Triangular Relations and Regional Competitive Advantage: the Case of Greater Boston

Greater Boston offers a real world industrial laboratory for exploring systemic innovation dynamics. Much of technological innovation can be attributed to university and national labs and federal funding of science and technology and the resultant deep scientific knowledge base. But this linear, science-push model of innovation is not the whole story. Kline (1985), followed by Myers and Rosenbloom (1996), argues that science and technologies were the enablers rather than the drivers of the innovation process. Kline's chain-linked metaphor of the technology innovation process captures the interaction and feedback loops common to many high tech enterprises. Here, instead of science-push we find science-pull from technology-driven enterprises.

In previous research colleagues and I deployed a finely granulated, engineering-based taxonomy to illustrate the high degree of company, product and technology differentiation within and across industrial sectors and regions in Massachusetts. We found that over a period of two to three postwar decades a population of over 3000 technologically differentiated enterprises had 'emerged'. The persistence and success of a large population of small and medium-sized technology-driven enterprises would seem to defy the historic logic of increasing industrial concentration R&D intensive industries as stronger competitors with greater access to financial resources gained market share at the expense of the less efficient or innovative.

The concept 'emerge' in this context does not imply an entirely bottom-up, self-organizing process void of purposeful intent. It is more complex as will be illustrated below. But once in place, the population of enterprises enjoyed the systemic capability to both create and enact opportunities for technological innovation. The purpose of the paper is to examine the historical and developmental origins of this localized population of enterprises and the systemic processes by which new opportunities for innovation are both created and effectuated in the form of emerging and growing high tech sectors.

What are the origins? The term high-tech was first used in the late 1960s to describe 'science-based' companies and government sponsored labs along Boston's Route 128. [1] One contemporary observer estimated some 690 such entities fit the description in 1968 (Lieberman 1968).[2] Lieberman writes that the key to the success of the companies located on Boston's "Golden Semicircle…is due to 'uniqueness' of the average company's technology…and the availability of government contracts during the early years" (referring to an unpublished 1960 study by Edward B. Roberts in Lieberman).

[1] A simplified description is to think of the high tech business enterprise as centered around two teams: a technology integration team and a business development team. A technology integration team is the organizational or institutional means to combine the expertise of a range of scientific and engineering disciplines all of which are required to develop and support distinctive technology platforms. The challenge is that every discipline has its own language, concepts, and perspectives and communication across disciplines is both problematic and critical to success. The business development team has the challenge of transforming a fledgling company with a novel technological idea and facing several years of zero sales revenues into a fully developed, growing entrepreneurial enterprise under the pressure of time.

[2] "It is not clear whether the name [high tech] derives from the high technologies flourishing in the glass rectangles along the route or from the Midas touch their entrepreneurs have shown in starting new companies. Maybe both" (Lieberman 1968).

In the 1970s and 1980s, the population of high tech business units in Massachusetts had increased to more than 3000.[3] This number represents all business units that engage in R&D and specialize in designing and developing next generation technologies as part of their ongoing operations. Some seek to establish a novel technology platform. All benefit from access to the region's scientific knowledge base and engineering expertise.

Greater Boston's open-system high tech business model could not have emerged and thrived without first, the sharp reduction in entry barriers to basic research enabled by the creation of a national S&T infrastructure and second, the achievement of an open-research knowledge base. The academic ideals of open research had powerful voices in the elite universities of the Boston area. This was a critical factor in proliferating connections of basic research in labs with applied research in enterprises.[4]

National labs, along with research intensive universities and hospitals, were and remain agencies that integrate the Boston area's business system and the national S&T infrastructure; one cannot be described without the other. National labs are prohibited from manufacturing activities. For this they need industry partners. As a consequence business development processes were and are inter-connected with a science and technology infrastructure unmatched in the prewar era by any but a handful of Big Business enterprises with corporate labs.

Nevertheless, entrepreneurship as the driving force for industrial innovation cannot be ignored. The Schumpeterian literature refers to large companies with the financial resources to invest in R&D and compete on the basis of technological leadership as Mark II as distinct from the earlier heroic individual entrepreneur as Mark I. In this paper a Mark III 'open-system' model of business organization is proposed in which a largely self-organizing population of high tech firms exhibit systemic opportunity creation and enactment capabilities.

For the first time a population of SMEs emerged in which each member could establish the full chain-linked innovation process described by Kline (1985). The full or extended process-innovation chain or innovation engineering strand includes basic research, developmental research, applied research, manufacturing design, product development, process engineering, production, and market research. In this important way, the inter-organizational relations of each firm was a small scale variant of the triangular inter-relations involving industry, academia, and government established to design, develop, and create technologically advanced weapons during World War II.

Opportunities for technological innovation are being created not because firms own labs independent of operations but because they design and conduct experiments as part of ongoing operations. As some opportunities are selected and others culled the region's knowledge base and expertise are advanced. The result has been the unintentional creation of an informal collective action capability in the form of

[3] Not all have been recipients of federal technology development programs but the region leads in take-up of SBIRs (*Index of the Massachusetts Innovation Economy*, various years).

[4] In contrast to the Boston area, the high tech region of Northern Virginia is home to a closed-system business model. The lack of a strong, research intensive university provided minimal counter pressure to the powerful forces within sections of the government and business to pursue classified research agendas (Ceruzzi 2008; Best 2011).

an ongoing, recursive process of the creation, closure, and re-creation of niche opportunities to pursue technological improvements. Firms are sensitive to and learn from ongoing experiments throughout the region which they input into their ongoing opportunity detection and creation process (Maskell and Malmberg 2007). Many have university research connections and do applied science, most have indirect access to the region's science base, and all draw upon the region's heritage of technical expertise.