Dent Associates
Science in Business

Driving Economic Growth - Knowledge Production

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Abstract

Against a background of an hypothetical ideal knowledge production system for driving economic growth through innovation, the different types of knowledge production system identified over the last 30 years are briefly considered and compared. The Mode 2 Knowledge Production system appears to incorporate all of the other systems and hence is capable of providing the basis of an holistic framework for government policy on knowledge production; one that is explicitly geared towards innovation and economic growth. The characteristics of Mode 2 are briefly explored and consideration is given to how the success of such an approach would be dependent on having a greater understanding of the market for innovation.

Background

In economics, growth is defined as the increasing capacity of the economy to satisfy the wants of the members of society. Economic growth is enabled by increases in productivity, which lowers the inputs (labor, capital, material, energy, etc.) for a given amount of output. Lowered costs increase demand for goods and services. Economic growth may also result from population growth and through the introduction of new products and services. New products and services are derived through innovation which in turn arise from the production of knowledge.

From the perspective of a government dependent on innovation to drive economic growth, a knowledge production system based on the following principles and attributes would seem ideal:

1. a problem-based approach delivering innovative solutions and applications of assured economic value and impact within a relevant definable time frame
2. operating freely across, and applicable to, any and all fields of human endeavour for which there can be derived a measurable economic benefit
3. engaging with and utilising the broadest range of skills, know-how and experience from all available practitioners
4. flexible, responsive and able to deliver to, and for, a wide range of economic conditions and circumstances i.e. offering resilience
5. wholly transparent, accessible and accountable to society

Such an ideal knowledge production system differs quite markedly from that currently existing in the UK. This is partly because economic growth has not been the only, or even the primary driver influencing and shaping knowledge production. Other factors have played a role; the value placed on academic knowledge for instance, and the relative importance of science and technology for economic growth, and the emphasis on scientific excellence as opposed to value and impact of application.

This paper briefly reviews our current understanding of knowledge production systems and their characteristics relevant to government policy compared to the above hypothetical ideal knowledge production system - based on the need to drive economic growth through innovation.

Knowledge, Academia and Science

Knowledge is ubiquitous - it covers the whole gamut of human endeavour. Knowledge may be tacit, based on what resides in an individuals head according to their experience and expertise or it may be codified. Knowledge that is codified is based on tacit knowledge that has been organised, categorised, indexed and is generally more accessible and available. Codified knowledge is exemplified by the work undertaken by academics in universities and research institutes and reported in academic journals, books and reports. The accumulation over time of codified knowledge has led to the creation of the global knowledge stock. This is not simply defined, but may be considered to encompass the sum of ideas relating to basic scientific and non-scientific understanding and their applications in technological and non-technological activities (Cave 2003). Technology then, can also be considered as a form of knowledge, but one that consists of a mix of codified (usually

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embodied as an artifact) and tacit knowledge, often with the tacit component playing a larger role than the codified. In the 1950's the Nobel Laureate Economist Robert Solow argued that technology (broadly defined as the application of new knowledge to the production process) is the main long term factor responsible for growing an economy (Garfield, 1988) and because scientific research is seen to underpin the development of technology, the work of academics has increasingly been seen to be crucial to such economic growth.

Academic knowledge may be considered as authoritative, objective, and universal knowledge which is abstract, rigorous, timeless – and difficult (Gilbert 2005). It is knowledge that goes beyond the here-and-now knowledge of everyday experience to a higher plane of understanding. Academic knowledge generated through basic scientific research is usually driven by the desire to answer specific scientific questions. This basic research - variously called "fundamental", "pure" and "blue skies" research, is highly regarded in the UK and is epitomised by the mantra of "scientific excellence" a belief in the delivery of knowledge for sciences-sake in order to enhance and build upon the stock of global scientific knowledge. Scientists careers in different disciplines are advanced by peer esteem through the publication of scientific work in respected, highly cited journals and essentially this is the force that drives additions to the scientific knowledge stock (Cave 2003). The information is openly available to the world's scientists to scrutinise, use and build upon, the ability to answer scientific questions with scientifically useful answers. The direction the research takes is not guided by any process other than the need to be leading edge, high quality science, recognised and supported through peer-reviewed publications and grant awards. In marked contrast to academic knowledge, Gilbert (2005) considered applied knowledge to be practical knowledge that is produced by putting academic knowledge into practice. It is gained through experience, by trying things out until they work in real-world situations, which may include incremental change through worker experience, trial and error, and practical knowledge of how to get things done.

These differences between academic knowledge and applied knowledge are representative of the attributes of two modes of knowledge production - so called Mode 1 and Mode 2 knowledge production; terms first coined by Gibbons et al. (1994) (Table 1.) in order to describe the shifts occurring internationally in knowledge production. Mode 1 knowledge refers to that largely generated in an academic context, based on disciplines of research (e.g. Food Science and Technology, Endrochrinology, Neurobiology, Pharmacology) carried out in our universities and research centres and measured for its effectiveness through peer review and citation indices. In contrast to Mode 1 (but potentially also embodying it), Mode 2 knowledge is generated in the context of application. Of course Mode 1 knowledge can also result in practical applications, but these are always separated from the actual knowledge production in space and time. This gap requires so-called knowledge transfer. Other attributes of Mode 2 Knowledge Production include its transdisciplinarity, heterogeneity, reflexivity and novel means of of quality control (Table 1.).

Table 1. Attributes of Mode 1 and Mode 2 knowledge production (Hessel and van Lente 2008)

Mode 1	Mode 2
Academic context	Context of application
Disciplinary	Transdisciplinary
Homogeneity	Heterogeneity
Autonomy	Reflexivity/social accountability
Traditional quality control (peer review)	Novel quality control

Transdisciplinarity refers to the mobilisation of a range of theoretical perspectives and practical methodologies to solve problems. Transdisciplinarity goes beyond what we normally think of as interdisciplinarity, in the sense that the interaction of scientific disciplines is much more transitory and dynamic. Once a theoretical consensus is attained, disciplinary parts become less relevant and even unrecognisable as research results diffuse to problem contexts and practitioners, during the process of knowledge production. This is partly achieved because Mode 2 Knowledge is produced in a diverse variety of organisations, resulting in a more heterogeneous practise. The range of potential sites for knowledge generation includes not only the traditional universities, institutes and industrial laboratories, but also other research organisations and agencies, think-tanks, high-tech spin-outs and consultancies as well as through individual inventors and entrepreneurs. These sites may be linked through networks of communication and research is conducted in mutual interaction related to a particular problem. Movement away from traditional knowledge production institutions with their monopoly on knowledge and its generation, towards a wider range of protagonists who may be more integrated and accountable to society, should ensure knowledge production that is sensitive to its impact is built-in from the start.

Traditional quality control in knowledge production is achieved through discipline-based peer review systems. In Mode 2 the trends are that these systems are supplemented by additional criteria of economic, political, social or cultural nature. Due to the wider set of quality criteria, it becomes more difficult to determine 'good science', since this is no longer limited to the judgement of disciplinary peers. However, this does not imply that Mode 2 research is generally of a lower standard.

Eight Systems of Knowledge Production

Hessels and van Lente (2008) review the eight different systems of knowledge production that have been considered, around and since the time of Gibbons et al. (1994) and the follow-up publication Nowotny, Scott

Table 2. The various diagnoses (A-H with main publication - see below) put emphasis on different characteristics of scientific knowledge production (after Hessels and van Lente, 2008).

Levels	Characteristics	A	B	C	D	E	F	G	H
Cognitive	Choice of research agenda (research content)	X	X	X	X	X	X	X	X
	Methods (teamwork, transdisciplinary)	X	X						
	Epistemology (socially robust knowledge)	X	X						
Organisational	Map of disciplines (transdisciplinarity)	X	X						
	Values/labour ethic of scientists (reflexivity)	X		X					
	Norms of quality control (extended peers)	X	X		X		X		
External Relations	Interaction with other societal spheres (industry, government)	X		X	X	X	X	X	X
	Incorporation of non-scientific expertise (participation)		X						

***A** - New Production Knowledge NPK (Gibbons et. al 1994, and Nowotny et. al 2001), **B** - Post-normal science (Funtowicz and Ravetz 1993), **C** - Triple Helix (Etzkowitz and Leydesdorff 2000), **D** - Post - academic science (Ziman 2000), **E** - Academic capitalism (Slaughter and Leslie 1997), **F** - Strategic science/research (Irvine and Martin 1984), **G** - Innovation systems (Edquist 1997), **H** - Finalisation science (Böhme et. al. (1983)*

and Gibbons (2001). Each of these different knowledge production systems have different attributes which Hessel and van Lente (2008) summarise in Table 2. Interestingly, Hessel and van Lente (2008) use their analysis to argue that Mode 2 knowledge production is not unique, and elements of it are embodied within other types of knowledge production system. They also argue that Mode 2 should be broken down and considered in its individual components to test it validity. There is a case to argue however, that this reductionist approach in fact misses the point about the value of Mode 2 Knowledge Production as presented by Gibbons et al. (1994): the real value of Mode 2 is its ability to embody all components of other knowledge production systems and thus provide a single coherent framework for the consideration of knowledge production. In some ways this might actually be viewed as quite a feat since it precedes in publication at least four of the other knowledge production systems (Triple Helix, Post-academic Science, Academic Capitalism and Innovation Systems). A single coherent framework embodied in Mode 2 Knowledge Production would have many advantages not least in the setting and implementation of government policy.

Innovation Centred on the Market

Clearly the Mode 2 Knowledge Production system incorporates many of those key principles outlined at the beginning of this paper which could form a hypothetical ideal knowledge production system. Firstly Mode 2 is a problem-based approach and if the problem is set so as to generate solutions of potential economic value, then the UK science base could be directed to deliver to that need. Mode 2 addresses the concept of transdisciplinarity - engaging across all aspects of human endeavour (science and the humanities) as well as utilising all available skills and know-how from any source (formal scientific research institutions to more informal bodies e.g consultancy companies) to ensure that solutions are generated. The need for transparency, accessibility and accountability to society is built into Mode 2 and although, Hessels and van Lente (2008) do not rank "participation" as a component of Mode 2 in their 2008 paper, reference to the original publication would suggest it is not ruled out although not explicit in Gibbons et al. (1994).

Such an approach however, does require a major change in emphasis so that the science becomes less of a driver of innovation relative to the market. This is largely because by taking a problem-solving approach one has to know what the problems actually are, and to identify these there is a need to look to the market. For each sector there would be a need to identify market gaps and opportunities, in each case defining the parameters of the gap and the specifications of the solution.

Vast financial resources are spent on research and the development of technologies but next to nothing is spent on research to understand the markets, the gaps and the opportunities to which the technologies are meant (at some distant point in time) to apply, and this would need to change in the adoption of an explicit Mode 2 Knowledge Production system.

Understanding markets is all about understanding the people, the industry, the products and services, their manufacturers, suppliers, distributors and sellers, how they organise themselves and how they advertise, market, sell and deliver to consumers. In understanding all of this, it becomes easy to see how the market is properly researched it can set the scientific and technological agenda, how the approach to solving the problems will be involve a diverse range of organisations, how it will be transdisciplinary in approach, how social accountability is built in from the start and how quality control will be dependent on delivery of solutions meeting the exacting standards of all players. Thus the market comes into play in innovation, in the same way markets drive other areas of life, one wonders why science and technology has been exempt from this all pervading rationale to date. With an explicit commitment to Mode 2 Knowledge Production through UK government science and innovation policy the way would be cleared to place the market at the centre of innovation, and ultimately, the potential economic benefits that would accrue from such an approach.

Conclusion

With an emphasis on the need to stimulate innovation in order to drive and sustain economic recovery the adoption of the framework offered by Mode 2 Knowledge Production as explicit government policy would provide a problem-to-solution focussed approach to research that could generate the required stimulus for growth.

References

Böhme, G., Vanden Daele, W., Hohfeld, R., Krohn, W. and Schafer, W.(1983). *Finalization in Science: The Social Orientation of Scientific Progress*. Riedel, Dordrecht.

Cave, J. (2003). Stocks and Flows of Knowledge and their Relation to the Sustainability of the Information Society. TERRA 2000 Project. www2.warwick.ac.uk/fac/soc/economics/staff/.../nesiscaverev1.pdf

Dent, D. R. and Theodorou, M. (2011). Market-led Innovation Centres: A New Model for UK Innovation. Dent Associates. pp. 26

Edquist, C. (1997). *Systems of Innovation: Technologies, Institutions and Organisations*. Pinter Publishers, New York/London.

Etzkowitz, H. and Leydesdorff, I. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research Policy* 29 (2), 109-123.

Funtowicz, S. and Ravetz, J. (1993). Science for the post-normal age. *Futures* 25, 735-755.

Garfield, E. (1988) Theory of Technology's Role in Economic Growth Brings MIT's Robert M Solow the 1987 Nobel Prize in Economic Sciences. *Current Contents* 17, p.123-128. April 25th 1988.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. and Trow, M. (1994). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. SAGE, London.

Gilbert, J. (2005) *Catching the Knowledge Wave*. Published by NZCER Press.

Hessels, L. K. and van Lente, H. (2008). Re-Thinking new knowledge production: A literature review and a research agenda. *Research Policy* 37, 740-760.

Irvine,J and Martin, B. R. (1984) *Foresight in Science: Picking the Winners*. Frances Pinter. London.

Nowotny, H., Scott, P. and Gibbons, M. (2001). *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty*. Polity Press, Cambridge.

Slaughter, S. and Leslie, L.L. (1997). *Academic Capitalism: Politics, Policies and the Entrepreneurial University*. The John Hopkins University Press, Baltimore.

Ziman, J. (2000). Real Science: *What it is, and What it Means*. Cambridge University Press, Cambridge.