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— Whats ahead?

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50 Years of R&D in Technology Management

— What's ahead?

Av Ove Granstrand

The comments on this topic from several colleagues in the technology, engineering and innovation management community are gratefully acknowledged. The short format of this article creates sins of commission as well as omissions, for which I ask for forgiveness.

1. In fact my first-year project as a PhD student 1969 at Chalmers Univ. of Technology was to develop methods for R&D project selection for the Swedish Navy.

As of 2019 technology and innovation management is well established as a discipline in academia and industry, with all its paraphernalia – associations, journals, conferences, schools and institutes all over the world. That was not at all the case 50 years ago when the label hardly existed. The purpose of this article is to make a short review of the research and development of this discipline from my personal perspective. The review is thus unavoidably incomplete and subjective but hopefully well-informed after having been active in the field since its humble beginnings[1].

The 1950-60s

The economic growth and growth of R&D investments after WWII, being a war that demonstrated the decisive role of S&T, spurred the attention to R&D management issues. R&D management and the related engineering management started to take off as subjects, primarily in the US, with universities like MIT and agencies like RAND Corporation taking a lead. Gradually, a consensus took root among academics about the decisive role of new technologies, innovations and entrepreneurs for economic growth, an old but so far slowly adopted theme developed by the Austrian/Harvard economist Joseph Schumpeter. Then one could ask: If technological innovations were driving economic growth would not then innovations in managing them be particularly important? A list of R&D related management innovations at the time could include new methods for R&D project management (e.g. PERT), R&D budgeting, technological forecasting, learning curve analysis (e.g. using the PIMS database), and organisation of corporate venturing (e.g. General Electric's unit for technical venture operations). R&D also began to appear in some of the tools, fashions and fads in general management that also developed at the time, primarily in the US, e.g. the strategy matrices and portfolio analysis of existing and new products and markets for diversification, and further developments of divisionalized organizations (the M-form) with centralized corporate R&D.

The 1970-80s

A growing concern about the impact of new technologies (like electronics, new materials and performance chemicals) in general, increasing R&D costs and the growth of technology markets widened the focus in firms from R&D as an in-house activity (being a verb) to technology as a tradeable asset (being a noun) which could be acquired and exploited in various ways or strategies and combined into asset portfolios and subjected to portfolio analysis. Innovation (being both a verb and a noun) started to become a buzz word (as increasingly used in ads for instance) and so did related terms like creativity, new (business) ideas and entrepreneurship. The increasing costs and benefits of new technologies and innovations fostered the idea that they could and should be managed, although met with scepticism rooted in the view that the underlying processes were hardly possible to manage, let alone to research and teach. Nevertheless, the phrase technology management began to appear and take root.[2]

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A leading institute in management of R&D and technology in the 1970s was (and still is) MIT's Sloan School of Management with several pioneers (such as Edward Roberts, James Utterback, Tom Allen and Eric von Hippel). In the early 1980s MIT researchers became engaged in Sweden, with IMIT as one collaborator. Gradually technology management became recognized as a field in the 1980s and related initiatives were taken in

various countries, especially in the US and in Asian countries such as Japan, S. Korea, and Singapore but also in China, wanting to catch-up technologically. In Europe and North America several universities - many if not most technical ones - created programs, conferences, associations, journals and centres related to technology management (e.g. in Portland OR, and Manchester). An important factor was the demonstrated international competitiveness of Japanese firms, who not only caught-up and forged ahead in product and manufacturing process technologies, especially electronic and mechanical ones combined, but also in management, with management innovations like JIT, Kanban, TQM, concurrent engineering and Kaizen. Scholars, also from IMIT, started to study leading Japanese firms and their management, as well as US and European firms, which helped develop both research and teaching of technology management.[3] The rapid catch-up of Japan, and later S. Korea and China, also illustrated an asymmetry in managing technology as a leader attempting to keep the lead and as a follower attempting to catch-up, which highlighted the importance of institutional structure and government technology policies. Technology management also became more strategically oriented, attempting to bridge a common gap between technology strategies and business strategies and make R&D and technology a regular concern in top management, as was very much the case in Japanese MNCs. A more economically oriented research theme also developed around strategies for appropriation of value derived from new technologies and innovations, with pioneers as D. Teece at UC Berkeley and researchers behind the seminal "Yale study" in the mid-1980s, a.o. R. Nelson, who together with S. Winter 1982 published An Evolutionary Theory of Economic Change 1982. These works became very influential in the innovation management community, not the least in Europe. This community also became influenced by the works of other prominent economists as well, such as E. Mansfield, N. Rosenberg and C. Freeman, works that helped infuse economics into technology and innovation management at the same time as economics of technology and innovation started to emerge as related research themes.

Technology management (or management of technology) thus internationalized during the 1980s both in terms of its institutional structure and its content, becoming international technology management, at the same time as it evolved into strategic technology management. The latter development must also be seen in the light of the way the Soviet Union was outcompeted by the US in the 1980s, essentially due to the inferior (if not absent) technological innovativeness in its centrally planned (managed) economic system compared to the US decentralized market-led system. For a long time military R&D has accounted for (and still does) a large share of total R&D, and military technology management has played an important but often forgotten role in developments of the field at large.

The 1990-2000s

New entrants entering into technology management, further spurred its growth (hardly any exits took place) and internationalization, but also led to a larger disciplinary diversity among scholars, who became attracted by innovation and entrepreneurship issues, in many cases already in the 1980s. The classical industrial management problem of integrating R&D, production, and marketing and a more holistic perspective on innovation also called for more interdisciplinary studies. Important infusions into the field came from business administration and economics, economic historians of technology, industrial marketing, work organisation, quality management, strategic management, financial management, evolutionary economics, and policy studies. A system approach developed and various types of innovation systems (national, sectoral, corporate etc.) became units of analysis. A legal perspective also became increasingly relevant through the raised importance of regulations, standards, product safety and liability, environmental issues and not the least intellectual property rights (IPRs), which had been strengthened considerably during the 1980s in the US (much in response to Asian competition). IP management thus became a branch in technology management and studies of best practices in Japan, helped grow that branch, just as studies of Japanese practices perceived to be at the management frontier in the 1980s had helped grow technology management.

Despite the disciplinary diversity in the field, some consolidation took place. The growing knowledge of the phenomena of R&D, new technologies, innovations and their diffusion since the 1950s, started to become common knowledge and language among scholars and to some extent among practitioners, including consultants. Various features and conceptualizations of these phenomena became more widely recognized and disseminated, such as technological convergence, fusion, diffusion, diversification, learning, transitions, substitutions and disruption, as did various qualities of technologies such as being generic (general purpose), key, enabling and core. Knowledge about these features and qualities of technologies then formed a basis for management methods and models, e.g. methods for technology road-mapping and models for techno-economic analysis. A wider knowledge, competence, learning and dynamic capability perspective had also been developed in general management, such as the core competence concept by Hamel and Prahalad. However, their normative message to focus and specialize could be challenged when applied to bodies of technical knowledge (i.e. technologies) which tend to combine as complementary assets in multi-technology products and firms, yielding economies of scope rather than scale. The normative discussions, based on a growing body of phenomenological knowledge and best practice studies nevertheless helped to consolidate the field to some extent. The inflow into the field of many entrants without engineering background but an interest in innovations in general possibly contributed to a certain shift in language and focus from technology to the broader concept of innovations more generally. Entrepreneurship in its various forms (independent start-ups, small firm businesses, corporate, university etc.) also became a more widely spread practice, which resulted in research and teaching. However, entrepreneurs (subjects) and innovations (objects), tended somewhat paradoxically to generate separate studies, while being integrated in practice, possibly influenced by disciplinary and institutional preferences. Some common themes also snowballed and helped consolidation. One in particular was open innovation, a new label coined by H. Chesbrough in the early 2000s, which attracted vested interests among supporters of collaborative innovation and the open source movement. The latter was in itself an innovative

2. It is hard to tell when and where the phrase was coined. A research program at the institute IIASA in Austria was created in the 1970s with the title "Technology and Management". My PhD thesis from 1979 was titled "Technology Management and Markets" (published abridged by Pinter Publ., 1982). The Institute for Management of Innovation and Technology (IMIT) was created in Sweden 1979 as well. To my knowledge this was the first appearance of Technology Management as a label of a book and an institute. MIT launched a teaching program labelled Management of Technology in 1980-81.

3. As a result competitiveness became a central theme in government, industry and academia in US and Europe and several studies were launched to search and research the sources of competitive advantages, e.g. the studies by M. Porter and the US National Research Council report 1987: Management of Technology - The hidden competitive advantage. Especially the latter report, with its explicit advocacy of broadening R&D management to the yet not established discipline of technology management, allegedly gave birth to many technology management programs in the US.
Thus, Japanese successful development of technology management practices contributed both directly and indirectly to the growth of the subject.

approach to managing R&D, enabled by Internet technology, which diffused rapidly after becoming user friendly around 1995. Various forms of open innovation had been practiced (as in technological catch-ups) and researched much earlier under other labels, however.

Another common theme taking off in the late 1990s, aided by fear of failure, was disruptive innovation, with C. Christensen, as a leading figure, again with several antecedents, going back to Schumpeter and his notion of "creative destruction". Service innovation, with the (justified) view that selling functional performance was the gist of business, was still another theme with growing interest, and so was user innovation, with E. von Hippel as a leading figure. Several more themes could be added to this list of common research themes in this period, often with labels referring to specific types of innovation (rather than specific types of technologies), such as frugal innovation, environmental innovation, continuous innovation, business innovation and even business model innovation. The development of a more common language in technology and innovation management also has had to face fashions and fads and "creative destruction" in its terminology.

2010s- and ahead?

A more narrow time window makes it more difficult to spot main developments in the 2010s. The existing themes have continued to attract attention among practitioners and work among management scholars along with shifts in relative emphasis. Among candidates for new sustainable research themes one could exemplify with environmental technologies and sustainability, university and social entrepreneurship, globalization of supply chains and value chains, national innovation policies, technology governance, and digital information technologies. Different types of new technologies (digital, materials, bio etc.) seem to be more defining the research agendas than different types of innovations as in the past, although information technology (IT or infocom technologies, ICTs) have constantly featured in management research, being perhaps the most important "process technology" in management. Finally one could note that financial innovations came into focus after the financial crisis but has not attracted much attention by innovation researchers.

What lies ahead? What past research trajectories could be extended into the future? Which new ones will appear and dominate research design and management practices?

Innovation policies and entrepreneurship with nationalist purposes are embraced worldwide with the entry of China, India and others on a large scale into international markets. A fair amount of policy convergence has developed in terms of national policy objectives with supply side policies targeting similar technologies, with digital information technologies, energy technologies, new materials, computer science and biology as good examples. This will likely impact technology management practices and research around the world. AI, data analytics and machine learning will be trans-formative, also of management, economics and law (e.g. via "smart contracts" and other contractual innovations). It is noteworthy that many management practices have been codified and disembodied as algorithms, and this development will likely accelerate. Data access will be an important determinant not the least for training these algorithms, which might favour large market countries like China, unless markets develop for data trade. The growing role of new technologies in management practices could in fact be referred to as management BY technology. Technological protectionism will moreover likely increase as new technologies become more valuable, costly and recombinant. At the same time IT lowers transaction and management costs, fostering technology markets, sharing and collaborations. Various hybrids and mixes of closed and open IP regimes might then evolve, enhancing the role of technology and IP management.

On the demand side the recent decade has witnessed a rapidly growing concern about global challenges and risks, including environmental issues, financial instability, technological unemployment, pandemics, wars and regrettably many more. This concern will likely pervade technology and innovation management and elevate its role, since most global challenges are results of overuse or abuse of technologies, which require new technologies and innovations in turn to meet these challenges, which may create new challenges in turn.

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A few questions and observations on the supply and demand side can thus be offered as food for thought about what's ahead in the continued developments of technology and innovation management. Perhaps the biggest question is how this by now large and established discipline could be sustained and generate more technology management innovations.

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