 15 years (about a billion in total)
- Mar 2014: formal complaint to ICO that PA put HES data in Google cloud despite many rules on moving identifiable NHS data offshore
- Apr 2014: HSCIC reveals that HES data sold to 1200 universities, firms and others since 2013
- HES ID leaks postcode, dob in most cases
- 2018: many patients' opt-outs were simply ignored

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- Scandal in 2014 when the HES data was sold to universities, firms, and others.
- For 2k pounds could buy a stack of CDs containing 20GB of data going back to 1998.
- Universities, including Cambridge bought these, as well as commercial data.
- Nuffield Bioethics Council set up a project on biodata - how do you go about doing medical research ethically when you have pervasive genomic tests? Link to individuals as well as families.

How can researchers deal ethically with privacy?

- See Nuffield Bioethics Council project on biodata for four principles
 - Ethics based on respect for persons
 - Satisfy human-rights and other applicable law
 - Set reasonable expectations in discussion with people with morally relevant interests
 - Effective and justified systems of governance and accountability

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4 principles:

- ethics should be based on respect for persons
- satisfy human rights and other applicable law
- set reasonable expectations in discussion with people with morally relevant interests - e.g. tell the patients - if there's too many to get informed consent from all - then speak to representatives. E.g. if doing diabetes research then speak with Diabetes UK.
- Effective and justified system of governance and accountabilities.

What about fake news?

- What's the equivalent for propaganda?
- Tim Wu's "The Attention Merchants" gives history of advertising and propaganda from 1830s tabloids through Hitler to sitcoms
- Auction theory tells us about polarisation
- Social network theory about echo chambers
- Politicians are now paying real attention...
- Do you want Google to be the censor?

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- Fake news - what to do
- Can recommend Tim Wu's book - Attention Merchants - Rich historical context for what's going on here.
- Auction theory - polarisation - ad quality matters. How this can become something like virality in social media.
- Social network theory - echo chambers.
- Probably see more and more social manipulation.

AI: justifying your decisions

- We saw Caliskan's work on how AI inhales racial and other prejudice with training data
- Broader problem: many AI systems cannot explain their actions
- "Computer says no" doesn't work in public sector where people have a right to an explanation, judicial review exists and many kinds of discrimination are explicitly illegal

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- Caliskan's work - AI inhales racial and other prejudices with training data.
- Random forest and deep neural networks - can't explain actions.
- Problem with public sector - can't explain decisions - which means can be overturned with judicial review.

Ethics in research

- Your part 2 project may involve human experimental subjects
- Independent review by uninvolved scientists greatly reduces risks of both civil litigation, and criminal prosecution if things go wrong
- Pay attention to the procedures for ethics committee approval
- And if they say no, don't do it – unlike in the Cambridge Analytica case!

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- Ethics in research for projects involving human experimental subjects.
- Independent review by ethics committee.

Conclusion

- Technology is constantly changing status, money and power. How do we navigate?
- Economic incentives have their limits
- Lawmakers take 10–20 years to catch up
- Human-rights law can give broad principles but it's a floor rather than a ceiling
- So even if your business model is legal today, it might not be tomorrow
- Does it pass the “front page test”?