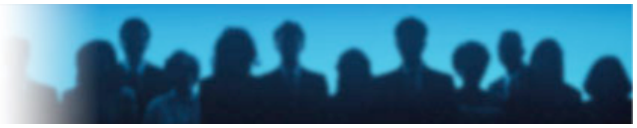


Annotated Bibliography II

Integrated Research Sub-Project (IRSP) I – The Role of Technology Companies in Promoting Surveillance Internationally

Innovation Diffusion and Technology Transfer

by Sandra Robinson*

May 2009

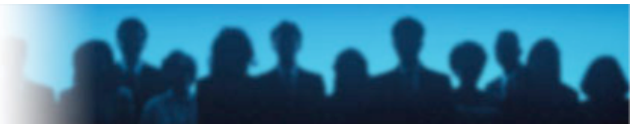
Introduction

Innovation, as a field of study within business, sociology, economics, and engineering, encompasses both the process of innovation within the firm as well as concurrent and subsequent diffusion of new or modified technology from the research and development domain of private and public organizations out to commercial and governmental markets and institutions. There is no standard definition of innovation; it can be loosely described as a new process, product, service, design, form of organization, or function of production that may lead to productivity increases and widespread market adoption and expansion (see Flichy 2007).[1] This literature review will address *innovation diffusion* and *technology transfer* and is a companion piece to three other annotated bibliographies or literature reviews that form a foundational framework for the New Transparency Integrated Research Sub-Project 1 (IRSP I) and its focus on technology companies in the surveillance and security sectors.[2] There is an evident bias in the literature included here:

* PhD Candidate, Department of Sociology, Queen's University, Kingston, Ontario, Canada.

1 Innovation, in the context of technology companies, can be defined as "a complex process that takes place at the level of specific products, businesses and sectors, as well as at the level of our national and international communities" (Smits 2002: 865) that generate technical artifacts, processes and socio-technical systems and collectives.

2 The terms *technology transfer* and *technology diffusion* appear in the business and technology literature and are used interchangeably at times. There is some difference between the two terms between the European context and the North American and this literature review will respect the which term is used in the original article discussed in the annotation. The sociological literature, which draws a more direct link to Rogers' work ([1962] 2003; 1976) refers to the *diffusion of innovation*.



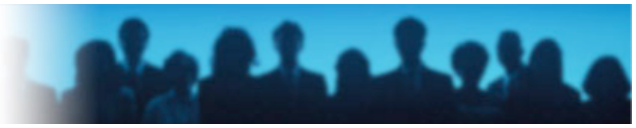
it reflects 'high' or advanced technology and not 'low', and it represents models constituted in the global north and does not address the imbalance in the north to south flow of so much technology and intellectual property (see Head 1989).

The literature on innovation diffusion can be split, for the purposes of this review, into two parts. In the first part is literature on innovation diffusion which addresses the uptake of new products and/or technology in which "an innovation is communicated through certain channels over time among the members of a social system" (Rogers 2003: 5). Everett Rogers' ([1962] 2003) classic work on a theory of innovation diffusion to explain the diffusion, widespread dissemination and market saturation of products, remains a foundational piece in subsequent studies of innovation. The second part is the technology transfer (also referred to in some instances as technology diffusion) specifically in and between firms, research institutions and government agencies; these studies are much less sociological in approach and proliferate within the business and technology literature.

Innovation diffusion, then, broadly describes the process whereby a product or service and the knowledge of its use and application moves from a source, such as a research and development domain to a point of reception leading, in the classic description of the process, to commercialization, market adoption and uptake (Bozeman 2000). However, the movement, transfer or exchange can also be within and between firms and institutions and in this case is sometimes cited as *technology transfer.* While technology transfer occurs around specific "capital goods ... standards, prototypes and industrial designs" it also encompasses "tacit knowledge" which requires close cooperation between the source and receiver (Komninos 2008: 174-175).

The articles referenced in this review outline both the process of innovation diffusion and of technology transfer to provide a detailed accounting of this dynamic adjunct to the process of innovation itself. The transference and absorption of technology between and among cooperating public institutions, organizations, private firms and markets operates differently across global geographic zones and industry sectors. The EU has seen some highly successful cooperative models within sectors and between governments, universities, and private firms, whereas, North American transfer protocols are more market-based complemented by university and government contributions (Komninos 2008; Bozeman 2000; Geroski 2000).

This review includes some specific case studies of technology diffusion within the surveillance and security technology sectors (Webster 2004; Carayannis and Turner 2006), but specific literature welding together surveillance and diffusion are rare. Across technology companies broadly, including those that are equipment and system suppliers to specialized manufacturers of surveillance products, one can describe general diffusion and technology transfer processes and flows which New Transparency (NewT) researchers might then apply to specific case studies within the surveillance and security industry.



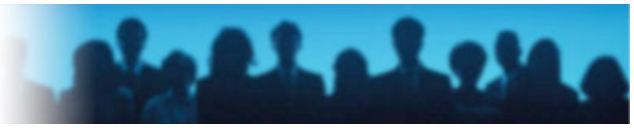
The Diffusion of Innovations Model

As an orientation to the diffusion of innovations field, NewT researchers might wish to read Castellacci *et al.* (2005) as a starter. Castellacci *et al.* is useful for these three reasons: firstly, as a brief introduction to and explanation of the theories of Joseph Schumpeter and neo-Schumpeterian concepts in relation to innovation, diffusion and economics; secondly, as an introduction to the diffusion of innovation at the macro level (since the following literature reflects the micro level); and thirdly, as it offers a brief review of classic diffusion literature and summarizes some of the contemporary critiques. Oddly, Castellacci *et al*. omit reference to Rogers (2003) model for innovation diffusion, which is addressed below, however, the article serves as a map of recent advances in innovation studies broadly and suggestions for future research.

Rogers book, *Diffusion of Innovations*, proposes a 'technology diffusion model' that adapts earlier sociological research on the 'technology adoption lifecycle' in relation to the practices of corn farmers in the United States. Rogers' monograph explicitly draws on Gabriel Tarde's notion of an S-shaped diffusion curve and the role of "opinion leaders" within diffusion, as well as Georg Simmel's work on group affiliations.[3] Rogers proposed five stages that influence or shape diffusion: knowledge, persuasion, decision, implementation, and confirmation (2003: 169). In addition, Rogers' configuration identifies five 'ideal types' that indicate where on the S-curve members of a social system are positioned as: innovators, early adopters, early majority, late majority, and laggards (282-284). Rogers also demonstrated the importance of relative advantage for a new product or technology as well as its overall compatibility; relative ease to comprehend and adapt; observable and tangible status; and the ability to perform in a product trial (Rivera and Rogers 2006: 4).

Although Rogers' foundational analysis and set of practices and categorizations have informed innovation studies over the last several decades, subsequent empirical research challenges the notion of an idealized, linear 'technology push-market pull' dichotomy first proposed in his work (see Baskerville and Prie-Heje 2001; cf. Dosi 1988). The linear model suggests a straightforward trajectory from invention, to requirements specification based on user needs, and to market commercialization. After Rogers early work (1962 and 1976), there was a profusion of scholarly interest in diffusion to which Giovanni Dosi (1982; 1988) made a significant contribution by examining innovation and diffusion adapting Thomas Kuhn's ([1962] 1996) notion of the scientific paradigm. Dosi offered an early critique of the linear 'technology push-market pull' approach suggesting instead that researchers ought to observe the "interplay between continuity and rupture" in technological change (1982: 161) and the interplay of the material technology with expertise and practice.

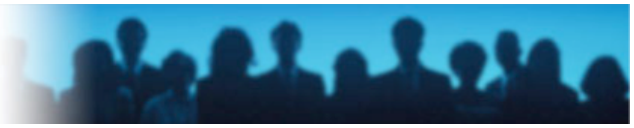
3 For further background on the evolution of the diffusion of innovation model Rogers applies, see Ryan and Gross (1943) and Rogers with Bohlen and Beal (1957).



In later work even Rogers broke away from the linear orientation of his original project suggesting that it might be augmented through the complex adaptive systems (CAS) model resulting in a hybrid framework to explain the diffusion of innovations (Rogers *et al.* 2005; see also Rogers 1976). The CAS model, Rogers *et al.* argue, captures the emergent characteristics of complex systems that produce order out of disorder and a 'fitter' system suggesting a similar pattern of emergence figures in the diffusion of innovations. Complexity in the context of diffusion enables researchers to draw on a "new toolbox" to map irregularities in diffusion and the multiplicity of factors that shape the process (Rogers *et al.* 2005: 13-14). While New Transparency researchers may benefit from consulting Rogers' original work, a concise distillation can also be found in Baskerville and Pries-Heje (2001) and Van den Bulte and Joshi (2007).

Very briefly, science and technology studies also offer NewT researchers a critical set of theories and approaches for analyzing innovation diffusion. The literature on socio-technical collectives such as from Akrich, Callon and Latour (2002), Suchman and Bishop (2005) and Bijker and Law (1994) offer an alternative to the classic sociological literature on the diffusion of innovations and to the business and technology literature on diffusion and technology transfer. For a nuanced approach to the emergent and messy networks of socio-technical collectives and innovation, Lucy Suchman encourages researchers to consider what counts as innovation and then to be aware of the multiplicity of being and doing "as ongoing, collective practices" (2005, 12; see also Suchman and Bishop 2000). Akrich, Callon and Latour propose the "model of interessement" over the model of diffusion in which interessement "emphasizes the existence of a bundle of links which unite the object to all of those which handle it" (2002, 205). Bijker and Law (1994) address diffusion in their edited volume which offers an examination of the role of objects and users, designers and decisions, and of social, economic and technical relations. This literature, the social construction of technology (SCOT) and the social shaping of technology (see MacKenzie and Wajcman 1999), present yet another approach for tackling the complex socio-technical networks that proliferate as part of, and are significant to, the diffusion of innovations.

Subsequent to Rogers and Dosi's scholarly contribution and the growth in innovation diffusion studies, market-oriented popular adaptations of his work have appeared. Geoffrey Moore's, *Crossing the Chasm* (1991), stands as the most 'marketable' product adoption strategy for contemporary technology firms; a sort of operationalized model of how to bridge the gap between early adopters and early majority phases, hence, "crossing the chasm." In a similar vein, Malcom Gladwell's popular, *The Tipping Point* (2002), sets out the trajectory of diffusion through connectors, mavens and salesmen using an epidemic or viral model to demonstrate the spread of ideas, products, or behaviours. Gladwell's (2002) work incorporates social network theory resulting in a more nuanced quasi-sociological analysis of the phenomenon of diffusion (see also Van den Bulte and Wuyts 2007; Goldenberg *et al.* 2009).

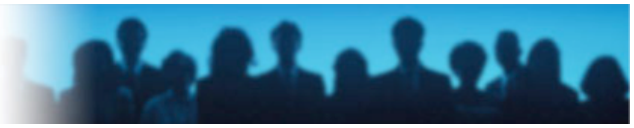


Richard Baskerville and Jan Pries-Heje (2001) present an analysis of information technology (IT) diffusion using multiple theories of diffusion viewed as complementary: the interactive model (technology push-market/need pull); the linked-chain model (mapping links between knowledge, invention and product); and the emergent model. Rather than excluding the interactive and linked-chain frameworks, the authors suggest that they are useful in modeling and understanding *ideal* diffusion patterns, however, the emergent model, they then propose, best captures the "unstructured and emergent phenomenon that is too multivariate and convoluted for modelling in steps or stages" of diffusion (187). These authors construct the interactive and linked-chain models as genealogical descriptions that trace the lineage of innovation and diffusion, whereas, the emergent model is ecological and maps the internal and external organizational dynamics of conflict, competition and politics (203) more in line with Rogers *et al.* (2005) 'hybrid' approach incorporating the CAS model. For NewT researchers pursuing analysis in the area of innovation diffusion, this article provides a useful framework for each model applied through case studies.

Much of the literature on innovation diffusion comments on the increasing importance among technology firms, centres of innovation, and research and development organizations, of clusters or hubs of innovation; of social networks among linked actors in a technology sector (see Porter 1998; Castilla *et al.* 2000; 2003). Goldenberg *et al.* (2009) examines the role of hubs in diffusion suggesting that hubs adopt new products and technology sooner as a result of expanded social links among key influencers. The article provides a concise overview of important concepts in innovation diffusion such as social network analysis, the role of key influencers, and social hubs divided into innovator and follower hubs (10). Results from the author's research suggest that innovator hubs drive the speed of adoption and follower hubs influence the market size (10). The authors argue that it is not that hubs are more innovative than other social networks or groups, but that they are often exposed to new innovations earlier through their particular social connections within the hub.

Watts and Dodds (2007) explore patterns of diffusion among "influentials" (cf. Merton 1968) within such social networks using a series of computer simulations based upon an 'epidemic' or 'viral' model. The authors claim that so-called "influentials" do not always influence early adoption or initiate "cascades" of diffusion that affect many individuals. More likely, their research suggests, "influentials" are themselves early adopters and influence a group of "easily influenced" individuals that drive adoption. The model Watts and Dodds propose, based as it is on computer simulations, could provide direction for empirical study on the role of "influentials" and social hubs and clusters within the surveillance and security industry.

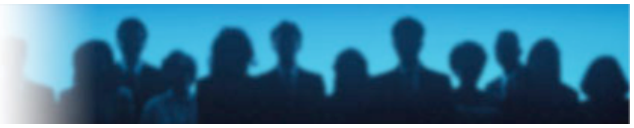
Some New Transparency researchers may be aware of William Webster's (2004) examination of the diffusion of CCTV networks in the UK. Webster's case study is that rare example of a specific analysis of surveillance *and* diffusion. He identifies three key trends of CCTV diffusion that may inform further research in this area: the migration



from private to public places; from metropolitan to other locations; and from simple to complex systems (Webster 2004: 237; cf. 1998). Webster's framework resembles a simplified typology of Rogers' five diffusion stages, but uses three CCTV "eras" with the accompanying pattern of diffusion and the emergent regulatory scheme for each phase (238). In view of the other literature reviewed here, Webster's approach addresses a gap or absence in research on the diffusion of a specific surveillance application: the importance of linking the processes of diffusion of a surveillance technology or system to the emerging regulatory environment in a given context (247). His work suggests that the emergence of regulation is related to the diffusion of innovations and that "networks of interested parties" are thus "active in shaping the uptake and regulation of the technology" (233). However, while Webster examines some of the processes of diffusion in the specific case of CCTV in the UK, his work does not directly reference the literature on technology diffusion, such as Rogers (2003), a linkage that might offer a different conceptual framework for examining CCTV uptake (see also Van den Bulte and Joshi 2007).

Elias Carayannis and Eric Turner (2006) describe a case study of Public Key Infrastructure (PKI) adoption. PKI is a set of codes, practices, policies and encryption techniques for the secure transmission of data over digital networks. This article provides both an excellent review of diffusion of innovation studies and of the important factors of diffusion as they relate to the uptake of a specific IT security product. In particular, Carayannis and Turner relate the adoption of PKI to Rogers (2003) claim that successful diffusion depends on a relative advantage (as opposed to simply competitive advantage). In the case of PKI, widespread adoption has been slowed down by interoperability issues, difficulties in the cross-certification of institutional users, system access, and the overall complexity of the PKI solution – each of which are identified in the diffusion of innovation literature as essential for successful adoption. Thus, in spite of having a relative advantage over other digital security products by offering a more secure framework, PKI does not meet most of the other requirements for successful product adoption. How might this case study relate to the question of why security products and solutions that are considered weak proliferate when other more robust solutions do not? Carayannis and Turner's work suggests that simplicity and interoperability are key to the uptake of new security solutions in information technology. This was also echoed in Websters (2004) analysis of CCTV uptake in the UK in which standardization and interoperability played a significant role in diffusion and to the emerging regulatory framework.

Very briefly, NewT researchers interested in quantitative analysis of the diffusion of innovations using frameworks such as the threshold model, the "Bass' model for S-curve generation, the viral-epidemiological model or other approach to measure diffusion will find Delre, Jager and Jonssen (2006), Van den Bulte and Joshi (2007), and Granovetter (1978) provide case studies and analyses using such techniques.

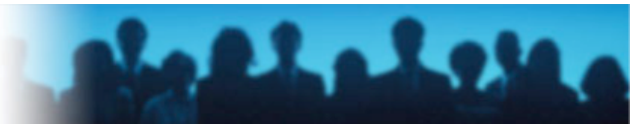


The Technology Transfer Models

In a review of technology transfer literature up to 2000, Barry Bozeman outlines three competing technology paradigms that govern technology transfer models in North America: the market failure paradigm, the mission paradigm, and the cooperative technology paradigm (*ibid.,* 630; see chart on 631). Government intervention, which figures in all three transfer paradigms to some extent, but is formally assigned to the market failure paradigm in Bozeman's framework, is intended to remove barriers to market access through industry de-regulation, R&D tax credits, trade agreements and so forth (2000: 632). The mission paradigm describes the strong link between government technology policy objectives and research and development. In this instance, governments carry out research and development central to important "national interest" objectives such as security and defense, but also health, energy and agriculture (*ibid.*). The cooperative paradigm signifies a strong role for both universities and government in technology development and transfer to the private sector, but this model is constrained in the US by its pro-market stance and flourishes more in Canada and the EU. As Bozeman suggests, under this paradigm, "universities and government labs make, industry takes" (*ibid.*, 633).

Nicos Komninos (2008) has a decidedly European focus overall on "intelligent cities", but through the lens of the globalisation of innovation networks and clusters/hubs and Chapter Seven is a good overview of current thinking on the process of technology transfer/diffusion. Komninos's work lays out three main strategies or avenues for technology transfer that differ slightly from Bozeman's characterizations: market-based inter-firm cooperation; university-industry cooperation; and licensing of technology (2008: 175-176). Across all three instances, the author stresses two common issues: firstly, the technology to be transferred must undergo an assessment regarding technical adaptability in terms of utilization, customization, and a search for previously unanticipated uses that may direct it into new markets. This is likely significant to the surveillance and security market in which technology may be developed for one purpose, but can be augmented or reconfigured for use in a specific security and surveillance application (cf. Ellul 1964) – as in feature or "function creep" or "surveillance creep" (cf. Winner 1977; see also Marx 1998; 2006). Secondly, the licensing requirements necessitate that intellectual property and contractual obligations are articulated as part of the transfer (Komninos 2008: 176).

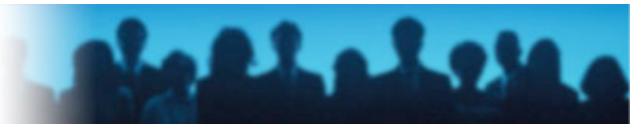
Komninos has summarized the routes of technology transfer in a concise chart which might serve as a good framework for future industry research within the New Transparency project (see page 176). The remainder of Chapter Seven provides a detailed account of technology transfer and some of the ideas in this chapter are usefully expanded in Chapter Eight's discussion of collaboration within innovation clusters, partnerships, and networks.



Castilla *et al.* (2000) offers a specific case study of Silicon Valley technology clusters or social networks which are fostered around the "movement of labor, the evolution of influence and power, and the actual production of innovation" involving both relational and structural connections (219). The case study offered here is illustrative of the inter-relationality of technology transfer discussed by Komninos, but Castilla *et al.* capture more specificity within the networks of institutional research and development (in this case, Stanford University), private investment, intellectual property and licensing, and corporate innovation (see also Castilla 2003). Central to the success of diffusion within Silicon Valley is the utilization of "boundary spanning units" (Hirsch cited in Castilla *et al.* 2000: 233), or a designated organizational actor, that exists solely to bridge disparate units or sectors among clusters and ensure technology transfer and exchange. Units such as these, or the organizational actor performing this role, are often similar to 'product champions' and might prove a productive research informant for NewT researchers seeking to understand the specific innovation dynamics in surveillance and security organizations.

Breznitz (2005) provides a case study of the Israeli military's influence on the software industry through the creation of "collaborative public spaces" (CPS). In relation to the aforementioned notion of hubs or clusters of innovation, Breznitz's example elucidates the effectiveness of social networks provided in a CPS which extend beyond simple labour provision and technology spin-offs. In the case of Israel, the CPS brings together former military colleagues linked through the Israeli military's software group, MAMRAM, who would otherwise have weak social ties. The CPS, Breznitz suggests, is a socially constructed space that provides a trusted environment in which competitors share information facilitating technology transfer and generating "social capital and community identity [and] extensive collective learning and efficient diffusion of technological information" (37). Breznitz's paper provides an overview of the Israeli defense complex and its historic linkages to institutional computer studies programs in Israel which have spawned a number of successful private sector software firms, some in the security industry, thus continuing a cycle of innovation diffusion within industry. It is a detailed case study which documents this well-known and successful example of technology transfer and diffusion.

Pavlidis *et al.* (2001) deviate somewhat from the selection of articles in this review by recounting the practical engineering design choices and actions required by a commercial surveillance research and development enterprise to meet market requirements for the final surveillance product. The article is an account of Honeywell Laboratories' development of the Detection of Events for Threat Evaluation and Recognition (DETER) prototype for advanced video surveillance systems. It is included here because the authors provide an overview of the security industry in the US and then walk through the design and implementation of the DETER system. For NewT researchers this article might provide a detailed overview of how such systems proceed through the innovation process to diffuse more widely into use.



In conclusion to this review on the diffusion of innovations, I also recommend Bronwyn Hall's chapter on "Innovation and Diffusion" in *The Oxford Handbook of Innovation* (2005). While Hall's chapter is part of a wider account of innovation collected in a reader, the format situates diffusion within the field of innovation studies which may interest NewT researchers. This chapter serves as a genealogy of diffusion weaving in popular examples of diffusion, both successful and not, that serve to demonstrate the progression of theory and thinking on the diffusion of innovations.

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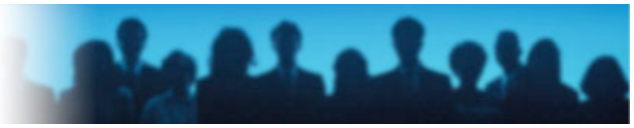

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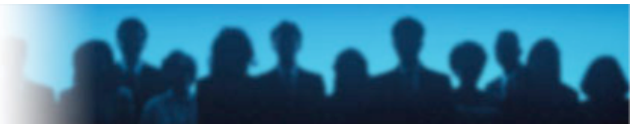

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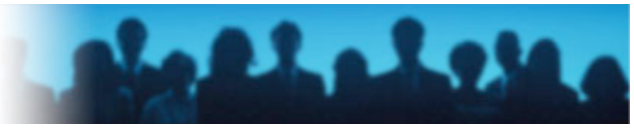

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