5. Measuring creativity and innovation based on knowledge capital investment [1]

Tony Clayton (ONS),
Mariela Dal Borgo (University of Warwick),
Jonathan Haskel (Imperial College, London),
Mark Franklin (ONS)

Abstract

Economists and policymakers agree that ideas and innovation contribute to productivity and economic growth, but the transmission mechanisms are less clear. The motivation for this presentation is the question posed by Jorgensen (2007) — How would an economy produce more output without innovation? Jorgensen's answer is to use the same ideas, but duplicate existing capital and labour inputs. Following this logic, innovation is represented by the production of more output over and above that which would occur simply by duplicating existing capital and labour

[1] This is an edited extract of the non-technical summary of a longer paper: 'An Innovation Index Based on Knowledge Capital Investment: Definition and Results for the UK Market Sector' written by Clayton, Dal Borgo and Haskel. For specialist economists, our definition of innovation is TFP plus the part of capital deepening accounted for by new knowledge investment. It, therefore, follows the research program set out in the expanded view of capital and TFP measurement proposed by Corrado, Hulten and Sichel (2004, 2006), which builds, of course, in turn on the work on growth accounting set out for example in the Jorgenson volumes (Jorgenson, 2007). The motivation for the index builds on an argument made by Jorgenson (2007) in his evidence to the Gutierrez committee. An important point of this work is the Corrado, Hulten and Sichel argument that admission of intangible spending as building a knowledge asset requires both the recomputation of inputs, since knowledge/intangible capital is an additional input *and also* output (value added) since the capitalisation of intangible spending removes it from intermediate spending and so raises value added. Thus both output, inputs and TFP are recalculated relative to the case where intangible spending is treated as an expense. To economists familiar with this work, we hope this paper will still have some interest: we explicitly ask how TFP relates to the many innovation definitions that have been proposed and bring new data on the TFP and intangible spending in the UK economy at the industry level (relative to Giorgio Marrano, Haskel and Wallis, 2007, we have new data on design; we use the industry data on intangible investment in Gill and Haskel (2008) and present industry growth accounting results). The full paper can be accessed at: http://www.innovationindex.org.uk/

inputs. Where does this extra output come from? In this presentation we assume that output is a function of labour, physical capital and knowledge/intangible capital. Thus the extra output comes from knowledge capital or ideas, and the process of converting knowledge capital or ideas to increased output is the innovation process. We seek to measure all stages of the innovation process, both 'upstream' (R & D, design) and 'downstream' (marketing, organisational change). This needs totally new data — the prize being a much fuller understanding of innovation and modern knowledge-based economics. Conventional measures of GDP and productivity treat most knowledge capital accumulation as intermediate consumption. We, therefore, use a growth accounting framework to compute revised national accounts based on capitalising the principal components of knowledge capital. These revised accounts provide both a direct measure of innovation, and a systematic basis for analysis of productivity and growth in the knowledge economy.

Introduction

A number of agencies have been charged with investigating and developing an innovation index. The National Endowment for Science Technology and the Arts (NESTA) in the UK is obliged to develop an index in 2010. An Advisory Committee to the US Commerce Department, including the CEOs of Microsoft, UPS and 3M have investigated the issue for the US (Innovation Measurement, 2008). The OECD is examining this question en route to an innovation strategy.

There are three main current approaches to such an index. The first is to propose a definition of innovation and then produce an index. Thus far however whilst there are plenty of proposals there are rather fewer implementations of such proposals. The second approach is the reverse, namely to calculate an index and assume (explicitly or implicitly) it is innovation. The third is to suspend the notion of an index altogether and do something else (Innovation Measurement, 2008).

The aim of this paper is pragmatic, namely to move toward producing an index (or to produce some unimpeachable logic as to why it cannot be done). This imposes the constraint that an innovation definition must be implementable with either existing data or data that can be collected quickly.

To state our proposal upfront, our innovation measure is the contribution to GDP growth of (market sector) investment in knowledge or intangible capital. This contribution derived from spending on knowledge/intangible assets and from Total Factor Productivity (TFP) growth. We can also add human capital building into the innova-

tion index. Thus our measure of innovation is the additional GDP over and above the addition due to existing physical capital and labour.

As background, it is worth starting by considering some of the definitions of innovation that have recently been proposed. NESTA (2007) proposed 'change associated with the creation and adoption of ideas that are new-to-world, new-to-nation/region, new-to-industry or new-to-firm' without being very clear on what 'change' is and how it might be measured. The Frascati Manual (2002), being the official R & D manual proposes 'technological innovation activities are all of the scientific, technological, organisational, financial and commercial steps, including investments in new knowledge, which actually, or are intended to, lead to the implementation of technologically new or improved products and processes' which confines attention to the technology and does not define how 'implementation' might be measured. Whilst the Oslo manual (OECD, 2002) broadens the definition to include organisational innovations 'a technological product innovation is the implementation/commercialisation of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer. A technological process innovation is the implementation/adoption of new or significantly improved production or delivery methods. It may involve changes in equipment, human resources, working methods or a combination of these', it introduces the term 'objectively new or improved' without defining it. Finally, the US Advisory Committee propose 'the design, invention, development and/or implementation of new or altered products, services, processes, systems, organisational structures, or business models for the purpose of creating new value for customers and financial returns for the firm' *(Innovation Measurement, 2008),* which is broad in innovation scope but focuses on commercialised products and so is, as they point out, orientated at a private sector definition (and in any case they end up rejecting the feasibility of an index altogether).

The logic of the approach in this paper contains four key steps. The first is to ask why we are interested in innovation. For many, the reason is because we believe it is a prime cause of economic growth and specifically that the commercialisation of innovations has been a key factor in converting technological improvements to economic growth in the past two hundred years [2]. Thus we propose to concentrate on the output of more and new goods and services as our main reason for interest in innovation. As we stress below, to implement this, we shall measure output as value

[2] There are at least two reasons why one might disagree with this. First, one might argue that the interest in innovation is because we think that innovation leads to new ideas (which may or may not then lead to growth). The problem of measuring ideas is, of course, a formidable one, since rating the relative importance of two ideas is very hard. The patents literature is, of course, a well-developed attempt to solve these problems, but it is well acknowledged that not all ideas are patented. Thus we do not study invention in this paper, but innovation, namely the commercialisation of ideas. Second, one might argue that increases in goods are of no interest in themselves since they might not signal a rise in prosperity at all, e.g. see the discussion in de Long (2000).

added or GDP, a key variable which avoids output double counting problems and is tightly related to measures of increased living standards and welfare.

But how does innovation contribute to this increased output? To answer this, the second step follows the question set by Jorgenson (2007) in his evidence to the US Advisory Committee: how would we get more output with no innovation? His answer is to use the same ideas, but duplicate existing capital and labour inputs. So Ryanair could fly more passengers on an existing route by simply buying another airplane and hiring another set of crew. McDonalds could sell more food by opening at another location buying more cooking equipment and hiring another set of staff. Thus *innovation is not just the production of more goods, but the production of more goods over and above that which would occur with simple duplication of existing labour and physical capital.*

A number of points are worth making. First, how does this relate to the definitions above? The NESTA definition refers to 'change' and the Frascati Manual to the production of 'objectively new or improved goods'. The definition operationalises this by referring to more goods. Second, by referring to more goods net of increases in physical capital and labour, it helps clarify a number of ambiguities in the literature. For example, innovation is sometimes defined as something that is new. Now, many would argue that the advent of low-cost airlines flying routes with an entirely new business model is an innovation. But few would argue that a low-cost airline, already flying from A to B in the morning, who then adds an evening service, has innovated. Similarly, many firms who describe themselves as innovative are often alleged by others not to be so since they are simply adopting the innovations of others. So, buying a new aircraft that flies twice as many passengers as before at the same cost, under the definition above, would not be an example of an innovation in the *airline* (service) industry. But, under our definition, it would be an innovation in the *aircraft* (manufacturing) industry, for the improved aircraft, assuming that it used new ideas, would be an example of an increase in output over and above that from simply duplicating capital and labour inputs in the aircraft industry.

The third step is to ask: if innovation is the extra output over and above capital and labour, where does this extra output come from? This requires us to make an explicit assumption about what inputs cause output. So we assume that production comes from labour, physical/tangible capital and knowledge/intangible capital. Thus extra production due to innovation, since we have ruled out more physical capital and labour, comes from more knowledge capital or ideas [3]. But where does the increased knowledge capi-

[3] Jones (2005) reviews what an idea is by quoting Romer (1993) who 'divides goods into two categories: ideas and objects. Ideas can be thought of as instructions or recipes, things that can be codified in a bit string as a sequence of ones and zeros. Objects are all the rivalrous goods we are familiar with: capital, labour, output, computers, automobiles, and most fundamentally the elemental atoms that make up these goods. At some level, ideas are instructions for arranging the atoms and for using the arrangements to produce utility'. Mokyr (2003) prefers using prescriptive and propositional to describe the body of knowledge.

tal or ideas come from? Unlike tangible capital, which has a location and cannot be used by others, intangible capital may be non-rivalrous. So some firms might get ideas for free by simply imitating what other firms did. Other firms might discover new ideas themselves. Such discoveries, we assume, will take resources. R & D is the usual measure for the spending needed to generate new ideas, but the innovation definitions above suggest that we broaden the scope of spending to other spending that builds knowledge capital: spending on software, design, training, organisational capital at firms. This assumption is described by Corrado (2007) as tantamount to trying to measure innovation spending at all stages of the innovation process: both the upstream spending of scientists, artists and designers on new ideas and the downstream spending on the commercialisation of these ideas by means of marketing, training and organisational change. Both spending on innovative ideas and obtaining them for free will show up as innovation in our measure, but in different ways, as we shall show below.

The final step is to account for how much this extra spending on knowledge raises output. For this we apply the economic theory of growth accounting, which uses observable prices and quantities to infer the impact of increased inputs on outputs. This step involves a number of assumptions, such as competitive markets, the depreciation of the knowledge stock and prices of knowledge all of which will be tested for robustness and require further work. Thus our proposed index will be the part of capital deepening in the economy that is knowledge capital deepening plus TFP growth.

To preview our results, our main findings are as follows. Over 2000–05, UK market sector labour productivity grew at 2.74 percentage points per annum (pppa), of which the contribution of knowledge capital, our innovation measure, was 1.24 pppa (of the 1.24 pppa, investment in knowledge assets contributed 1.19 pppa and TFP growth 0.05 pppa). In turn, manufacturing accounted for about 60 % of the 1.24 pppa figure. If one includes increase in labour skill deepening (0.45 pppa) as innovation, then innovation contributed 61 % (= (1.24 + 0.45)/2.74) of labour productivity growth over the period.

There are of course a number of things that our work does not do. First, as mentioned above, we do not count new ideas. We count the value of the new output stemming from new ideas and we will count investment in new ideas. Second, since we focus on output, we have obvious problems with the hard-to-measure sectors. Thus at the moment we consider it unlikely that we can obtain good indices of the public sector, and many parts of financial services are also likely to be hard. This might be important depending slightly on the degree of disaggregation needed.

Third, it is often argued that an important, possibly the most important, knowledge capital source is education. To the extent that this is paid for by firms, we count it as firm investment. To the extent that it is paid for by the public sector or households,

it shows up (albeit somewhat indirectly) via our labour quality measures [4]. Fourth, our approach of locating innovation via its effect on growth, clearly relies on a number of assumptions, in particular, using, respectively, knowledge capital deepening and TFP as summary measures of the growth impact of new ideas paid and not paid for by firms. For those who find the assumptions in building these measures unacceptable, we do provide data on spending on series of knowledge/intangible assets which should be of interest, (even if the assumptions on the mechanism by which such spending then changes output are of no interest).

The present paper has dealt with the measurement of innovation, not with creativity per se. However, it seems clear that the development of new ideas, that are the origins of innovation, will require creative capacity. Thus, our measurement of innovation would have embodied also specific aspects of creativity and could be considered to measure aspects of it.

References

De Long, B., (2000), *Consequences of Growth: Slouching Towards Utopia?* http://econ161.berkeley.edu/TCEH/Slouch_causes3.html.

Corrado, C. A. (2007), Comment submitted to the Advisory Committee on Measuring Innovation in the 21st century Economy: http://www.innovationmetrics.gov/comments/051107FederalReserveBoard.pdf

Corrado, C. A., Hulten, C. R. and Sichel, D. E. (2004). Measuring Capital and Technology: An Expanded Framework. In Corrado, C. A., Haltiwanger, J. C. and Sichel, D. E (eds), Measuring *Capital in the New Economy, Vol. 65*. Chicago: The University of Chicago Press.

Corrado, C. A., Hulten, C. R. and Sichel, D. E. (2006). Intangible Capital and Economic Growth. *NBER Working Papers 11948*, National Bureau of Economic Research, Inc.

Frascati Manual (2002), http://europa.eu.int/estatref/info/sdds/en/rd/rd_frascati_manual_2002.pdf

Innovation Measurement (2008). A Report to the Secretary of Commerce by The Advisory Committee on Measuring Innovation in the 21st Century Economy, January 2008. Available at: http://www.innovationmetrics.gov/Innovation%20Measurement%2001-08%20rev%20040908.pdf.

Jorgenson, D. W. and Griliches, Z. (1967). The Explanation of Productivity Change, *The Review of Economic Studies* 34, 249-283.

[4] As a matter of official National Accounting measurement practice, households are not regarded as producers and so their education spending is not investment.

Jorgenson, D. W., Ho, M. S., Samuels, J. D. and Stiroh, K. J. (2007). Industry Origins of the American Productivity Resurgence, *Economic Systems Research*, 19, 229-252.

Marrano, M. G., Haskel, J. and Wallis, G. (2007). *What Happened to the Knowledge Economy? ICT, Intangible Investment and Britain's Productivity Record Revisited*. London: Department of Economics, Queen Mary, University of London.

Mokyr, Joel, 2005. Long-Term Economic Growth and the History of Technology. In P. Aghion & S. Durlauf (ed.), *Handbook of Economic Growth, edition 1, volume 1*, pages 1113-1180. Amsterdam: Elsevier.

Mokyr, J. (2006). Review of William J. Baumol, The Free-Market Innovation Machine: Analyzing the Growth Miracle of Capitalism." *EH.Net Economic History Services*, Jul 26 2002. URL: http://eh.net/bookreviews/library/0517

NESTA (2007), Innovation Index Call for Ideas Document, http://www.innovationindex.org.uk/forum/attachment/download?id=2132323%3AUploadedFi38%3A394

OECD (2002), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition,* http://www.oecd.org/document/23/0,3343,en_2649_34273_35595607_1_1_1_37417,00.html