A technology delivery system for characterizing the supply side of technology emergence: Illustrated for Big Data & Analytics

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ABSTRACT

While there is a general recognition that breakthrough innovation is non-linear and requires an alignment between producers (supply) and users (demand), there is still a need for strategic intelligence about the emerging supply chains of new technological innovations. This technology delivery system (TDS) is an updated form of the TDS model and provides a promising chain-link approach to the supply side of innovation. Building on early research into supply-side TDS studies, we present a systematic approach to building a TDS model that includes four phases: (1) identifying the macroeconomic and policy environment, including market competition, financial investment, and industrial policy; (2) specifying the key public and private institutions; (3) addressing the core technical complements and their owners, then tracing their interactions through information linkages and technology transfers; and (4) depicting the market prospects and evaluating the potential profound influences on technological change and social developments. Our TDS methodology is illustrated using the field of Big Data & Analytics (“BDA”).

1. Introduction

One can view technology development from a number of perspectives. The supply chain perspective views technology development as an attempt to deliver a system to meet specific human needs or wants, while the market embedding perspective looks at technology development in terms of uptake, adoption, and the wider use of technology. Through this perspective, innovation is strongly affected by the dynamics of the economic and the social/political contexts that shape the transformation of new technology into products and services that are well embedded in markets and society. Both perspectives are technocentric, in that they start with a technology option and explore the future pathways of development and uptake. When facing constantly fluctuating economic environments and swiftly changing markets, industrial actors are driven to pursue continual technological innovation as a response to maintaining a competitive edge (Wang et al., 2008). However, the process of technological innovation, which takes place through highly complex socio-techno-economic systems, is marked by the increasing role played by other factors, such as regulation and marketing. The social acceptability of innovation, especially where organized critical groups are concerned, must also be considered (Giget, 1997). Addressing these important relationships in the process of socio-technical change associated with complex technologies, thus, becomes a thorny problem for decision makers, both in government and industry.

Over the past few decades, a large number of innovation system approaches to explicate innovation in complex competitive environments have emerged. We have found the “Technology Delivery System (TDS)” conceptual model, first proposed in the 1970s, offers a helpful techno-centric approach for understanding what translates an idea into
The notion of a TDS was employed by the National Academy of Engineering to represent the complex processes by which knowledge of the consumer is deliberately applied to achieve amenities and social values (Wenk, 1973). In this model, the innovative process is driven by the market, where the government attempts to minimize the barriers that impede the TDS and to support struggling industries through an innovation policy of fixing market failures (Branscomb, 1973). Each technology has its own delivery system, consisting of a number of interactive components, and each component consists of a set of institutions that contribute to a common function. These institutions might include research institutions, manufacturing firms, public and private institutions, intermediaries, and outcomes) to project the important factors involved in a particular innovation. The TDS approach strives to address the most important relationships in the process of dynamic socio-technical change in order to reflect the ongoing process of technological development. The TDS depicts the innovation process as a stream of activities, driven by the invention of new capabilities and pulled by the demand for products, and the process is greatly influenced by a variety of exogenous societal influences, such as government policy (Porter et al., 1985).

The National Academy of Engineering report was innovative for its time. However, it has now become abundantly clear that actors and stakeholders play a central role in the delivery of new technology. Two prominent sources soon set out the fundamentals of a new discipline of stakeholder analysis and management (Freeman, 1984; Mitroff, 1983). Sources such as these helped educate subsequent generations of engineers and engineering management. Other developments focused on the right delivery of technical analyses. Analysts soon asked whether a single correct solution to technical problems could be delivered at all – when the very definition of correct is something that can be contested (Rittel and Webber, 1973). This led to new forms of operational research addressing both the “hard” and “soft” sides of a problem. The field is now more correctly known as problem structuring methods (Rosenhead and Mingers, 2001). References such as these were so persuasive and so central to thinking about engineering problems that they arguably helped launch the new fields of engineering management and technology management (Cunningham and Kwakkel, 2011).

Despite the widespread influence of thinking about actors, stakeholders, and socially contested problem solving in engineering, a question remains: How can we best update the National Academy of Engineering report on TDS to take this well-established knowledge base of engineering and technology management into account? This is a much more specific question, as we can now focus specifically on the needs and requirements of the TDS and its users. After reviewing a dozen distinct strands of literature, a question arises as to whether there is something uniquely useful about the TDS concept. The purpose of this review is to overview a number of potentially relevant and closely-related concepts regarding TDS modeling. This review and synthesis seeks to generate a clearer perspective regarding the strengths, weaknesses, limitations, and future opportunities for research into TDS. We divided the literature into three parts – perspectives on technology, perspectives on delivery, and perspectives on systems.

The technology perspective emphasizes the R&D processes required to produce a new technology. A key contribution is technology roadmapping (TRM). According to Phaal et al. (Phaal et al., 2004), a technology roadmap helps organizations reconcile the technological and commercial perspectives on the emergence of new technology. These authors identify eight distinct kinds of maps, developed for eight different kinds of organizational purposes. Kappel (Kappel, 2001) provides further direct evidence of how technology roadmaps promote useful strategic conversations inside a technology-driven organization. TRM became important for guiding large R&D consortia, particularly those surrounding the development of semiconductor technologies. Walsh (Walsh, 2004) provides a useful modern case study demonstrating the continued relevance of roadmapping for the newest generation of semiconductor technologies. The technology roadmapping perspective is most widely cited in the fields of management and business.

The “delivery” notion focuses attention on the complex network of organizations, policies, and incentives that help produce and deliver technology-based products or services. This perspective is largely adopted in the social sciences literature, including the fields of sociology and public administration. The policy analysis framework emphasizes a feedback loop between perceived gaps in policy and strategy, and the measures taken to enact desirable changes in a system (Walker et al., 2001). Prominent within these theories is the concept of a small coalition of actors who negotiate with each other in pursuit of specific policies or economic interests. Representative theories include advocacy coalition theory and growth coalition theory (Sabatier, 1988; 1993).
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