Economics and Law

CST part 1b

Ross Anderson, Nicholas Bohm,
Richard Clayton

Why teach you this course?

- Increasing importance to computing as systems involve many competing principals
- Systems: Internet now so big it's often more like a market than a deterministic system! Economics used for protocol design, congestion control, etc
- Theory: the combinatorial auction is now seen as the archetypal complexity-theory problem
- Professional: about half of you will go into consultancy, finance etc
- Policy: arguments about copyright, blocking,…

Aims and Objectives

- Aims: introduce you to some basic concepts in economics and law
- 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 and legislation place on firms dealing in information goods and services

Outline

- Game theory: prisoners' dilemma, iterated games
- Classical economics with competitive markets
- Market failures – monopoly, asymmetric information, network effects, lock-in
- How information goods and services markets are different
- Auction theory and mechanism design
- Principles of law – contract, tort and other ways you can become liable for things you do online
- Law and the Internet

Resources

- Shapiro and Varian “Information Rules”
- Varian “Intermediate Microeconomics”
- Course website, plus as further reading:
  - Adam Smith, “The Wealth of Nations”
  - JK Galbraith, “A History of Economics”
  - Len Fisher, “Rock, Paper, Scissors”
  - William Poundstone, “Prisoners’ Dilemma”
  - Paul Seabright, “The Company of Strangers: A Natural History of Economic Life”
  - Paul Krugman, “The Return of Depression Economics”
  - Glanville Williams, ATH Smith, “Learning the Law”

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 opposing viewpoints: how would a socialist / libertarian / keynsian / monetarist approach this problem? What decides if people cooperate or compete, what resolves conflict?
- Write proper essays!

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 tool we use to tease them out and analyse them is game theory

Game theory

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

Strategic form

- Example: matching pennies. Alice and Bob throw H or T. If their 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

- A zero-sum game: Alice's gain = Bob's loss
- A strategy is an algorithm: input state, output play

Dominant strategy equlibrium

- In the following game, no matter what Alice plays, 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

- Each player's optimal algorithm outputs a constant
- The is called a 'dominant strategy equilibrium'

Nash equlibrium

- Consider this game:

Bob

Alice	Left	Right
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 sometimes called 'Battle of the sexes'

Pure v mixed strategies

- If we allow only deterministic algorithms, some games have no Nash equilibrium. E.g.

Bob

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

- Alice plays scissors → Bob wants to play stone → Alice wants to play paper …
- Fix: randomised algorithm. This is called a ‘mixed’ strategy; deterministic algorithms are called ‘pure’

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

Alfie

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

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

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
- Large simulation competitions run by Bob Axelrod played off many iterated-game strategies; tit-for-tat did consistently well
- Some tweaks, e.g. 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 20 years or so that strategy evolution explains a lot of behaviour

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!

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

Bernard

	chase hare	hunt stag
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

Chicken

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

Jim

Buzz	jump	drive on
jump	2, 2	1, 3
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
- Biologists call the iterated version hawk-dove (more later)

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

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

- The 1989 dilemma: "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

Deadlock

- Differs from PD in that (defect,defect) is preferable to mutual cooperation.

Alice

Bob

	cooperate	defect
cooperate	1, 1	0, 3
defect	3, 0	2, 2

- That is, I'm going to defect anyway but it would be nice if you were a sucker and cooperated
- Is mutual defection a dominant strategy equilibrium, or a Nash equilibrium?

Asymmetric games

- In the game of ‘Bully’, the first player plays chicken while the second plays deadlock

Deadlock player

Chicken player	cooperate	defect
cooperate	2, 1	1, 3
defect	3, 0	0, 2

- Example: the ‘Wisdom of Solomon’
- The baby’s real mother plays chicken (rather see the baby live) while the thief plays deadlock (rather not lose)
- (Depressing) model of military aggression

Game theory and evolution

- John Maynard Smith protposed 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	v, 0	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 $c > v$?

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	v, 0	v/2, v/2

- I.e. $p(v-c)/2 + (1-p)v = (1-p)v/2$

  $\Leftrightarrow pv - -c + 2v - 2pv = v - pv$

  $\Leftrightarrow -pc = -v$

  $\Leftrightarrow p = v/c$

Evolution of ideas of justice

- Brian Skyrms, "Evolution of the social contract" posits three types of individual
  - Fairmen demand half of a resource
  - Greedies demand two-thirds
  - Modests demand one-third
- Two greedies fight and waste everything; two modests take 1/3 each and waste the rest
- Nash equilibria: all fairmen, or half greedies and half modests
- Evolution: if initial population of fairmen > 1/3, they win out. But if they can recognise each other they can start from a much smaller initial share

Price-fixing

- If it costs $250 to fly someone LHR-JFK and back, 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 how other airlines respond. If they ‘defect’ by competing, play tit-for-tat
- If you’re the regulator, how do you cope?

Broader implications

- Anthropology – 10,000 years ago we were ‘the shy murderous ape’. If you saw a man you didn’t recognise, you’d better kill him first.
- Now we collaborate globally and live in largely peaceful societies (Seabright, “Company of Strangers”)
- Cooperation supported by many institutions from religions (“do unto others as you’d have them do unto you”) to markets and legal codes
- There are also constructs such as ‘honour’ and ‘trust’

Broader implications (2)

- The formalisation by Nash, Axelrod, Maynard Smith and others opened up many applications
- Politics: models of conflict, of civil war, of when religions are dominated by fundamentalists
- Criminologists: model everything from duelling to the Mafia as alternative means of contract enforcement
- Computer science: how do you get people in peer-to-peer systems to do their share rather than free riding? How do you get AS operators on the Internet to tell the truth about routing? …

What do economists study?

- 17th century France: land, labour, produce
- 18th century Britain: explanation of growing trade and the industrial revolution, starting with Adam Smith's 'Wealth of Nations'
  - Specialisation leads to productivity gains
  - 'Invisible hand' – equilibrium arising from self-interested striving of millions of people
  - Theory of markets and value extended to labour and capital too
- 19th century 'marginalist revolution' made all this rigorous leading to Marshallian synthesis

What do economists study? (2)

- Late 19th century: Marx's theories of poverty, oppression and inevitable revolution
- Monopoly as the big problem: antitrust law
- 1930s: persistent unemployment of the Great Depression
- 1970s: how to explain and cope with inflation
- 1970s/80s: asymmetric information
- 1990s: other factors in IT goods/services markets
- Now: huge diversity of subjects (healthcare, insurance, security, environment …) but a core of common tools and concepts

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, savings, credit, exchange rates, GNP…
- We will touch on this only briefly

Roadmap (2)

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

Example – theory

- Example of a model of how incentives work: George Akerlof "The Market for Lemons"
  - 100 used cars on the market in a town: 50 'plums' worth $2000 and 50 'lemons' worth $1000
  - Only the sellers know which is which
  - What's the equilibrium price?
- Many wider implications: why old people can't get affordable insurance, why bad security products drive out good ones, why Cambridge degrees are valuable …

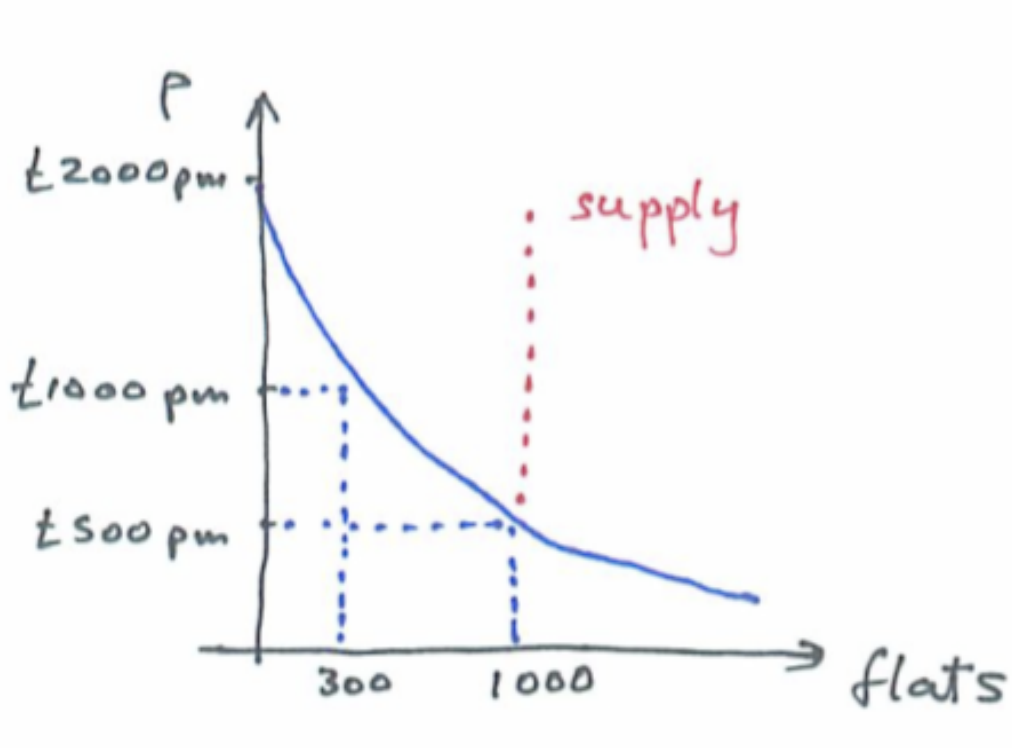
Example – empirical research

- Todd Kendall, "Pornography, rape and the Internet" (2007)
  - Internet uptake went at different speeds in different US states
  - What crimes were correlated?
  - Rape and prostitution went down, while 'runaways' went up
  - The first two had significance concentrated among 15-24yo males
- For more examples of this, see "Freakonomics"

Prices and markets

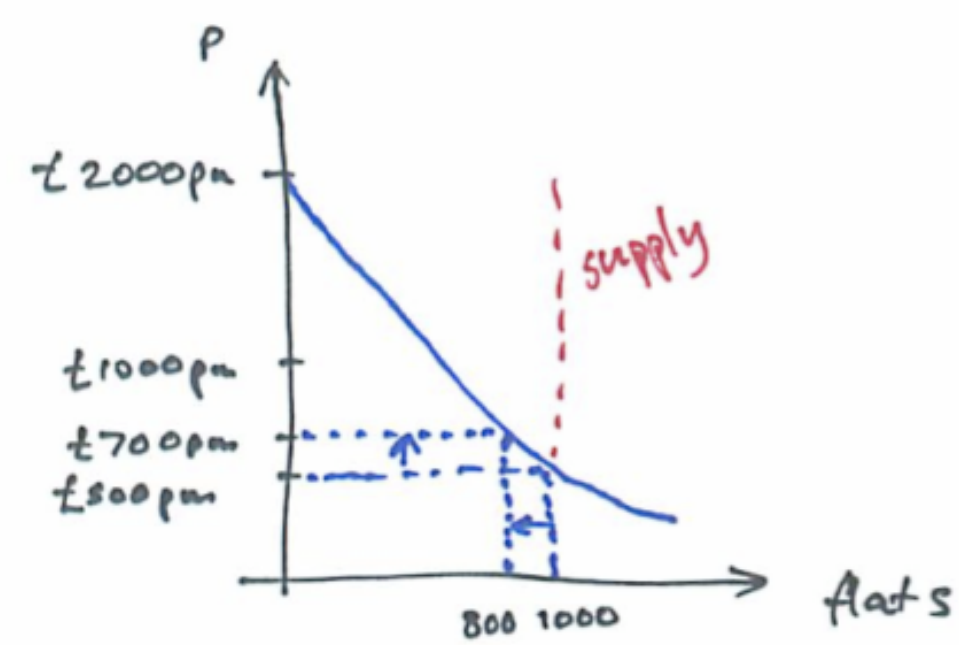
- As an introduction to theories of prices, consumers and markets, consider an idealised market for flats in Cambridge
- Assume only two types – one-bed flats in town, or house-shares in Chesterton. People who can afford flats will rent them, and those who can't will get house-shares instead
- Assume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

Monopoly

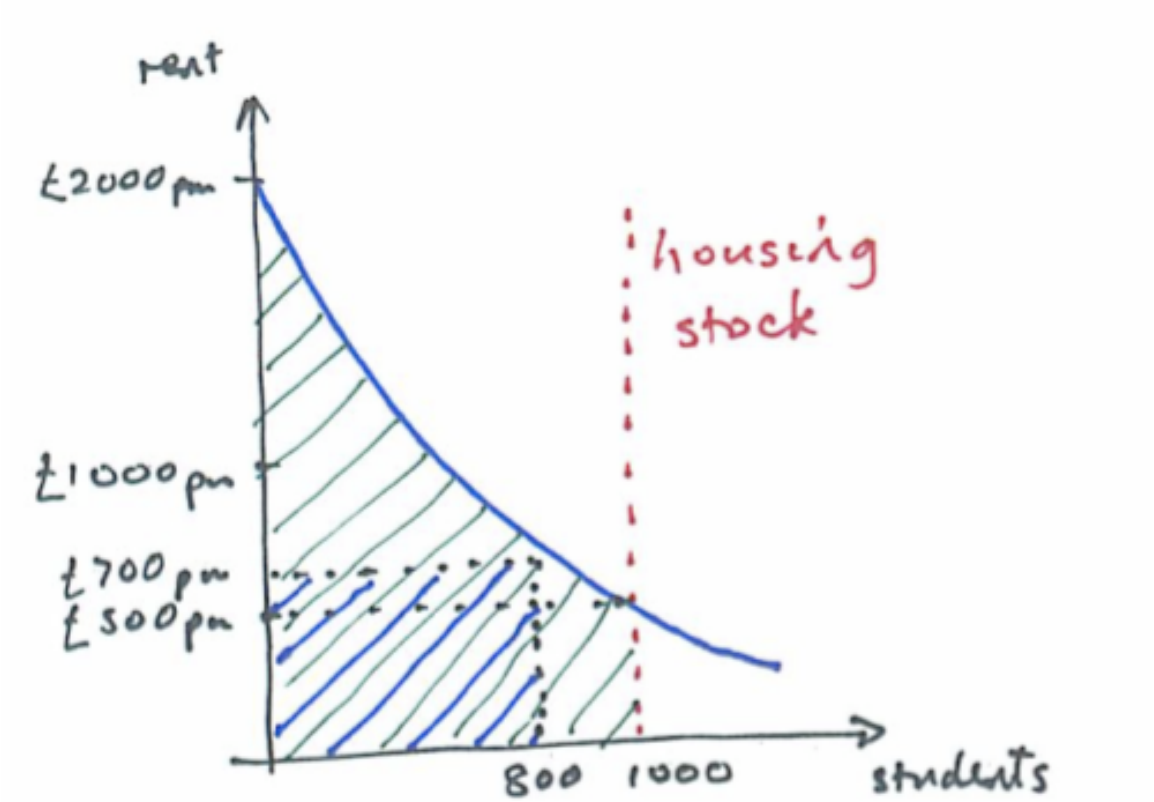


- If the market is rigged, might restrict supply – 800 flats at £700 pm can earn more than 1000 at £500 pm
- Intuitively, this is inefficient! (empty flats which people would pay to rent)
- How can we formalise this?

Efficiency

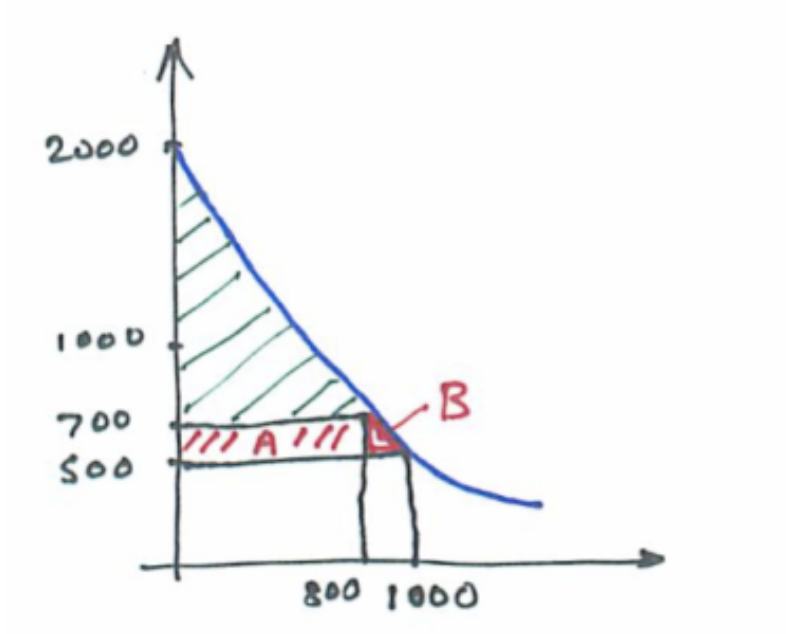
- A monopolist might leave some flats empty despite there being people who'd pay for them
- Definitions
  - A Pareto improvement is a way to make some people better off without making anyone worse off
  - A Pareto efficient allocation is such that no Pareto improvement is possible
- This is weak: pure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

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 …

Consumer surplus



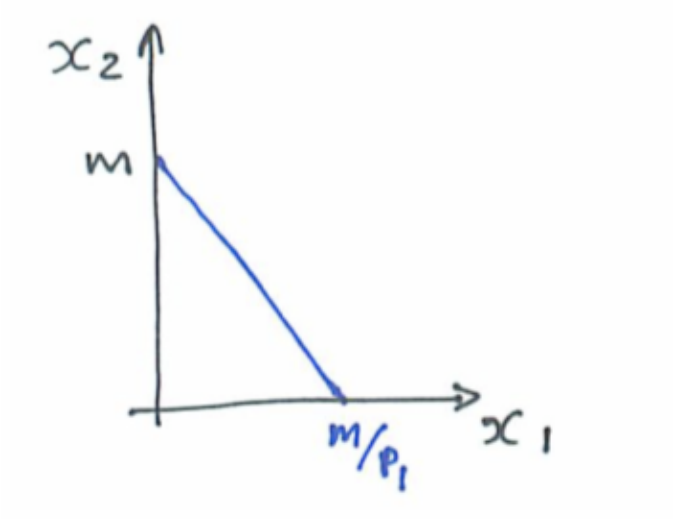
- Consumer surplus is the total amount people saved on their reservation price
- Ordinary monopoly: green area left to consumers
- The monopolist diminished surplus by A and B
- The discriminating monopolist gets the lot!

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 a strong incentive to price discriminate so as to mop up all the available surplus
- Hence the many prices of Vista!
- But it's not just tech. Think airline tickets, cars, and even food.
- So what factors determine the structure of markets?

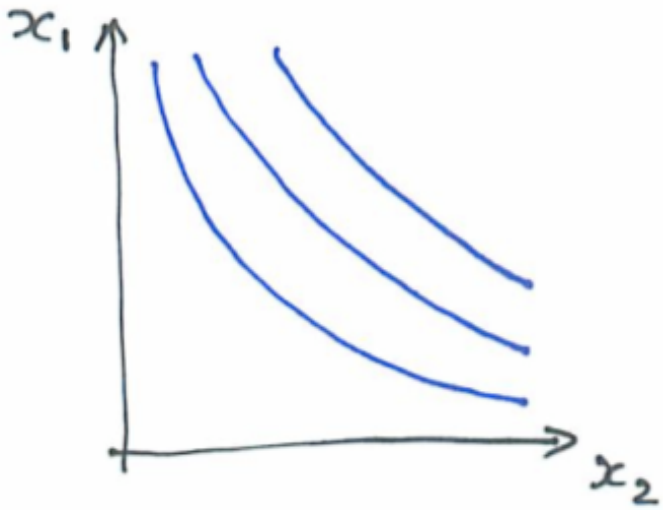
Basic consumer theory

- 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



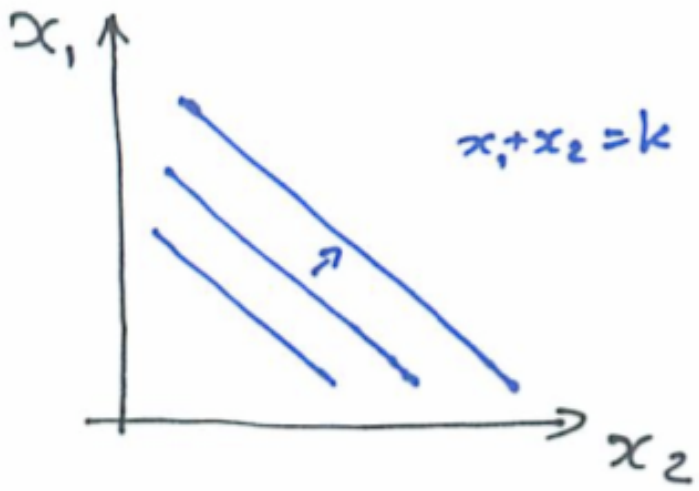
Preferences

- 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’)



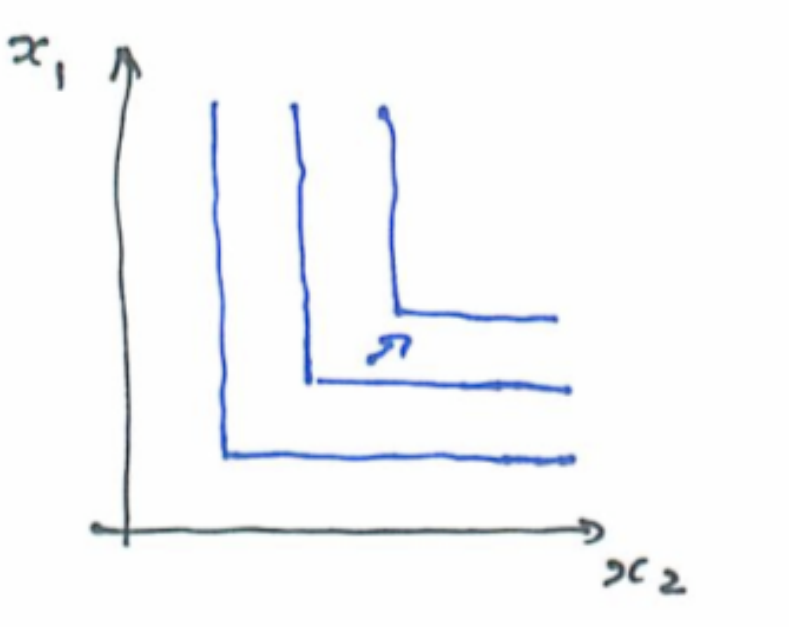
Substitutes

- 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 substitutes



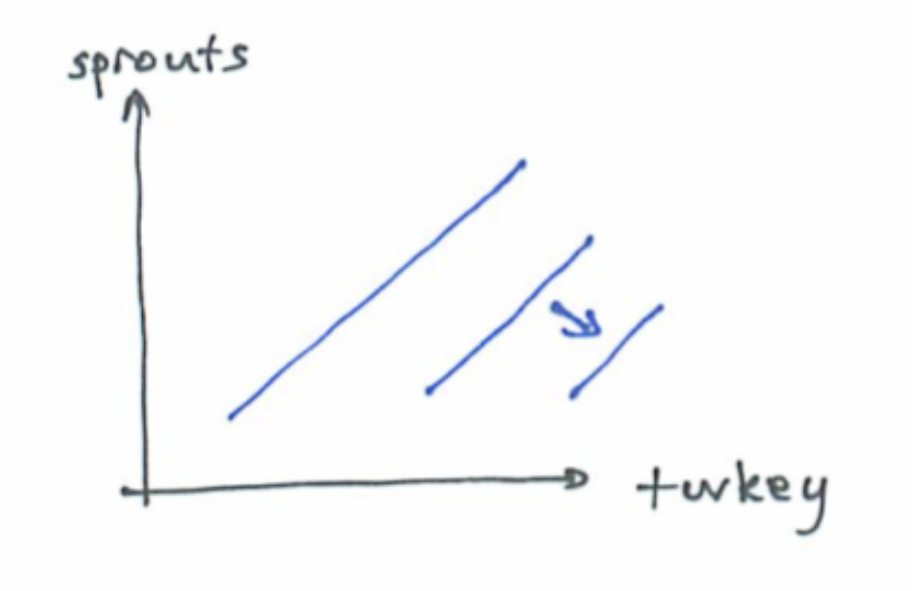
Complements

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



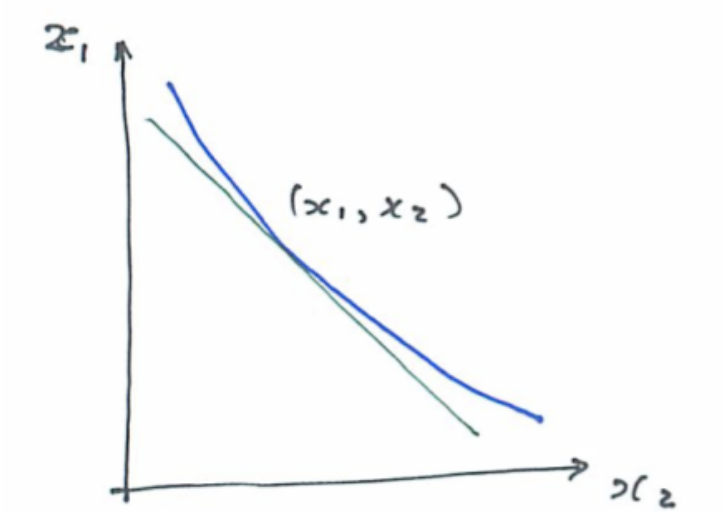
Bads

- 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



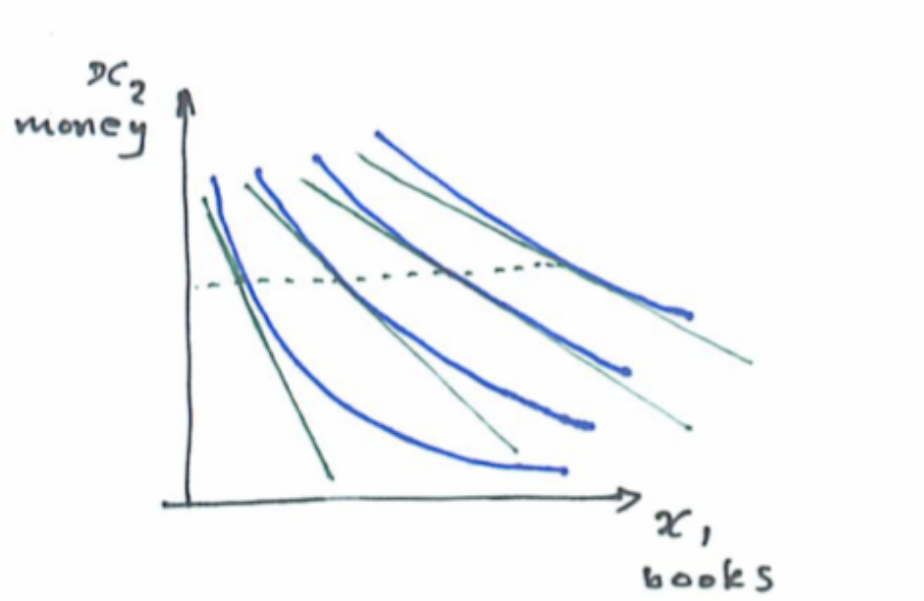
Marginal rate of substitution

- 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 = $\Delta x_1/\Delta x_2$
- Comvex curves: you're more likely to trade the good if you have more of it



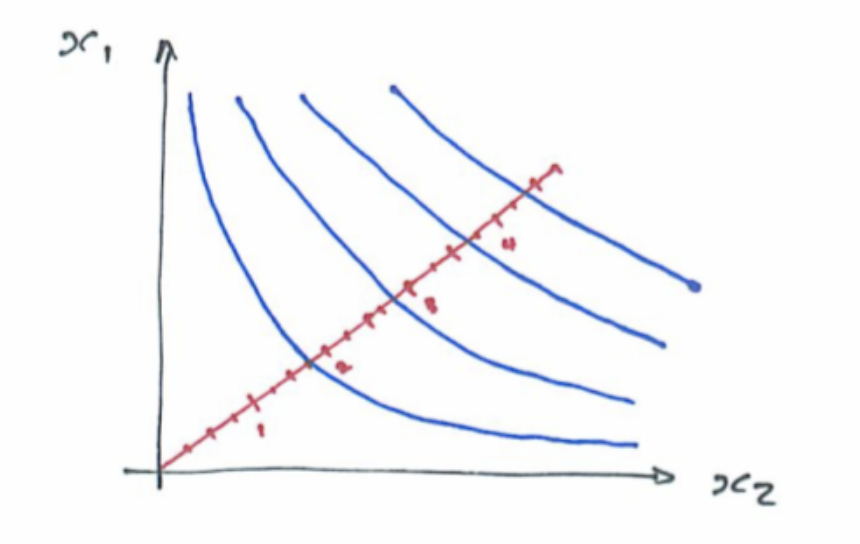
Diminishing MRS

- 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'



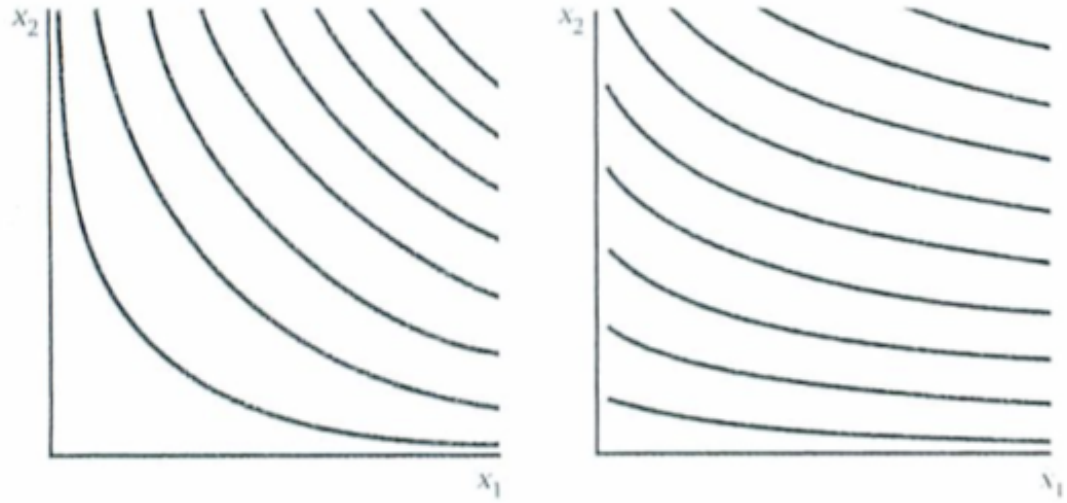
Utility

- 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 / …



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



A $c = 1/2$ $d = 1/2$ B $c = 1/5$ $d = 4/5$

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
- Discovered by 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, labout, finance etc in a world of free competition

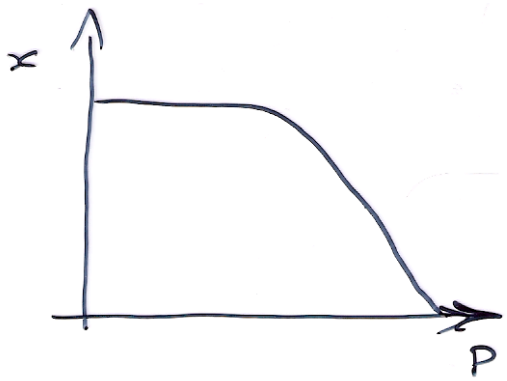
Concrete example

- 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-case mine	2s	Export	3s

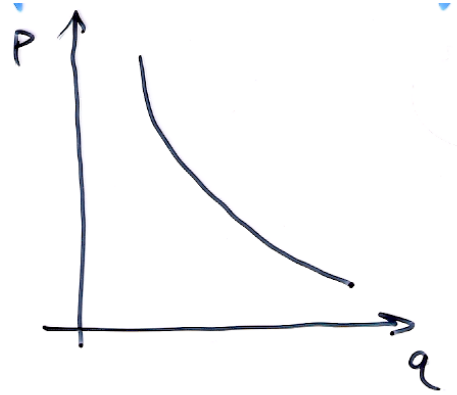
- The market price determines who produces and who consumes
- It's determined by the marginal transaction
- It fluctuates with demand (weather) and can evolve in the long term with tech, investment…

Demand



- Assuming functions are 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)
- Economists talk of Marshallian demand and Hicksian demand; the latter has constant utility (consumers compensated for changes in income)

Elasticity

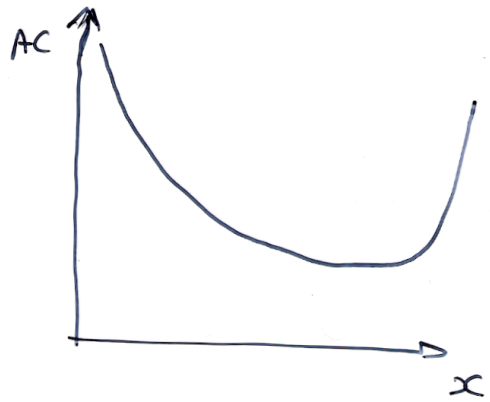


- Given a market demand curve, elasticity measures the effect on demand of a small change in price
- Formally, $\varepsilon(p) = (\Delta q/q)/(\Delta p/p) = p\Delta q/p\Delta p$
- Elasticity = 1 means there are substitutes
- Revenue R = pq, so

  $\Delta R/\Delta p = q + p\ \Delta p/\Delta q$

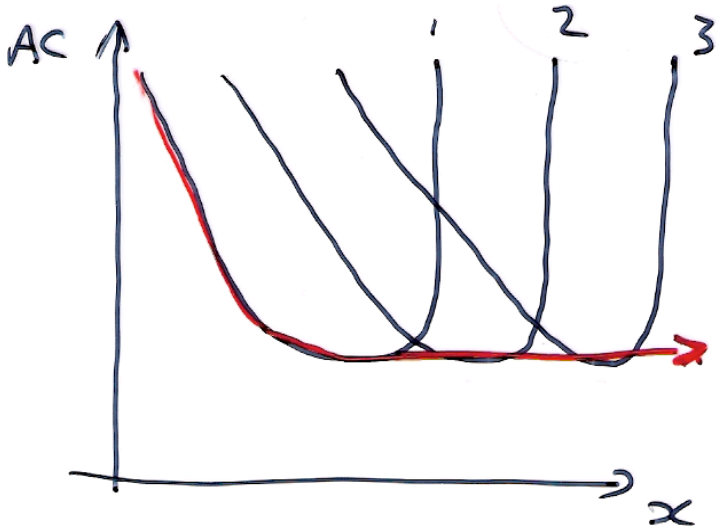
  $= q\ (1 + \varepsilon(p)\ ) = q\ (1 - |\varepsilon(p)|\ )$
- Key fact: price increases boost revenue iff $|\varepsilon(p)| < 1$

Supply



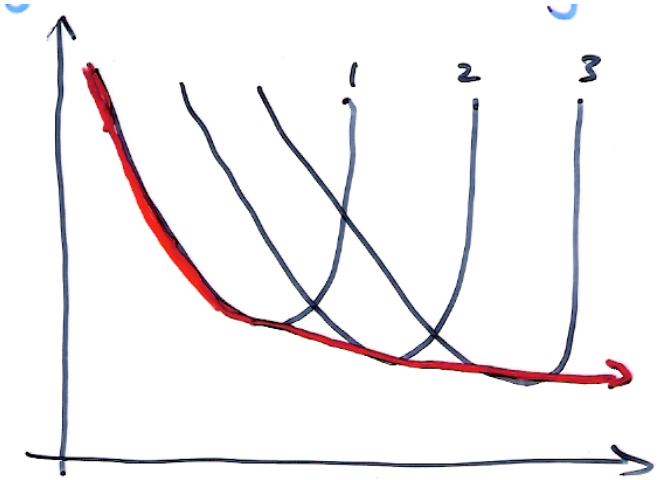
- Firms typically have fixed costs and variable costs, so the average cost of goods initially falls with output
- The variable costs typically rise at some point (overtime etc) and eventually rise sharply due to capacity constraints
- Thus the supply curve typically takes the above convex shape, at least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

Cost evolution



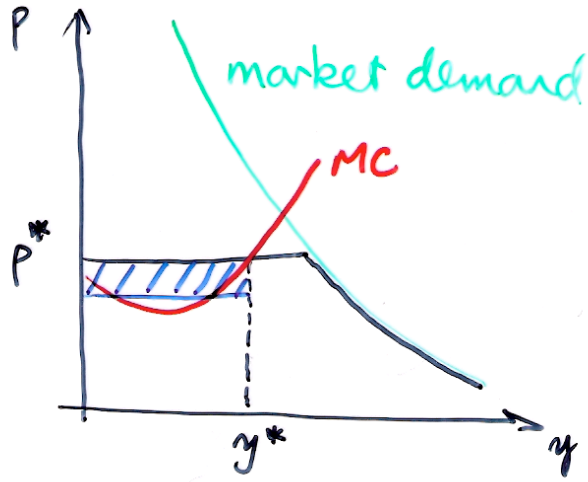
- In the long run, firms can fix capacity constraints by building more factories
- This gives nearly constant fixed costs and thus constant returns to scale as the firm / industry expands

Effects of technology



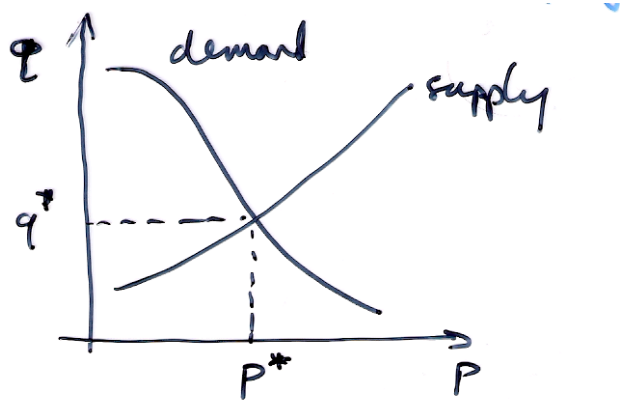
- In a traditional industry, technology can improve the process; larger / newer factories may be better
- Some industries have natural limits (not everyone wants to drive a Ford)
- In information goods and services industries, marginal costs may never rise – so firms like Microsoft enjoy ever-increasing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

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*

Putting it all together



- In the classical synthesis, prices are set where supply and demand curves intersect in competitive markets
- 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

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 promided preferences are convex
- Technical conditions include rational actors, property rights, complete information, no transaction costs … (more later)

Efficiency, welfare and justice

- These are different concepts! Giving the king all the money is Pareto efficient
- Different theories of justice are consistent with different welfare functions
  - $W = \sum U_i$ is classicial 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!

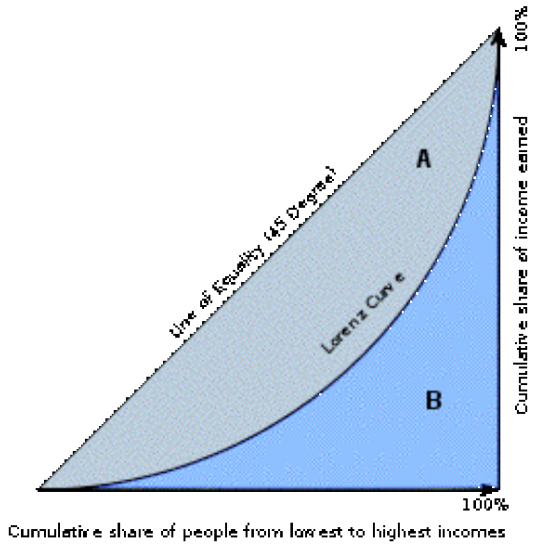
Efficiency, welfare and justice (2)

- Composing utilities into welfare is hard!

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

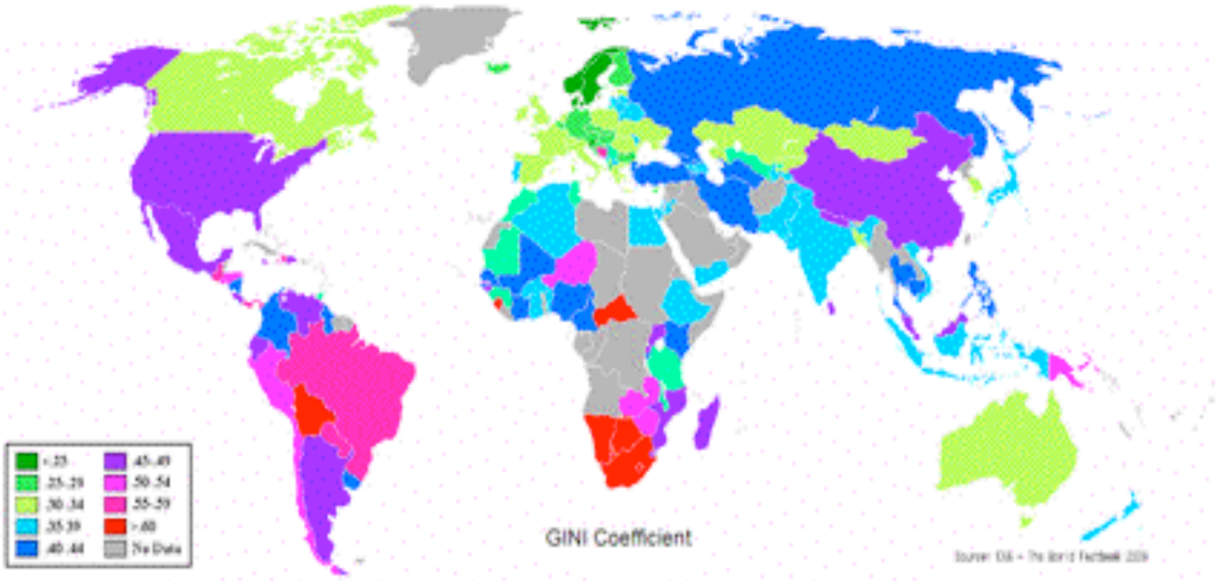
- Arrow's impossibility theorem says there is no perfect way to aggregate personal choices into social welfare that's consistent with democracy

Income distribution



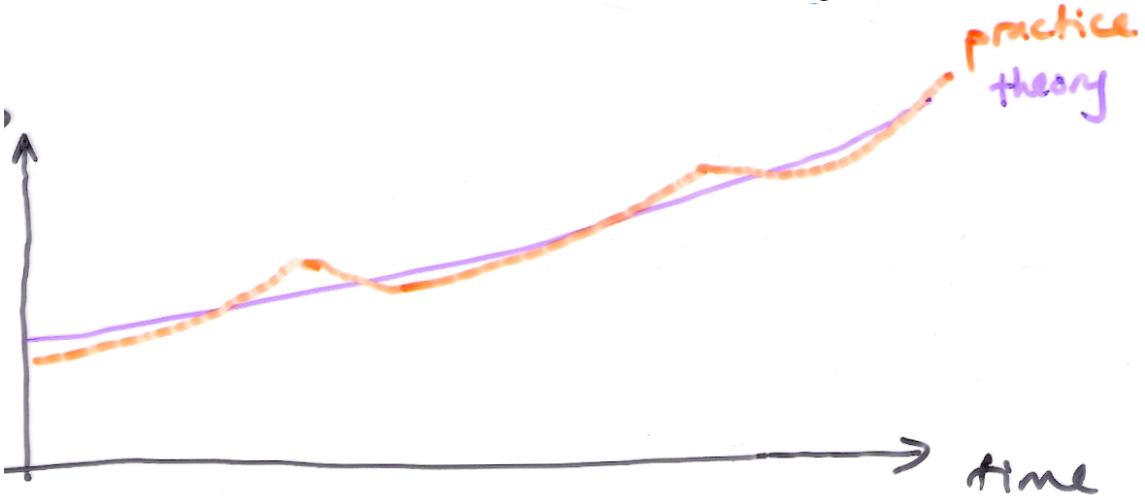
- The Gini coefficient is used to measure inequality
- Gini = A/(A+B) in the above graph where B is the cumulative income distribution
- Gini = 0: communism; Gini = 1: the king has the lot

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
- It cuts both ways though: e.g. a farm policy that brings each farmer £20000 but costs each nonfarmer £200

The business cycle

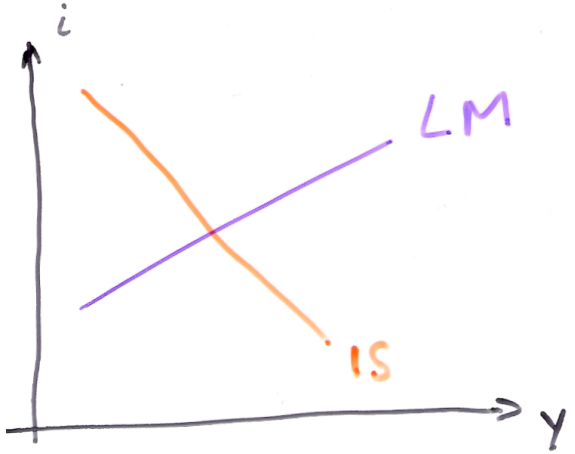


- The business cycle was a puzzle for classical economists. Why the pattern of boom and bust?
- Falling wages should clear the labour market, and the money firms spend on wages, raw materials etc should be exactly enough to buy their output (Say's law: supply and demand in the economy should be equal)

The business cycle (2)

- Mill and Ricardo argued that demand for goods + savings = supply of goods + investment, and savings = investment, so demand = supply
- Malthus and Sismondi argued that savings and investment could differ in the short term; falling confidence → people hoard cash
- 1930s: Keynes elaborated this with '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…

The business cycle (3)



- In the 1930s, the world stuck in recession for years
- Keynes' 'General Theory' set out in 1936 to explain why. A summary is in Hicks' IS-LM diagram
- I: interest rate Y: national income IS: investment / savings LM: liquidity preference / money supply
- Idea: when savings, investment and money supply are modelled in enough detail, the equilibrium isn't necessarily one with full employment. Need to get money supply right

The business cycle (4)

- Credit introduces instability at many levels.
- In a boom, people and firms borrow assets that appreciate faster than the interest costs
- 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 contracts sharply

The current recession

- Kicked off by US subprime mortgage crisis of 2007 which led to collapse of money markets – no bank knew which other banks were still sound
- A common pattern – see Reinhart & Rogoff
- Big question: will the recession be
  - Small (2y, asset price fall 30%)
  - Medium (4y, asset price fall 50%)
  - Large (8y, asset price fall 80%)
- History tells of two biggies (US 1930s, Japan 1990s); dozens of medium; very many small
- UK: questions over budget deficit, house prices

Recession and tech

- Recessions may be fed by bubbles and triggered by financial markets but are often tried up with tech change
- Railways 1840s, cars 1920s, tech 1990s – boom creates capacity, bust drives down prices
- Schumpeter: ‘creative destruction’
- Tech doing much better now than 2001-2: some suffer (Sun, Motorola) but most firms thriving
- Jan 2010 Microsoft profits up 60%, Google 17%…
- IT now a thoroughly global industry: if the USA does better than Europe, or people buy consumer electronics instead of cars, we still get our share

Recession and tech (2)

- Known patterns: capital goods hit first in recession (e.g. new car sales down 30-50%)
- Services fairly stable thanks to many long-term facilities management contracts
- Outsourcing booming as firms cut costs
- Financial sector IT is struggling (like 1991)
- Government systems folks confident (though Conservatives say they'll cut waste)
- Hardware is always cyclical – fab capex down a bit but firms know they must keep investing
- When will Moore's law run out?

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 of 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

Trade (2)

- Consider 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

Trade (3)

- Suppose England has 270 units of labour, Portugal 180

	wheat	wine
E	8	5
P	9	6
Total	17	11

	wheat	wine
E	18	0
P	0	12
Total	18	12

- Mill's insight: welfare gains from trade come from cheap imports
- Heckscher-Olin looks at capital v labour (outsourcing)
- Under perfect competition, free trade optimal; almost all economists agree it's also a pragmatic optimum

Growth

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

Tragedy of the commons

- 100 peasants each graze a sheep on the common
- What if one peasant adds one more?
- He gets 100% more, the others get 1% less, and he common ends up overgrazed
- Modern examples: overfishing …
- Welfare theorems assume complete property rights, atomistic principals and full information
- Where this fails, private cost ≠ social cost
- Observed forever, documented by 1830s, used to justify enclosure movement, inspired Malthus

Externalities

- Externalities are goods / bads people care about, but not traded: typically side-effects
- Consumption externalities include smoking in restaurants, domestic heating emitting CO_2
- Production externalities include a steelworks polluting a fishery downstream, or emitting CO_2
- 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 where there are many players

Public goods

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

Monopoly rents

- Absent barriers to entry, firms will enter a market until excess profits competed away
- What if we regulate prices?
  - In 1986, New York taxi licenses cost $100,000 yet drivers earned $8 an hour
  - License owner makes $17pa net – 17% ROI
  - Politicians put up fares, to help drivers
  - Extra $10,000 per annum just added $60K to the value of a license
- Monopoly / entry barriers in effect create a rent
- ‘Rent-seeking’ drives much of politics

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, …?

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 software for a computer or PBX, or CDs for a sound system
  - skills, e.g. fluency with Win/Mac/Linux of 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 entirely new (fewer people change their bankers than their spouses) but has some pronounced effects in information goods markets

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 you can find a business model that makes the customer worth £100, offer them £60 cashback to switch
  - They're £10 ahead, £15 ahead
- So the value of Microsoft is what it would cost people to switch to OpenOffice and 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 Gmail and Facebook Connect
- Asymmetric switching costs add complexity – a mobile phone network has to supply a phone to win a customer, but to keep a customer can offer extra minutes whose marginal cost is zero

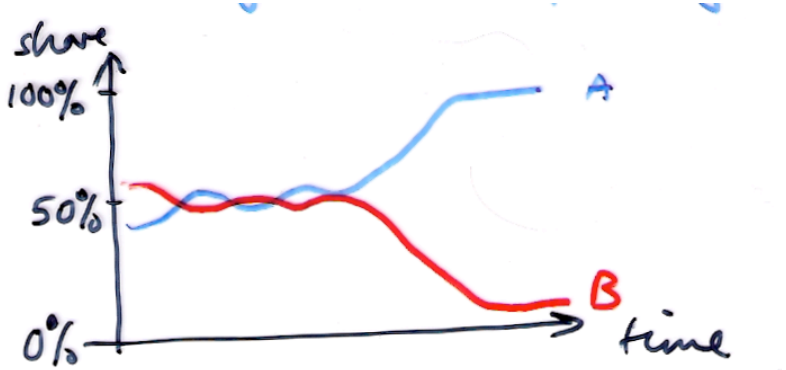
Network externalities

- 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
- Overall effect: past some threshold, network use takes off rapidly
  - Telephone – late 19th century
  - Fax – 1985–88
  - Email – 1995–99

Network externalities (2)

- As well as ‘real networks’ like fax and email there are ‘virtual networks’ such as PCs and software
  - Most people buy PCs (rather than Macs or Linux boxes) 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

Network externalities (3)

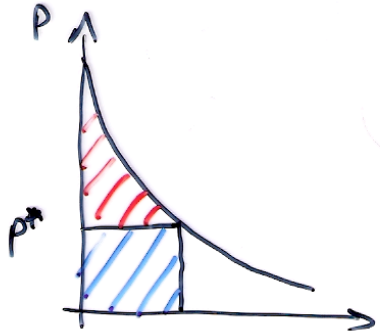


- So markets with network effects can ‘tip’
- It’s particularly common with two-sided markets
- Other examples:
  - Rail guages in the 19th century
  - Colour TV standards in the 1950s
  - VHS v Betamax, Blu-Ray vs HD-DVD, …
  - Paypal v eGold etc
  - Facebook v Myspace, Bebo, Friendster, …

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
- With all three together, monopoly is even more likely
- Hence the race for market share whenever a new information market opens up
- Hence the 1990s Microsoft philosophy ‘ship it Tuesday and get it right by version 3’
- Competition in the market versus competition for the market
- Policy: do you hope that tech change will make incumbents obsolete, or do you regulate?

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 for generations – but getting more powerful, more pervasive
- Tech simultaneously increases the motive and the means

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)

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 you usually rent
- Versioning can include marketing incentives – e.g. Wall St Journal online sub free for academics, cheap for students and expensive for business
- Much of the promised efficiency gain from e-commerce was based on hope of more effective price discrimination
- To what extent did this actually happen?

Price discrimination (3)

- Price discrimination is in general efficient
- E.g. suppose my students and I will analyse a new bank security product for £10,000; we find that Bank A will pay £8000 and Bank £4000
- Uniform pricing means no deal! But if I can set p_A = £7500 and p_B = $3500 we all win (i.e. Pareto improvement)
- But public reaction against discrimination can be strong, especially when the strategy is 'damaged goods' and especially when discrimination overt
- Even economists are surprised at depth and persistence of discrimination in some markets, e.g. air fares (London-New York £300 econ, £3000 business, £6000 first)
- One way to conceal discrimination in 'bundling'

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	£100	£150
Bob	£150	£100

- With separate pricing, MS would charge £100 per product and get £200 per customer, or £150 and get £150
- By selling them together, it gets £250
- Can also sell different bundles (Office vs Works)

Asymmetric information

- Recall Akerlof's 'market for lemons'
  - 100 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
- Labour markets too – it's hard for employers to tell smart diligent employees from interview, so use education as a signal
- Signalling theory is also important for recommender systems – Google, eBay, Grameen

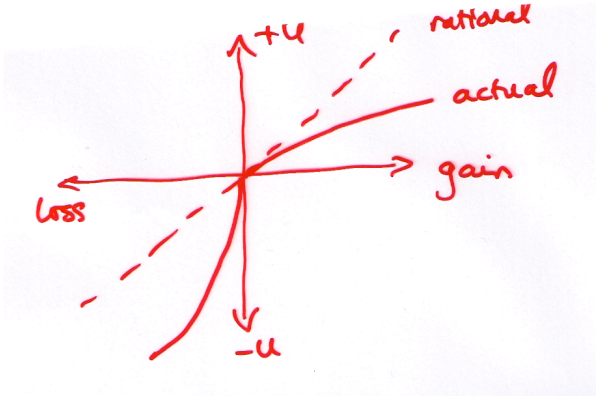
Asymmetric information (2)

- 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: trashed by adverse selection
- Insurance markets can also be trashed by moral hazard; hence excess, no-claims bonus, …
- Moral hazard can lead to surveillance, rationing

Transaction costs

- Trades are not free! Time & effort; commissions; search; bargaining; policing and enforcement
- Ronald Coase (1930s): why do some sectors have large companies, and others small firms? External transaction costs higher than internal ones
- Oliver Williamson (1980s-90s): determinants are frequency, specificity, uncertainty, limited rationality, and opportunistic behavior
- Again, a big promise of the dotcom boom was to cut transaction costs via efficient B2B markets
- So should tech make firms smaller on average?

Bounded rationality



- 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!
- Kahneman and Tversky's "prospect theory" seeks to explain this via mental heuristics and biases
- That's why marketers talk 'discount' or 'saving' – framing actions to make them more attractive
- The misperception of risk is a big deal (terrorism)
- 'Behavioural economics' studies all this stuff

Bounded rationality (2)

- Herb Simon coined ‘bounded rationality’ in the 1950s along with ‘satisfice’
- A satisficier will work hard until his lifestyle goals are met, then slack off. Most of us are satisficiers, and VCs don’t like us!
- Another common rationality bound is ‘hyperbolic discounting’ where people disregard far-future events. Most people have inadequate pension provision
- The endowment effect: people generally demand a higher price for something they already own. Innate conservatism, plus sensitivity to change

Bounded rationality (3)

- Decisions are heavily influenced by framing. E.g. the 'Asian disease problem' where the subject is making decisions on vaccination. Two options put to subjects. First:

  A: "200 will be saved"

  B: "p=1/3, 600 saved; p=2/3, none saved"
- Here 72% choose A over B!
- Second option is

  C: "400 will die"

  D: "p=1/3, no-one will die, p=2/3, 600 will die"
- Here 78% prefer D over C!
- Defaults also matter. Most people won't opt in, or opt out. 'Libertarian paternalism' is about setting socially optimal defaults (e.g. you have to opt out of pension schemes)

Agency effects

- Classical economics sees institutions as rational
- But decisions are made by individual managers, who optimise their own utility too
- New institutional economics: look at how managers behave. Should you give managers stock options to align 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?

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
- Spectrum auctions a big deal for tech biz
- Rapidly growing interest in theoretical computer science: auction resources in distributed systems
- Many issues of asymmetric info, signalling, strategic play… – plus some solid 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)

Strategic equivalence

- A Dutch auction and a first-price sealed-bid auction give the same result: highest bidder gets 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

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), suitable reserve price, valuations independent, …
- Then the English, Dutch and all-pay auction yield the same – because bidders adjust their strategies
- So auction design must focus on departures from the ideal conditions

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 somewhere between these two extremes

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: in 1991, ITV franchise auction required bidders to draw up a detailed programming plan. In Midlands & Central Scotland, 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

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
- Signalling games: show aggression by a large price hike
- Simultaneous auctions, as in USA "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

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…
- Critial app for CS: routing in presence of congestion (bid for AB and BC, or AD and DC, or…)
- 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 bext strategy)?
- New field of ‘algorithmic mechanism design’

Patent

- 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 covered; can't protect 'the theories above, or the facts beneath'
- However USPTO in particular has really stretched the boundaries, to business methods, genes, …

Patent overstretch

- E.g. long fight by ACLU to overturn patents by Myriad on human genome
- US 5,747,282 (1998) includes any 15-nucleotide sequence appearing in BRCA1 breast cancer gene – that's 1.6m sequences of 1.06bn possible.
- Every human gene contains on average 15 such
- Most lab directors had decided not to develop a test / perform a service because of a patent
- See "I patent your ass. And your leg. And your nostril", Ben Goldacre's 'Bad Science' blog, April 2 2010

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 enforcements (McDonalds)

Copyright

- Since Statute of Anne (1709–10), copyright has protected literary works – extending from novels and drama to art, music, and software
- No need to register – but asserting copyright (© RJA) can make litigation easier
- Duration – has steadily increased over recent years and is now author's lifetime + 70 years (only 50 years for sound recording rights)
- Protects against copying, adaptation etc; "fair use" and "fair dealing" get-outs for criticism, parody…
- Moral rights remain with author even if copyright sold

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
- Limits – e.g. an employer can’t restrict knowledge that’s become part of the ‘tools of your trade’

Software

- Primary protection is copyright
- 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! (See Richard Stallman’s talks here on Mar 25 2002, Apr 30 2008)
- So far only four CS patents earned serious money
- In general, innovation in CS is highly incremental: a large program can use thousands of ideas, while a blockbuster drug is a single patentable molecule

DRM

- Copyright owners panicked at printing, audiocassette, videocassette … and now the Internet
- Huge push to introduce DRM over last ten years
- Not clear that file sharing harms sales
- DRM seems to benefit platform vendors more
- Yet the legal bandwagon continues from DMCA to ACTA to Digital Economy Bill…
- Lexmark v SCC, compared with IPRED
- ‘Trusted Computing’ and lock-in
- Further reading: Richard Stallman, Pam Samuelson, Suzanne Scotchmer, ORG, EDRI…

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')
- The real game is how you lock customers in
- Biggest winnings historically went to those who control platforms and interfaces