The Knowledge Exchange, An Interactive Conference
26th and 27th September 2013, Lancaster University

Technology Transfer, Knowledge Transfer and Knowledge Exchange in the Historical Context of Innovation Theory and Practice.

Jeremy DAVENPORT

University of Lancaster

This paper explores the concepts of Technology Transfer (TT), Knowledge Transfer (KT) and Knowledge Exchange (KE) as models of external University collaboration in the context of innovation theory. It begins the process of constructing a taxonomy based upon their key characteristics. I also outline a possible fourth concept Knowledge Creation (KC) to describe and understand the nature of collaboration in the digital context.

Keywords (3 max): innovation, knowledge exchange, knowledge creation

Initially perceived as exogenous and beyond study, innovation has become a central area of interest for researchers, policy makers and managers. Godin (2008) explores how the concept of innovation has changed through time. He argues that at different points in time, and from different perspectives (social, cultural, political, and organisational) the use of the term has gone far beyond the narrow technology and commercially focused meaning that is has centred upon in the 20th century.

However, for my own exploration, it is this narrower utilitarian concept of innovation that provides a starting point. Specifically, in exploring innovation as the basis for understanding the dynamic nature of economic development and social change. In this context, the concept and practice of innovation has become a political and corporate mantra. From the micro perspective of individual companies (large and small) to the imperative to improve public service delivery or secure national economic well being, innovation is argued to be an essential ingredient of success.

A key assumption in this argument is that innovation, as a process, can be influenced by government and by managers. Further, that Universities have the potential to play a strategic role in catalyzing and supporting innovation, as part of global, national and regional innovation systems (Erdquist 2005, Godin 2009). This is the broader context within which the concepts of Technology Transfer, Knowledge Transfer and Knowledge Exchange can be placed.

Drawing upon literature and my own professional experience, this paper begins to develop taxonomy to explore the dimensions of meaning and underlying assumptions associated with the three concepts. It also provides a framework for mapping different tools deployed in facilitating innovation and to interrogate whether the existing concepts adequately reflect the nature of a collaboration, which is focused upon Knowledge Creation rather than Transfer and Exchange.

Table 1 The Key Dimensions of Technology Transfer, Knowledge Transfer, Knowledge Exchange and Knowledge Creation.

	Technology Transfer	**Knowledge Transfer**	**Knowledge Exchange**	**Knowledge Creation**
Disciplines	Basic and applied research with science/technology bias.	Broader range of skills across a wider range of disciplines. Emphasis on problem solving within the collaborations.	Inclusive of different disciplines with acknowledge of the value that Arts Humanities can bring to the collaboration.	Inclusive of different disciplines with the potential for creative practice and design to play the leading role
Partners	Commercial / Investors/Corporate	Commercial and Non Commercial	Commercial and non commercial	Commercial and non commercial

Innovation Model	Linear[1] model and subsequent variations such as Open Innovation.	Linear (although definitions acknowledge the 2x way flows of information and knowledge.	- Non-linear[2] with emphasis on iterations and prototyping solutions. - Technology and non technology based.	- Non-linear with emphasis on iterations and prototyping. - Technology /non technology based. - Co creation.
Nature of Knowledge	Explicit[3]	Explicit/Tacit[4]	Explicit and Tacit (Emphasis on existing knowledge that is shared.	Explicit and Tacit (Emphasis on new knowledge/skills generated within the collaboration.
Source of Knowledge	- Experts - Reports - IP - Technologies - Labs - Research papers	Experts (but reflecting a broader range of disciplines than technology transfer).	Experts, companies, users, consumers, partners who provide the basis for exchange and problem solving (catalyzed by the collaboration).	Experts, students, users, companies, which provides the basis for new knowledge.
Mechanisms	- Spin out - IP advice/Legal - Licensing - Contract research - Collaborative Research - Investment funds - Incubators	- Contract research - Consultancy - Collaborative Research - KTP[5] - Secondment	- Research - Rapid prototyping - KTP - Consultancy - Secondment - Sand pits/ - Co-design workshops. - Social networking	- Fabrication Labs - Hack labs - Co-design - Sand pits - Workshops - Social networking - Crowdsourcing - KTP - Secondments
Intellectual Property	Patent	Patent/Non Patent	Generally non-patent but IP can be generated.	Emphasis on foreground IP
Observability[6]	Tangible and precise. Can be measured.	- Less tangible and more amorphous. - More difficult to measure although qualitative measures can be used.	Less tangible and more amorphous. Qualitative measures can be used.	Tangible and embodied in the form new products/ services/skills.

Technology Transfer

"Technology transfer is the process of transferring scientific findings from one organization to another for the purpose of further development and commercialization. The process typically includes:

- Identifying new technologies
- Protecting technologies through patents and copyrights
- Forming development and commercialization strategies such as marketing and licensing to existing private sector companies or creating new start-up companies based on the technology[7]

[1] Assumption that knowledge is generated and held by the University/individual and emphasis is on finding ways of commercializing in the form of new products and services through a staged process of development and deployment.

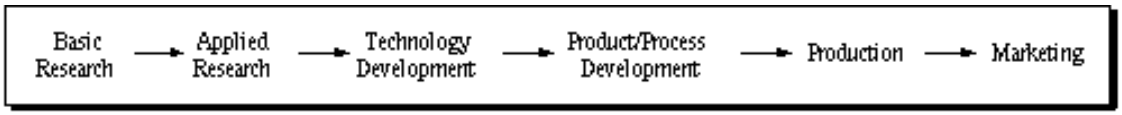
[2] Innovation within a company/organization is catalysed and supported by knowledge from a variety of sources (often driven by the identification of market opportunity) and develops through an iterative process of feedback loops from within and external to the organization.

[3] Knowledge that can be codified and made explicit as easier to be transferred/shared e.g. writing/IP/programmes/formulae/blueprints.. The working definition reflects initial reading of Nonaka & von Krogh (2009).

[4] Knowledge that is difficult to transfer in formalized and explicit ways (writing/IP/codified forms) but that reflects experience and expertise gained form-undertaking tasks/roles etc. The working definition reflects initial reading of Nonaka & von Krogh (2009).
[5] Knowledge Transfer Partnership, funded by Technology Strategy Board
[6] Gopalakrishnan and Santoro, 2004.
[7] Source: Association of University Technology Managers, AUTM website, 2013.

The emergence of Technology Transfer as an explicit concept has been attributed[8] to Vannevar Bush' in his report for President Roosevelt, *Science: The Endless Frontier* (1945). The report outlined a vision for US post war economic recovery and success, based upon government funding in science and technology focused research.

Figure 1 The linear model of Innovation



Source: Industry Canada, 1996-97 Performance Report.

While many firms in Europe and the US had recognized the strategic importance of science and technology in generating corporate success (Graham, 2007), Bush's report acknowledged the linkages between public investment in RD and the commercialization of technology. This linkage became central to the arguments supporting continued public funding of R&D.

A central assumption underpinning Technology Transfer is a linear model of innovation (Figure 1). A model that reflects a central assumption that basic research is the primary driving force in the development and commercial exploitation of technologies in the form of new products and related services. The linear model has at its heart the assumption that successful innovation originates in scientific breakthrough.

The stages by which basic research generated new products and services, were explicitly articulated by W.R. Maclaurin (Professor of Economics and President of MIT 1909 to 1920). Godin (2008) argues that Maclaurin, while neglected in the literature, played a critical role in recognizing that innovation was a dynamic process and in defining the discrete stages to the linear model (Figure 1). In practice, the policy and related tools of technology transfer evolved from this model over the succeeding decades.

The OECD (2005) notes that explicit policies for technology transfer and supporting infrastructure have been established in many economically developed countries. The TT tool kit includes dedicated staffing, IP policy and agreements, incubators and business support for spin outs, investment funds and licensing frameworks all supported (at least initially) by public funding.

Knowledge Transfer

"Knowledge Transfer describes how knowledge and ideas move between the knowledge source to the potential users of that knowledge. The Research Councils encourage Knowledge Transfer by supporting schemes and activities to transfer good ideas, research results and skills between, for example, universities and other research organisations, business, the third sector, public sector and/or the wider community." Research Councils UK, RCUK, 2013.
http://www.rcuk.ac.uk/kei/ktportal/Pages/home.aspx

Over the last decade, a critique of Technology Transfer has emerged in academic literature and practice. Specifically stressing the inability of Technology Transfer to meet expectations in generating positive economic and commercial returns. At the level of Universities, it is argued that too much attention has been given to a small number of success stories which have distorted the evaluation of the effectiveness of the policy and its related tool kits.

That when looked at in a wider context, other forms of Knowledge Transfer (e.g. collaborative research, consultancy, CPD) have greater economic impact (2-3 times, *Hagen, 2008)*. While questions have been raised on Technology Transfer's focus upon science and technology, the critique did not bring into question the underlying positive role that Universities play in the innovation system.

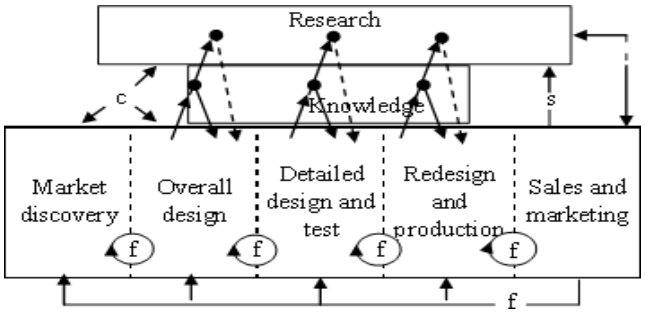
Knowledge Exchange

"a set of policies and practices which enable the efficient and effective exchange and co-creation of knowledge between producers and users: a virtuous circle of multiple-track engagement between knowledge producers (typically scientists, but potentially all academics) and knowledge users (typically policy makers, practitioners, stakeholders, businesses, social enterprises and other publics) so that the boundaries between the producers and users ultimately become merged." (Hagen, 2008)

[8] IPO, Godin (2009).

Over the last five years, the term Knowledge Exchange has been increasingly adopted by policy makers, funders and Universities to describe a third way of University engagement with the innovation agenda. The concept (as reflected in the definition above) reflects a broader range of methods, disciplines and forms of knowledge, not captured by the domains of Technology and Knowledge Transfer. As such the concept appears to more accurately reflect a process of innovation which is non linear and iterative.

Figure 2 Chain linked model of innovation



f: Feedback
i: New Equipment stimulates science and science generates new equipment
c: idea germination
s: Company's support for long term research.

Source : Centre for Research and Development Strategy based on the chain-link model of Stephen J. Kline

One such non-linear model of innovation was outlined by Kline (1985, Research, Invention, Innovation and Production: Models and Reality). He developed the model (Figure 2) based upon his professional experience in the automotive, paper, power plant and automotive industries. Kline argued that the process of innovation was iterative and uncertain as market needs created and shaped opportunities for the use of existing technology. Central to the model is the emphasis on design (not technology) as a driving force the development of new or modified products, specifically through iterations and prototyping.

Geoffrey Crossick's in his article, *"Knowledge Transfer without Widgets; the Challenge of the Creative Economy"* (2006) also explores a nonlinear process of knowledge creation and dissemination, where new knowledge is generated through the act of collaboration, often across disciplines. On this basis he sets out a critique of the dominant Technology / Knowledge Transfer paradigm and a lack of alignment between the transfer-based mechanisms with the nature of innovation across the creative and digital economy

Conclusion

A recent survey of professionals working in the Knowledge Transfer Offices of 20 UK universities highlighted that while Knowledge Exchange was identified as being a more accurate description of the two way flow of knowledge that characterized their projects (95.9%), only a small percentage felt that the concept of Knowledge Exchange was based upon academic theory (22.7%). Further, 59% of those interviewed considered Knowledge Exchange to be a "buzz word".

While often used inter-changeably Technology Transfer, Knowledge Transfer and Knowledge Exchange embody fundamentally different assumptions about the structure of collaborations and the nature of knowledge. In response to the ambiguity reflected in the Bournemouth survey (Polkinghorne, 2011), the emergent taxonomy provides scaffolding to make explicit the underlying assumptions behind these concepts. It also provides a framework for exploring policies and tools focused upon supporting and facilitating successful collaborations.

I have also used the taxonomy to begin to explore the concept of knowledge creation as a discrete and separate category. The initial definition of knowledge creation below makes explicit this key dimension of collaboration, specifically the dynamic process by which collaborations can catalyze the creation of new knowledge, in addition to the transfer and exchange of existing knowledge (often within the context of a single project).

"Knowledge creation describes the dynamic process by which knowledge is created through the act of collaboration itself (across disciplines and organizational boundaries) explicitly as a driver to product and service innovation and as a means for problem solving."

References

AKRAM, K. (2011). Role of Knowledge Management to Bring Innovation : An Integrated Approach, *11*(11), 121–134.

ATKINSON, P, Orchestral Maneuvers in Design, (2009) in Abel, Evers, Klassen, Troxler, Open Design Now, Why Design Cannot remain Exclusive, BIS Publishers Netherlands, 2011.

BOWER, J.L, and CLAYTON M. CHRISTENSEN (1995), "**Disruptive Technologies: Catching the Wave",** Harvard Business Review, Harvard.

BUSH, V. (1945) , Science: The Endless Frontier Author(s): Vannevar Bush, Source: Transactions of the Kansas Academy of Science, Vol. 48, No. 3 (pp.231-264Published by: Kansas Academy of Science Stable URL: http://www.jstor.org/stable/3625196. Accessed: 24/04/2013

KLINE, STEPHEN J. Centre for Research and Development Strategy based on the chain-link model of Stephen J. Kline, website http://www.mext.go.jp/english/whitepaper/1302787.htm, (Accessed 15th May, 2013).

CHANDLER, A. (1962), "Organizational Capabilities and the Economic History of the Industrial Enterprise" Journal of Economic Perspectives 6(3), pg. 79-100.

CHESBOROUGH, H. (2006), "Open innovation a new paradigm for understanding industrial innovation" in Chesbrough, H, Vanhavenbeke, W. and West, J, Open Innovation Researching a New Paradigm, Oxford, Oxford University Press.

CROSSICK, G. (2006), "Knowledge Transfer without widgets: the challenge of the creative economy", A lecture to the Royal Society of Arts in Leeds, May 31st 2006, Goldsmiths College.

ERDQUIST, C.(2005) Perspectives and Challenges, in Fagerberg, J, Mowery, D. and Nelson R.R, The Oxford Handbook of Innovation, Oxford, Oxford University Press.

FAGERBERG, J. (2005), "Innovation a Guide to the Literature", in Fagerberg, J, Mowery, D. and Nelson R.R, The Oxford Handbook of Innovation, Oxford, Oxford University Press.

FRUIN, W. MARK, (2007), "Business Groups and Inter firm Networks", in Jones, G and Zeitlin, J, Oxford Handbook of Business History, Oxford, Oxford University Press

GODIN, B (2008), *In the Shadow of Schumpeter: W. Rupert Maclaurin and the Study of Technological Innovation*, Paper no. 2, Project on the Intellectual History of Innovation. Published in *Minerva*, vol. 46 no 3, p. 343-360. Paper

Godin, B (2008), *Innovation: the History of a Category*, Working Paper No. 1, Project on the Intellectual History of Innovation, Montreal: INRS. 62 p.

GOPALAKRISHNAN, S., & SANTORO, M. D. (2004). Distinguishing Between Knowledge Transfer and Technology Transfer Activities: The Role of Key Organizational Factors. *IEEE Transactions on Engineering Management*, *51*(1), 57–69. doi:10.1109/TEM.2003.822461.

GRAHAM, M,B.W. (2007), "Technology and Innovation" in Jones, G and Zeitlin, J Oxford Handbook of Business History, Oxford University Press, Oxford.

INDUSTRY CANADA. (1996-97) Performance Report, web page http://www.oagbvg.gc.ca/internet/English/att_9919xe01_e_9901.html, (Accessed May 14th, 2013).

KEITA (1992), Science Rationality and Neo-Classical Economics. Associated University Press.

KLINE (1985). Research, Invention, Innovation and Production: Models and Reality, Report INN-1, Mechanical Engineering Department, Stanford University.

KLINE, S. J. & N. ROSENBERG (1986). "An overview of innovation." In R. Landau & N. Rosenberg (eds.), The Positive Sum Strategy: Harnessing Technology for Economic Growth. Washington, D.C.: National Academy Press, pp. 275–305.

LAMOUREAUX, RAFF and TEMIN (2007), "Economic Theory and Business History", in Jones, G. and Zeitlin J, Oxford, Oxford Handbook of Business History Oxford University Press.

LAZONICK, W. (2005), "The Innovative Firm" in Fagerberg, J, Mowery, D. And Nelson R.R, The Oxford Handbook of Innovation, Oxford, Oxford University Press.

LAZONICK, W. (2007), "Business History and Economic Development", in Jones, G and Zeitlin, J Oxford Handbook of Business History, Oxford, Oxford University Press.

MOWERY, D. C., & SAMPAT, B. N. (1980). Universities in national innovation systems, 1–38.

NONAKA & VON KROGH (2009), "Tacit Knowledge and Knowledge Conversion: Controversy and Advancement in Organizational Knowledge Creation Theory" , Organization Science, Vol. 20, No. 3, May–June 2009, pp. 635–652 issn 1047-7039 eissn 1526-5455 !09 !2003 !0412

POLKINGHOME, M. Bournemouth University in collaboration with the Institute of Knowledge Transfer, 2011, Bournemouth University, ISBN 978-1-85899-279 -2

ROTHWELL and ZEGVELD, "Re-industrialization and Technology", 1985, Longman Group Ltd.

ROGERS, EVERETT M. (1995) "The Diffusion of Innovation", Fourth Edition, The Free Press, Simon and Schuster Inc., New York

SCHUMPETER, J (1942) *Capitalism, Socialism and Democracy* (New York: Harper, 1975) [orig. pub. 1942], pp. 82-85:

SHARROCK, W and READ, R. (2002), Kuhn Philosopher of Scientific Revolution, Key Contemporary Publishers, Polity Press.

TIDD, J. (2006), Deputy Director Science and Policy Research Unit, University of Sussex, Innovation Models Paper 1, Published by Imperial College London, 2006.

TROTT, P & HARTMAN, D, (2009) "Why Open Innovation is Old Wine in New Bottles", International Journal of Innovation Management, Vol.13, No.4 , pg. 715 to 736, Imperial College Press.

UK DEPARTMENT OF TRADE AND INDUSTRY, 2000), *Excellence and Opportunity: A Science and Innovation Policy for the 21st Century.*

VAN de VRANDE et al.Open innovation in SMEs: Trends, motives and management challenges. *Technovation*, *29*(6-7), 423–437.m doi:10.1016/j.technovation.2008.10.001.

VERGANTI, ROBERTO. (2013), Design Led Innovation, Personal website, http://www.verganti.it/research.html#a1-ddi Accessed April 2013.

VON HIPPEL, Eric A. (1976) "The Dominant Role of Users in the Scientific Instrument Innovation Process." *Research Policy* 5, no. 3 (July 1976): 212–239. doi:10.1016/0048-7333(76)90028-7. *Research Policy*, *5*(3), 212-239. doi: 10.1016/0048-7333(76)90028-7.