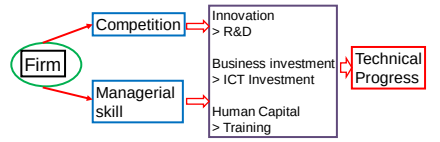
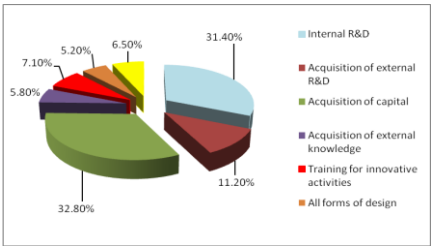
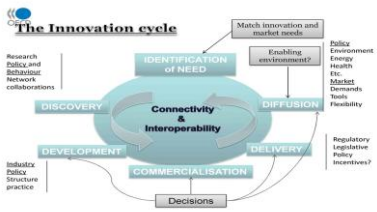
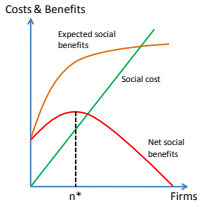
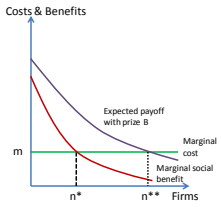
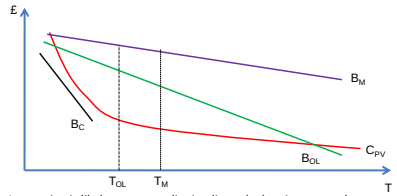
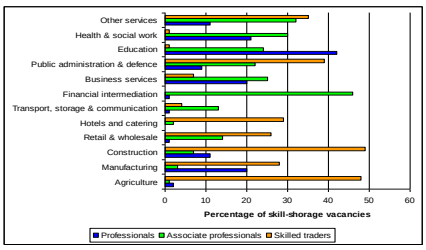
Reading map:

This lecture is based on Chapter 16 of the Carlton & Perloff textbook, but some material has also been adopted from the Waldman & Jensen book, and from OECD and UK government publications. In the Carlton & Perloff textbook, it may be useful to read through pages 526-548.

Technical progress in firms  Source: Bhaumik, S.K. (2011). Productivity and the Economic Cycle. BIS Economic Paper No. 12, UK Department of Business Innovation and Skills.	This diagram explains how firms achieve technical progress. Competitive pressures provide firms with the incentive to innovate, whether through R&D or otherwise. But firms also need managers with the appropriate skills to adopt the appropriate innovation strategy. Once a firm decides to innovate, it has to choose some combination of actions such as investment in R&D, investment in physical capital such as ICT, and investment in human capital of its employees. These actions eventually results in technical progress which improves the firm's productivity and efficiency.
Innovation across sectors – UK  Source: UK Innovation Survey 2009: Science and Innovation Analysis (Figure 2.6)	It is now widely understood that while the academic literature focuses a lot on R&D, only a handful of firms actually invest in it. A much greater proportion of firms simply buy technology off the shelf, or innovates in other ways (e.g., changes in design of their products). This diagram highlights the different aspects of innovation.
R&D and innovation – inter-connectivity  Source: OECD	Organisations such as the OECD are adopting the view that innovation is not just something that firms do on their own, but that it is part of a wider process. For example, private firms may identify the need for a particular kind of innovation, the basic research can be done at universities, this research can thereafter be commercialised by private firms, and the market can then facilitate the diffusion of the new technology. Governments too have a role to play, e.g., they have to provide the legal (intellectual property laws), institutional (contract laws) and technological (high speed broadband) backdrop that facilitates innovation and its diffusion.
A world without patents **Firms in Bertand competition** **Cost of innovation = 1** **Cost of imitation = 0** **Company B** **Innovate** / **Imitate** **Company A** **Innovate**: (-1, -1) / (-1, 0) **Imitate**: (0, -1) / (0, 0) **Firms collude to maximise joint profit** **Cost of innovation = 1** **Cost of imitation = 0** **Company B** **Innovate** / **Imitate** **Company A** **Innovate**: (2, 2) / (2, 3) **Imitate**: (3, 2) / (1, 1)	Here, we are addressing the question as to why we need patents. In the upper panel, we have two firms, each of which can either innovate or wait for the other firm to come up with a new product or process and then imitate it. (Since we are talking about a patent-free world, imitation is possible.) Given the payoffs, you can verify that it would be the dominant strategy of each firm to wait for the other firm to innovate. In equilibrium, therefore, there will be no innovation. In the lower panel, we allow the firms to collude, such

	that one of them invests in innovation, and once the new product or process has been developed both use it in a non-competitive manner. In this case, you can verify that there is no dominant strategy. Instead, each firm has a Nash strategy: it will innovate if the other firm does not do so, but if the other firm innovates then it will wait for the new product or process to be in place. Hence, there are two Nash equilibria. In each equilibrium, one firm innovates and the other imitates. Hence, in equilibrium, there is innovation, but only because we permit collusion which is generally frowned upon.
Patents – optimal research  • Assumptions: – *n* firms in the industry – each undertakes one project with MC = AC = 1 – probability of success of at least one project increases with the number of firms – if successful, the new product will generate value for the society of magnitude B > 1 • Optimal number of firms: – Expected social benefit does not rise fast after a certain number of firms enter the industry – Social cost is *n* – Net social benefit is maximised for *n** number of firms	The implication of this diagram should be clear from the bullet points on the slide. Read the section entitled "Determining the Optimal Number of Firms", pages 541-542.
Alternatives to patent  • Government contract • Joint ventures – Benefits: reduces duplication of research; gains from exchange of ideas – Cost: likelihood of tacit understanding about products and prices, i.e., collusion • Prizes – Winner takes all – Expected payoff to each firm increases – In equilibrium, there are more firms in the industry – The likelihood of success is higher, but not commensurate with the cost	This slide covers material discussed on pages 543-548. The diagram itself makes the following point: Suppose that there is a prize with a high payoff (R); the payoff goes only to the firm that comes up with a new technology or product or process ahead of the others. In that case, even if the probability of success ahead of others (p) is low, the expected payoff (= p x R) is still high. If so, the expected marginal benefit for individual firms derived from investing in R&D may be higher than the expected marginal benefit for the society. Given the marginal cost of R&D, it is easily seen that in such a case the social optimum would ne n* investment in R&D, but the actual investment is n**. In other words, there is more investment in R&D that is socially optimal.
Strategic decision – using vs. licensing new technology MONOPOLY • Demand: P = 100 – Q • Initial cost: $AC_{M1} = MC_{M1} = £30$ – $Q_{M1} = 35$; $P_{M1} = £65$ – Profit = £1225 • Innovation reduces cost: $AC_{M2} = MC_{M2} = £20$ – $Q_{M2} = 40$; $P_{M2} = £60$ – Profit = £1600 • Gain to monopolist on account of profit = £375 PERFECT COMPETITION • In competition, profit is always zero in the long run, and hence there is no gain from innovation • Competitive firm licenses the product for £10: – Production cost with licensed technology: $MC_C = AC_C = 20$ – Overall cost including royalty for technology = 30 – Royalty payments = 70 x 10 = 700	Here, we are trying to deal with a paradox. The popular wisdom is that competition provides the incentive for innovation. However, in a competitive market, a firm only earns zero profits in the long run. What incentive does a firm have to innovate in a competitive market? It can be shown that in a competitive market it is possible to earn a positive payoff by developing a new technology and then by licensing it to all the other firms in the market. The innovative firm will then earn zero profits from its productive activity, but may earn a positive profit from its licence fee. Firms in a competitive market would therefore have the incentive to innovate. This discussion, of course, does not take into consideration the possibility that even if a

	firm in a competitive market earns zero profit, it could still innovate just to survive, to keep up with new entrants with better technology, products and processes.
Market structure and innovation  • Innovation is likely to start earlier in oligopoly than in monopoly • The cost structure would determine how many markets would witness innovation	This diagram summarises the following argument: A firm has the choice of investing in innovation in periods 1, 2, 3 .... etc. If it invests in innovation in period 1, then the present value of both the benefits and the costs associated with innovation is high. If the innovation is undertaken in the later periods, then the benefits and the costs are deferred and hence discounted. In that case, the present value of the benefits is costs are reduced. Hence, if we have time along the horizontal axis then the (present value of) benefits and cost curves are downward sloping. The present value of benefits from innovation is highest for a monopolist and lowest for a firm in a competitive market, and somewhere in the middle for a firm in an oligopolistic market. Hence, in a competitive market, firms may not have the incentive to undertake innovation unless the present value of the cost of innovation (C_{PV}) is quite low. For a monopolist, the benefits (B_M) might exceed the cost (C_{PV}), but since it is a monopoly to begin with, the net benefits from innovation might not be significant. In an oligopoly, however, not only is the (present value of) benefits (B_{OL}) higher than the cost (C_{PV}), but the net benefit could be significant if innovation helps overcome competition from rival firms. Hence, innovation may start earlier in an oligopolistic market (at time T_{OL}) than in a monopolistic market (T_M).
Complementary factors – skills  Source: *Skills for Jobs: Today and Tomorrow*, Volume 1, UKCES (2010), Table 3	In order to successfully innovate, and also in order for innovation to get disseminated through imitation, it is important for firms to have access to skilled labour. This diagram summarises the skills gap in the UK economy, by sector.