Innovation: A Guide for the Perplexed *

Jonathan Haskel
Imperial College Business School; CEPR, UKIRC and IZA

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Abstract
A non-technical guide to innovation, with links to more technical work in the footnotes and a final section on further reading.

*Contact: Jonathan Haskel, Imperial College Business School, Imperial College, London SW7 2AZ, j.haskel@imperial.ac.uk. In the spectrum between hysterical rants and guarded academic prose, this is more towards the rant. So if I overstate my case and offend anyone, apologies, this note is designed to be a provocation. Let me make it very clear that these are my views and my mistakes. For financial support for ongoing innovation projects, I would like to thank, again, without any implication, NESTA and the UK-IRC at Imperial and past support from (what was) BERR. And for those who care about these things, the intellectual debt to Corrado, Hulten and Sichel’s work will be obvious (as will the title to EF Schumacher).
Innovation: A Guide for the Perplexed

1 How to think about innovation

1.1 The big picture
We need some innovation. Innovation to deal with a broken financial system, innovation to police riots, innovation to boost economic growth. So we have a profusion of agencies, indices and think tanks competing to offer ideas. The UK produces an innovation index.1 The EU an innovation scoreboard.2 The OECD an innovation strategy.3

But what is innovation? How is it measured? What should policy do about it? Among this melee, there is surprisingly little agreement. The EU scoreboard measures innovation by a weighted average of 24 indicators for each EU country, with the indicators ranging from GDP, ICT spend, exports of high technology products and broadband penetration. Eurostat mandates all signatory countries survey businesses asking them to self-report how innovative they are.4 And whilst everyone seems to agree innovation is a good thing (except of course in finance), no one agrees on the policies to boost it: more science, less big science, more basic skills or more advanced skills, stronger IP, weaker IP etc.

Behind all this economists have been labouring away at innovation more or less since Adam Smith5. Perhaps unwisely, I have been dabbling in this area myself. Now, every economist believes in competition. There should be lots of approaches to a problem. But I have come to the view that, actually, economists have a really useful, focussed and sensible approach to thinking about innovation. It’s an approach that helps clear up so much of what’s puzzling and contradictory about other approaches. It tells you what data to collect. And it tells you about policy.

So, this note is an attempt to put over the Economics approach. You may not be convinced; that’s fine. But I hope at least this note will spread understanding of what economists do into a field where that understanding often seems lacking.

1 http://www.nesta.org.uk/areas_of_work/economic_growth/the_innovation_index. Declaration: I have contributed to this.
3 http://www.oecd.org/innovation/strategy
5 A technical outline of more recent work is in Hulten (2001), Total Factor Productivity. A Short Biography
Let’s start by clearing up the difference between innovation and invention. An innovation is something that is commercialised. An invention is a discovery. So a new planet of Venus or a drug are discoveries. The planet cannot be patented nor (yet) commercialised. The drug, if commercialised is an element of innovation.

1.2 Some clear economics thinking: an economy with no innovation
At the heart of innovation is surely something new, something different: lets label it progress for shorthand. Now comes the clear bit of economics thinking. Economists like to think about models. They are abstract descriptions of the world, built by assuming away all manner of complications to concentrate on the key matters at hand (just like physicists start by considering falling bodies in a vacuum, say). Let’s apply that logic to think through the following abstract model: how could we have progress without any innovation?

After a bit of reflection, the answer is clear:. we could just do more of the same. We could get more passengers from London to Glasgow by having more flights, or trains or cars and more airports and track and roads. We could get more sales at Wal-Mart by having more shops, more staff and more trucks supplying them. Banks could process more cheques by having more machines to sort them and envelopes to post them. To economists, none of this would be innovation. It would all be duplication, of planes, or roads, or staff.

What then is innovation? It’s doing things differently. It’s having more passengers by ticketless boarding, better-written software to roster crews and faster turnarounds at airports. Its more sales at shops by improved co-ordination of deliveries and tessellated packing of goods. More payments processed by bypassing cheques altogether and using e-payments. And so on.

So how do we measure innovation? It’s not total growth in output. It’s the growth in output over and above the duplication. That is to say, it’s the growth in output not from more machines and more staff, but from better use of them. That of course clarifies the link between innovation and growth. We can have growth perfectly reasonably with duplication: with more machines and more people working. But innovation is that part of growth in excess of the contribution of the duplication.

in New Developments in Productivity Analysis, Charles R. Hulten, Edwin R. Dean and Michael J. Harper, editors.
6 This expands the argument made by Jorgenson (2007) in his evidence to the Gutierrez committee.
Lets put this thinking to work and see if it clarifies the issues. I think it does.

Consider first China. Here’s a clear way of asking what China’s growth strategy is. Is it growing because it’s just throwing more labour and capital into the economy? Or is it using those inputs more cleverly? In other words, is it a duplication economy or an innovation economy? The framework clarifies the question admirably.8

Second, what happens when you ask firms to self-report innovation? Work on the answers given to the UK survey found that many firms answering the “have you innovated?” question wrote down they were introducing new capital equipment.9 That’s duplication, not innovation. Of course, if the machines are better, cheaper, faster, some innovation has been going on, but that’s innovation in the capital-producing industry, not the industry that is introducing the capital. (When Airbus build a better, faster, cheaper jet, that’s not innovation in the airline industry). So if you ask firms to self-report, you double count: both the airline industry and aircraft industry might report an “innovation”.10

Third, what do we make of the endless scoreboards and indices? Many of them are a mix of outputs, like GDP, and inputs, like ICT. The failure to distinguish between inputs and outputs means they cannot even start to address the issues above.11

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8 To reinforce this point, consider an economy where we know the answer to this question: the Soviet Union. They achieved growth, but it was only by adding more capital to the economy. That’s why growth slowed so badly as diminishing returns set in (raised somewhat in the last years by copying military technology from the West).

9 See the Appendix to Crespi, Criscuolo and Haskel (2007), http://www.ceriba.org.uk/bin/view/CERIBA/ProdOrgchange

10 This is assuming even that firms understand what you are asking. As mentioned above, self-assessed innovation surveys are so popular that Eurostat mandates EU statistical agencies to question, every two years, firms, asking them if they have innovated or not. The definitions offered on the questionnaire have varied somewhat over the years, but are mostly words to the effect of “have you introduced new products or services”. The snag is that when you ask firms this question you get a pretty wide range of answers, indicating, to me at least, that firms don’t really understand the question. In the Spain, around 17% of service sector firms say that have introduced a new of significantly improved product or process innovation. In the US, the figure is 9%. So we really think the US is half as innovative as Spain? In US computer manufacturing firms, 33% of firms said they innovated 2006-8. That is to say, 66% of US computer manufacturing firms apparently introduced no innovations over that period. Really? (Sources of data: Borouch: http://www.nsf.gov/statistics/infbrief/nsf11300/nsf11300.pdf, OECD: http://dx.doi.org/10.1787/834827023338.

11 The report of the EU “High-Level Panel on the Measurement of Innovation”, http://ec.europa.eu/commission_2010-2014/geoghegan-quinn/hlp/index_en.htm, proposes a mix of inputs and outputs. The EU Lisbon R&D target of 3% R&D spend to GDP is a target on inputs, and is understandable. R&D is an important expenditure on knowledge building and so part of innovation since it will discover how to do things differently. In focussing on getting more output from existing inputs, looking at R&D is the right next step to take. But its only one such input: firm also spend on building new knowledge in design, business processes, firm-specific training. So the net has to be cast wider, which is what the EU high level commission is doing.
Fourth, how does the creative economy fit into this? The approach emphasises that innovation is broader than just R&D that makes better, say drugs. It’s anything that makes progress over and above duplication: better design, better marketing, better process engineering. And that brings in the creative economy. The creative economy is that part of the economy devoted to innovation: thinking of ways to do things differently, not just duplication. Some of those employees work independently, or for design, R&D or software specialist firms, who are classified in business services. But don’t forget that some work within manufacturing or service firms, in in-house labs, or R&D or product development centres.

Fifth, does this approach help policy? Yes it does. Growth via duplication (which is how most developing countries do it) involves spending on tangible goods, mostly machines. When you invest in a machine it’s yours to use. What about growth via innovation? When you spend on knowledge you may be able to keep it for your own use, if, for example, its tacit and hard to duplicate (production methods at Brompton Bicycles for example) or if you can patent it. But knowledge can slip out of organisations to the benefit of others. It therefore has a “public goods” element and leaving knowledge investment to the market won’t provide the right incentives. So there is an a priori case for subsidising knowledge investment and that’s what public support for R&D, via universities or tax credits, are designed to do.

And there’s another insight. Where in the innovation chain should you subsidise? Some argue sciences not arts. Others physics, not biology. Others big science, not small science. This approach says subsidise knowledge that’s mostly producing public goods. So, don’t subsidise very close-to-market research by firms, which is likely going to produce few public goods (but plenty of private goods). Of course, we need some work to find out just what part of the innovation value chain to subsidise. Haskel and Wallis (2010) argue its university research councils

2 How to measure innovation

How can we measure the addition to growth over and above the duplication of capital and labour? Fortunately we have the data we need. And even more fortunately, it’s the National Accounts. So we immediately relate what we do to the everyday concerns of policy makers elsewhere: be they the Treasury, the Bank of England or indeed anyone who cares about GDP growth.13

12 Paper available from here http://www.ceriba.org.uk/bin/view/CERIBA/PublicSupportCeriba
The National Accounts collect economy output, namely the value of GDP. By the rules of accounting, that value consists of payments to labour (about 2/3rd of the total) and payment to capital (the remaining 1/3rd).\[^{14}\] It also collects price indices so we can tell if the value of GDP grows via general prices increasing (which would not be innovation) or volume of goods rising (which might be). In addition, National Accounts collects data on the labour force, broken down by age, experience, educational qualification etc. So we can measure growth in labour input. Finally, we also have very detailed survey data on investment in plant, vehicles and buildings by firms. We can use this to work out growth in (tangible) capital input.

GDP typically grows at 3% per annum, labour at 0.5%pa and capital at 4%pa. But before we can capital and labour growth from GDP growth, to get growth net of duplication, we need to know what weights to use for capital and labour growth. Those weights have to be the contribution of capital and labour growth to output growth i.e. the extra output you would get if you just had more trucks and more planes and more staff with nothing else changing. Robert Solow (1957) showed that in a competitive economy the weights would be the shares in GDP of the inputs, here 2/3\(^{rd}\) and 1/3\(^{rd}\), that the National Accounts collects. And if you do that, you get what economists call “total factor productivity growth”, which here I interpret as innovation. Statistical agencies all over the world make this calculation. In developing countries TFP growth for example is a very small fraction of total growth, since growth is mostly duplication. In most developed economies in recent years you typically find that TFP growth is about 30-50% of total growth.\[^{15}\]

We do just this for the innovation index (Haskel, et al, 2010), but with one important twist. Modern day economies are increasingly knowledge based. That is to say, whilst they invest in “tangible” assets, like buildings, they increasingly spend on “intangible” or “knowledge” assets like software, R&D, design and business processes. That investment is done in part by private sector firms and in part by the public sector e.g. universities. And parts of that knowledge investment are public and private goods. So we can go deeper in measuring innovation than by just subtracting off the tangible and labour duplication part. We can also study how much of what is left over is accounted for by private knowledge investment within firms and how much (the rest) by publically available knowledge. (We can then look at the conditions that might aid such knowledge investment and its public transfer, such as tax credits, clusters, IP legislation etc.)

\[^{13}\] Those who believe that GDP is a useless indicator of anything might ask themselves if their fellow citizens are similarly unconcerned about the prospect of years of near-zero GDP growth.

\[^{14}\] What about payments to other inputs, like land or raw materials? Payments to land are, by accounting convention, omitted. Payments to raw materials, or more generally, inputs used up in production, are not counted to avoid double counting: if I use coal to make steel and steel to make cars, I don’t want to count the steel twice.
So what do we find? Here are the results for the UK market sector (that is, the whole economy, excluding the hard-to-measure public sector).

Figure 1 shows how much firms are investing in intangible, that is knowledge assets, over time, compared with tangibles. At the start of the period tangibles was less, now they are more: so we truly live in the age of the knowledge economy.

15 Some guidance on the details of this are in http://www.ceriba.org.uk/bin/view/CERIBA/DigitalEconGrowthImperial, slide 18.
Figure 1: Investment by UK annual market sector firms in intangible and tangible assets, 1990-2008.

Figure 2 shows how growth breaks down into duplication and innovation.

**Figure 2: Breakdown of components for UK annual average labour productivity growth, 2000-2008.**

Market sector value added per person hour\(^{16}\) grew at 2.24% over the period, about average for the past decades. Capital per person hour, that is simply giving each work more capital to work with, accounted for 0.67% per annum (consisting of capital per worker growing at around 2%pa, but the capital share of 1/3\(^{16}\)). As the pie chart shows, capital growth, duplication, is 30% of growth.

So 70% of growth is due to innovation. What does that consist of? 7% of growth is labour quality. In this exercise we have measured not just labour, but the adjusted labour inputs by weighting together age, gender and educational categories. So if education of the labour force rises, and if those educated are paid more, then this index of “labour quality” rises. Some regard this rise in quality as part of innovation, since we are not just adding more heads but upgrading it.

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\(^{16}\) Measuring per person hour is useful since labour input varies across time and country by both number of people but also the hours they work.
The rest is “innovation” i.e. the part of growth left over from duplication of physical capital and employment. That in turn is made up of the contribution of intangible investment by firms plus knowledge that is freely available (which could be part of the private investment that leaks out and also knowledge from universities, abroad etc.).

How does all this vary by industry? This is set out in Haskel et al (2010, table 12, 13 and 14). The main point is the contribution of manufacturing. Although manufacturing is only 19% of market sector value added, manufactured goods are inputs into the rest of the economy (think of planes as an input into airlines). So productivity growth in manufacturing has a direct effect on manufacturing but also an indirect effect via its use elsewhere. It turns out then that manufacturing accounts for 42% of total innovation in the economy (measured by the contribution of intangibles and TFP growth).

This is a coherent framework for innovation analysis. It’s logical, consistent and implementable with the data at hand. It provides a clear roadmap on what data to collect and how to analyse it. Sure, it depends on assumptions and is only as good as the data that supports it. But all this can be tested and improved. For clear, rigorous and evidence-based thinking about innovation, it’s best game in town.

3 A note on further reading.

For those that want more here are some other notes, that I will try to update as I see more work.

3.1 Universities

Universities contribute to innovation in two ways: (a) they raise the quality of labour and (b) produce new knowledge that the private sector can use. Here are some details.

http://www.ceriba.org.uk/bin/view/CERIBA/CeribaUniversities

3.2 Measurement and the self-reported innovation method

I’m not keen on innovation surveys. Here’s a presentation in Washington DC on why.

3.3 **International evidence on intangible spending**
After an introduction, here’s a presentation from a keynote in Berlin.
http://www.ceriba.org.uk/bin/view/CERIBA/InnovationBerlinJune2011

3.4 **Science policy**
A presentation to the Cambridge science festival.
http://www.ceriba.org.uk/bin/view/CERIBA/CambridgeScienceFestival

3.5 **The digital economy and growth**
I think of digitisation as new methods of encoding and transmitting information. This ICT revolution has completely transformed this, since such new methods are better, faster, cheaper: its analogous to mechanisation that made, say, pencil making, better faster and cheaper. How do we think about this?
Here’s a lecture at Imperial to the Digital Economy group there.
http://www.ceriba.org.uk/bin/view/CERIBA/DigitalEconGrowthImperial

3.6 **Relation to innovation definitions and other approaches**
Haskel et al (2009, part 2.2ff)\(^{17}\) sets out the relation of this to existing definitions from Frascati, Oslo, NESTA and the US Committee to measure innovation\(^{18}\). The thinking here is very close to that of the key papers by Corrado, Hulten and Sichel (2005, 9) and Corrado and Hulten (2010), see also Corrado (2007)\(^{19}\). The paper by Sissons (2011)\(^{20}\) from the Big Innovation Centre, quotes some of this intangible work but is unclear on what it means by innovation (“it makes sense to use growth as a proxy for innovation” page 9, but it then uses various other indicators like exports).

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