International Journal of Innovation and Technology Management
Vol. 12, No. 2 (2015) 1550008 (31 pages)

DOI: 10.1142/S021987701550008X

Demand-Driven Innovation: An Integrative Systems-Based Review of the Literature

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Received 4 December 2012
Revised 7 November 2013
Accepted 1 April 2014
Published 9 December 2014

In this paper, we provide a comprehensive review of the literature on demand-driven innovation, using a generic national innovation ecosystem map as a unifying framework. We organize the literature review around four key innovation dimensions and seven related demand-driven processes. Our review reveals that business networking which accelerates access to new markets and technologies is vital for free markets. But classical competition alone cannot sustain the creation of new technologies or innovation paths. Rather, national policy is essential in creating lead markets. On the other hand the private sector has a crucial task in leading R&D activity. We found that the relationship between R&D stock and productivity is mostly positive. With regard to cluster strategies our literature review suggests that increased variety of innovative activities strengthens regional economic growth through "spillover effects" between products and industries. Based on the literature, we found that universities are evolving to play a major role in the research of innovation. The enormous innovative potential of universities therefore should be directed toward shaping more effective tools for public–private cooperation. But innovation, whether its origin is in academe or elsewhere, must follow a standardization process in order to converge into a well-defined technology. Our paper highlights a fundamental paradox underlying pro-innovation policies: while innovators often express the desire for a liberal, open and flexible market system with minimal bureaucracy and governmental interference, to allow market-driven innovation to flourish, they often benefit greatly from a variety of governmental interventions that include direct or indirect financial support (such as tax credits).

Keywords: Innovation ecosystem; entrepreneurship; R&D; demand-driven innovation; innovation policy.

1. Introduction

This paper comprises an integrative review of a large body of research on demand-driven market-based innovation and related policies. We have chosen to organize this paper in the context of a systems approach to innovation. According to this approach, effective innovation policy must begin with a big-picture visualization of national innovation systems, one that captures the key stocks and flows of the innovation process as well as the essential feedback mechanisms that link them. Only by embracing a true systems approach can effective innovation policies be designed and implemented.

In this context, to understand how and why innovation revolutions happen, it is necessary to understand the underlying innovation ecosystem that generated them. These ecosystems have many components, related to history, culture, legal and regulatory frameworks, education, science, and finance. The components are interrelated in complex ways. In most countries, innovation policies are fragmented, driven by individual government ministries and other organizations, each of which are well-meaning but fail to achieve, and act on, a fundamental integrated big-picture view of the problem.

In his comprehensive textbook *Business Dynamics*, Sterman [2000] shows how complex businesses can be fruitfully modeled as a system of interdependent feedback loops. Countries, too, are businesses, and the innovation aspects of national business systems can also be fruitfully modeled using system dynamics [see Edquist (1997) on systems of innovation: technologies, institutions, and organizations].

Our review of the literature discusses the entire components of this complex system by using a visual portrayal of national innovation ecosystems as the framework for discussion. The methodology that facilitates constructing this visual portrayal was developed by Frenkel and Maital [2014]. This method has now been applied extensively to eight countries and regions: Israel, Spain, Germany, Poland, France, Singapore, Greater Toronto (for health care innovation) and Shanghai, China (for the Zhangjiang Science Park). They represent a fairly diverse spectrum of case studies where they belong to global geographical distribution, present countries or regions of different sizes, and act under different types of regimes and cultures which had clear influence on the local innovation system design.

The methodology that had been used to create the visual portrayal of national innovation ecosystems is described at greater length in Frenkel and Maital [2014, Chap. 2]. More generally, in each of the eight selected countries and regions we constructed, an “experts workshop”, combining around 15–30 experts or more with proven field experience in academe, industry and government. Through these experts data were collected regarding the components of the nation/region innovation system. The data refer to key “quality anchors” (core competencies, or basic infrastructures, that drive innovation) for the nation or region, and “processes and trends” (“flows”, or processes, that drive innovation and overcome strategic weaknesses, e.g. R&D funding). The data was analyzed by employing statistical procedure (e.g. explanatory factor analysis) in order to identify the key elements that construct the nation/region innovation system. The innovation ecosystem map is generated, using the “clusters” emerging from the factor analysis, and the linkages generated by cross-impact matrix.

Based on these eight visual portrayals of national innovation ecosystems a generic overview of national innovation ecosystems was constructed and is presented in Fig. 1. In our survey of the literature, we use Fig. 1 as a generic anchor, to include all

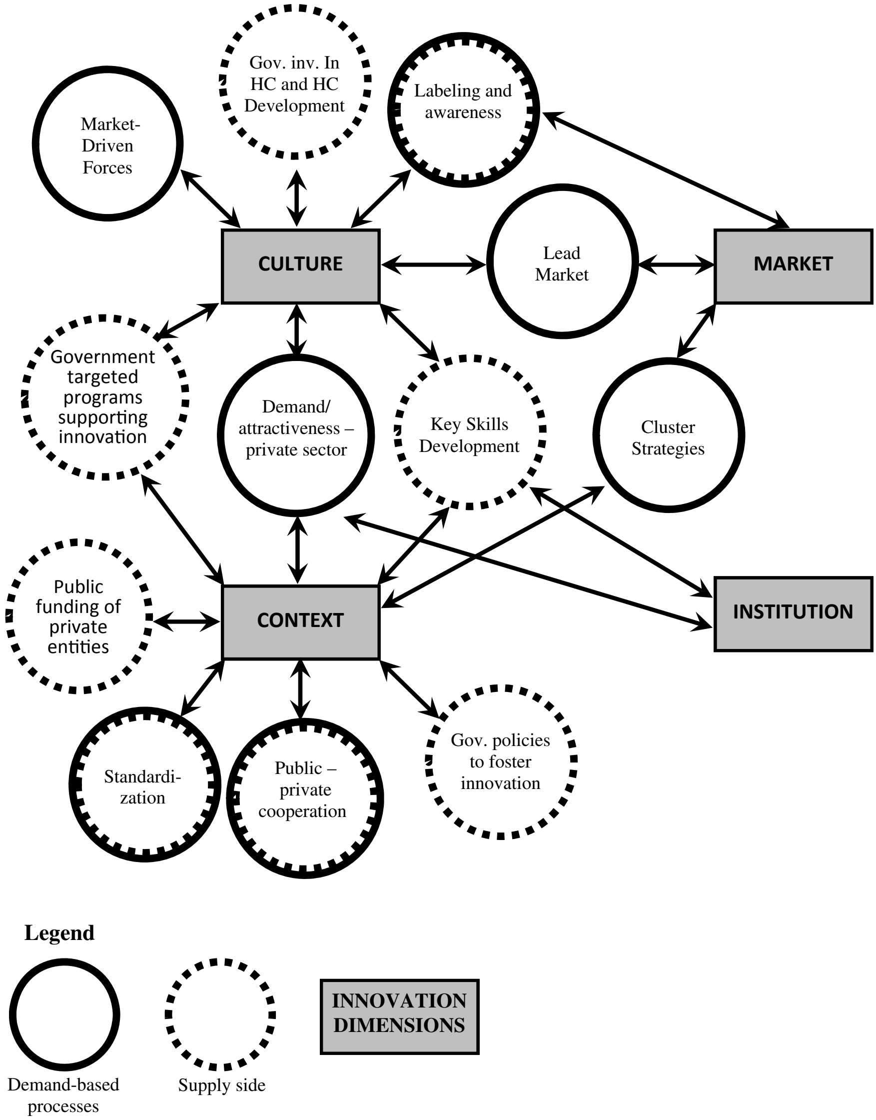

Fig. 1. Generic demand-driven innovation ecosystem map.

the key elements of innovation ecosystems. Our research on constructing empirically-grounded national innovation maps revealed a great deal of similarities in the components of the various national ecosystems in terms of their components. Some variance between countries was found in relation to the importance of the different components of the ecosystems and their inter-relationships. Figure 1 focuses on the common ground identified in the mapping process.

In our generic overview of national innovation ecosystems, we identified four key dimensions of innovation, shown as large rectangles (Fig. 1). They are: Culture, Markets, Context (including infrastructure) and Institutions (including regulations). Surrounding these dimensions are 12 key processes, shown as circles. Four of them are key demand processes, five are key supply processes and the remaining three present both demand and supply processes. It distinguishes between innovation drivers based mainly on the demand (marketplace) side, and those based mainly on the supply (policy and infrastructure) side.

Clearly defining "demand-driven" innovation elements is not a simple task. Most innovation combines elements that are both demand-driven and supply-driven. For our purposes, we define demand-driven innovation as innovation whose primary source or origin lies in the existence of a clear market-based need or want that is currently unsatisfied. Such demand-driven elements are identified by an innovator through a variety of mechanisms, including market research, personal experience and need, and lead user requests [von Hippel (2006)]. In contrast, supply-side innovation is innovation in which the initiative lies principally with the innovator or within government-directed policies, and whose origin lies other than in market forces. In Fig. 1, standardization, public–private cooperation and labeling and awareness (consumer education policies) clearly combine both supply and demand elements. In contrast, "market forces" refer to lead markets (markets that seek and promote new and innovative products and technologies ahead of other markets), cluster strategies (creation of groups of firms that "cluster" geographically around demand for a single product or product group) and demand attractiveness (market-generated economic signals, such as price, that "pull" innovation efforts and resources).

Innovation policy often focuses single-mindedly on supply-side elements — changes in the supply of innovation infrastructure, resources and capabilities by the government and academe through public funds. But this can easily lead to neglect of key demand-side and demand-driven innovation. At the extreme, massive supply-side intervention can be inimical to open-market demand-driven innovation. Maital and Seshadri [2012] observed that successful innovation is not, as is commonly assumed, primarily a matter of creative ideas and inventions, but is principally a result of effective operational implementation of those ideas, using creative business designs. A key part of such implementation is the focus on identifying market needs and wants, and listening to marketplace preferences throughout the innovation process. The bulk of innovation and technology policies have been designed by relying on a supply-side perspective while the demand-side has long been neglected in innovation policy [see e.g. Bottazzi and Peri (1999) and Edler and Georghiou (2007)]. It provides a strong basis for further research on demand-driven innovation policies.

Therefore, we choose to focus, in the present paper, on the demand-side of innovation. We use our generic overview of national innovation ecosystems framework (Fig. 1) to organize and structure the review of the literature on demand-driven innovation, with emphasis on public policy. Our review is based accordingly on the seven key market-based innovation processes that are (starting at upper left and moving clockwise): (i) Market-driven forces (forces driving innovation that emerge largely from markets and customers). (ii) Labeling and awareness (educating consumers and markets). (iii) Lead markets (key markets at the cutting edge of technology and innovation). (iv) Cluster strategies (regional policies for fostering innovation, including creation of agglomerations). (v) Private-sector demand attractiveness. (vi) Public–private cooperation. (vii) Standards and standardization that “pulls” innovation.

We may now undertake a systematic review of the research literature, placing each finding in its appropriate spot in the generic demand-driven innovation ecosystem shown in Fig. 1. Accordingly, the structure of our paper is as follows. The next section present the literature review under the culture dimension, with an emphasis on market-driven forces, labeling and awareness and lead markets demand attractiveness. Section 3 reviews the literature on market dimension with particular view on cluster strategies. Section 4 provides description of the literature review concerning the institution dimension while Sec. 5 focuses on the context dimension with emphasis on public–private cooperation and standards and standardization. In Sec. 6, we conclude and discuss some policy implications.

2. Culture Dimension

We begin with the “culture” dimension which somewhat surprisingly has a pervasive presence in all the national innovation ecosystems that have been mapped to date.

The central importance of culture in innovation ecosystems encounters a major difficulty — ambiguity in defining precisely what culture is. The term “culture” has emerged primarily from research by anthropologists. The definition most appropriate for our purposes, which we choose to emphasize, is: “the distinct ways that people living differently classified and represented their experiences, and acted creatively”, because it explicitly mentions innovation. Anthropologists draw an important distinction between “material culture”, represented in objects, and “intangibles”, like language, customs, and values. We have found that it is the intangible aspects of culture that drive innovation. In social theory, functionalism sees society as a complicated system whose separate parts combine and interact to achieve social goals. This approach views society as a kind of evolving organism. We embrace this view of culture, and the innovation that it drives, and will organize our literature review concerning culture dimension of innovation based on it.

The simplest definition of culture is “shared values”, about what a society believes is important and valuable. That definition suggests *prima facie* that culture is strongly linked with entrepreneurship, partitioning nations between those for whom innovation is important and valued and those for whom it is less so. Another valuable definition is given by Guiso *et al.* [2006, p. 23] who define culture as: “those customary beliefs and values that ethnic, religious, and social groups transmit fairly unchanged from generation to generation”. This definition reinforces the transmission of entrepreneurship across generations. Kreiser *et al.* [2010] use data from 1048 firms in six countries to assess the impact of national culture on entrepreneurship, and focus on a key aspect of culture, that of risk-taking among SME’s. Another interesting example is given by Landes [1998] an economic historian, in his epic book, who uses culture to explain income and the differing technological histories among nations. Within this context a study by Schein [1996] similarly focuses on the clash between three cultures — engineers, managers and operators — which further complicate the organizational difficulty arising from clashes of national cultures.

Management guru Peter Drucker once said famously, paraphrasing Charles Darwin, that the organizations that compete best in competitive environments are those that learn the fastest to adapt to changing circumstances [Maital and Seshadri (2012, p. 345)]. Lundvall and Johnson [1994] emphasize the key role of the value of "learning". The ability to learn plays a key role in understanding cultural differences regarding innovation. Scholars who use culture and other factors to explain cross-country differences in high-tech industry include Chen [2008], to explain differences in entrepreneurship Ardagna and Lusardi [2008] and in adoption of information and computer technology (ICT), Erumban and de Jong [2006]. The latter find (p. 307) "that national culture and ICT adoption rate are closely related". Power distance dimension (refers to the inequality of the distribution of power in a country) and uncertainty avoidance dimensions (the degree to which members of a society feel uncomfortable with uncertainty and ambiguity) are the most significant cultural factors by which some of the differences in ICT adoption rates among countries can be explained. The research on the role of culture (shared values) should be balanced by noting that often, entrepreneurs have unique personality traits that shape how they behave [Nga and Shamuganathan (2010)]. Key cultural drivers that explain differences between the US and Germany were found for the specific case of food biotechnology. In Germany, "appreciation of nature" (i.e. concern for the environment) is much stronger than in the US (some explain this as the result of the threat to the beloved German wald or forest, through air and water pollution). In the US, stronger institutional trust than in Germany is also a factor in adoption of new food technologies [Peters *et al.* (2007)].

Many multinational firms have R&D centers outside their home country. The impact of different cultures on R&D performance has, according to Ambos and Schlegelmilch [2008], not been sufficiently researched. The authors, in this study, define two types of R&D activities, and link each to culture: (a) exploiting the capability, and (b) augmenting the capability. The former is defined as abilities linked to later stages of development, after initial breakthroughs; the latter is defined as capabilities that contribute to breakthrough developments. They link these two R&D activities to five measured and measurable cultural dimensions, derived from Hofstede [1994]: power distance, collectivism–individualism, masculinity–femininity, uncertainty avoidance and long-term orientation. The authors hypothesize that these five dimensions of national culture impact R&D activity type A differently, perhaps oppositely, to R&D activity type B (for instance, long-term orientation might strengthen type B, which is more long-term, but hamper type A, which is more short-term in nature). The research covers some 500 German multinationals with R&D centers abroad. Their hypotheses regarding type (a) R&D activity are confirmed, but less so for type (b) R&D activity. Despite this, the authors conclude that national culture must be taken into account when managing global R&D activities; the interaction between the culture of the home country and the culture of the country in which the R&D center is based cannot be ignored.

A strong example of culture-driven growth is that of Shanghai, China (one of the eight countries and regions on which we based our Fig. 1). Zhang [2002] uses "coalition growth" theory to show how pro-growth coalitions drive growth in Shanghai under a socialist system, combining strong local government with once-excluded community organizations and free enterprise.

The view of culture that we embrace, and in part our definition of culture, relates to social and cultural values as emerging from society's ability to adapt to its changing environment and ecosystem. China, for instance, is undergoing a culture change, shifting from Confucian emphasis on disciplined learning of past knowledge, to a culture of innovation and entrepreneurship that stresses the value of new approaches to solving old problems. Israel's entrepreneurial energy derives from the country's origins, its struggle to survive in a hostile environment, and the culture of improvisation that was instilled, out of survival, from the outset. Singapore's culture of innovation is derived from Singapore's discipline and operational excellence, also emerging from Singapore's emergence as an independent nation and the need to "hold together" major frictions among its three main ethnic groups: Chinese, Malay and Indian.

Culture dimension in our generic innovation ecosystem map is inter-related with three demand-driven innovations and one combining the demand-and-supply-side. We now turn to describe these inter-relations as depicted in our review of the innovation policy literature.

2.1. *Market-driven forces*

The culture dimension interacts strongly with market-driven forces, broadly interpreted. Same innovation may be perceived differently by different agents in the market: customers, suppliers, innovators [Afuah and Bahram (1995)]. Afuah and Bahram [1995] note that the same innovation may be perceived differently by different agents in the market: customers, suppliers, innovators. Arthur [1989] emphasizes market "lock-in" effects: the difficulty is in displacing a well-entrenched technology, even when newer technologies are far superior. Disruptive technologies (technologies that perform far inferior to existing technologies, but with a steep improvement gradient) are a key source of market-driven innovation. Disruptive technologies tend to be used and valued in new markets or new applications; actually, they generally enhance the emergence of new markets. Thus firms must give managers of disruptive innovation free rein to realize the technology's full potential even if it means ultimately killing the mainstream business [Bower and Christensen (1995)].

Baumol [2002] makes a powerful case for market-driven capitalism as a key engine of innovation. His path-breaking 2002 book is a lengthy song of praise to the innovative energy generated by capitalism — written before the global crisis of 2008–2011 generated, according to some, by out-of-control capitalism. Other social and economic systems have generated path-breaking inventions; for example, those developed by the Romans, especially in architecture. But no other system has proved so fertile for generating an unending stream of innovations. In free-market capitalism, Baumol observes, organizations are forced, by fierce competition, to be perpetually innovative, transforming inventions into commercial marketplace success simply in order to survive. Similar to Darwin's model of natural selection, competitive markets "select" organizations for survival according to their ability to innovate successfully. A key part of this capitalist model is financial incentives — the ability to create wealth through successful innovation. No other system, observes Baumol, has been as powerful for generating massive amounts of wealth. Because of the pressure of competition, Baumol notes that organizations must create orderly systematic processes for innovation, in capitalism, or "routinization" of innovation. But he does not fully address the painful inequality in the distribution of wealth and income, created routinely by capitalism, which has now become a highly charged, controversial issue.

A number of other studies stress the importance of public procurement (government purchases of goods and services) as an important factor in stimulating innovation [Edquist and Hommen (2000); Edquist *et al.* (2000); Geroski (1990); Edler and Georghiou (2007); Lee (2009); Weber (2009); Uyarra and Flanagan (2010)], a process of particular importance in France's innovation ecosystem. The OECD reports at length on procurement and synthesizes a variety of findings. Cross-country comparisons of government goods and services purchases are difficult, because of differences in measurement and definitions. A key distinction is the share of procurement that is "tradable" (i.e. open to international trade and hence contestable by other nations). "Defense-related expenditure" is included in the "non-tradable" segment, but in fact there is substantial trade in defense goods and services among nations [Audet (2002)]. In addition to public procurement, innovation may be derived by private actors within the market, such as consumers. For example, some researchers note the value of innovation in which customers are co-innovators [Business Decisions Limited (2003); Dahlerup (2009); Jeppesen and Molin (2003)]. The latter constructed a theoretical model, in which firms build a well-structured process for motivating and harvesting consumer-driven innovation. An accompanying case study shows an example in which this is done using a public website.

Within this context, Lotz [1993] studies the role of demand in medical innovation. He identifies two key aspects of demand: the likelihood that new markets can be created and then achieve significant growth, and the ability to acquire reliable data on what consumers truly need and want, when often such consumers are not able to articulate clearly their needs. Nemet [2009] examines the role of demand-pull versus technology-push in radical innovation and argues that policy makers should have limited expectations about the extent to which demand-pull policy instruments alone will induce non-incremental technical change. The link between networking and innovation produces numerous proven benefits of business networking, such as: the sharing of risk, accelerating the time-to-market and delivery of products to markets, the aggregation of complementary skills, protection of property rights when legal contractual protection is not feasible, providing a means for gaining access to knowledge outside the organization and gaining access to novel technologies and new markets [Pittaway *et al.* (2004)].

2.2. *Labeling and awareness*

This process, also linked to culture, is somewhat ill-defined, but relates to measures for educating and protecting consumers, without hampering introduction of innovative products. It is the subject of several key OECD works [2009, 2010a,b], a UNDESA study [2003] and a study by Hellman-Trutert [1999] on consumer education in schools. The OECD [2010a] provides a useful case study of Profeco, Mexico's consumer protection agency, which uses a variety of tools (website, fax, hotline, print publications, etc.) to inform consumers of their rights. The report notes: "Profeco has an outreach strategy in order to educate consumers about their rights and effectively promote the principles of smart consumption" (p. 2). The link to innovation is clear — educated consumers are more likely to be favorable for more innovative products.

Benn [2004] provides an interesting study of consumer education among 12–19-year-old Danish students. He found that in modern society, from a relatively early age, young people are socialized to become consumers. Goods and services become predominant in the lifestyles of even young children, as a result of globalization, rising affluence and aggressive marketing. This study focuses on a key dilemma. Should "enlightened consumership" be taught — "educating for critical consumer awareness and action competence"? [Benn (2004, p. 108)]. If it is, this may come at the expense of further exaggerating the importance of consumption, and further diminishing the importance of citizenship (actions that help society that do not involve purchase of goods and services). Treading the fine line between these two "poles" should be a goal of consumer education. The Danish program reveals how difficult this is, and how many improvements can and should be made to existing consumer education programs for children and teenagers.

At the Rio de Janeiro Earth Summit Conference in 1992, a decision was adopted stating: "Governments, in cooperation with industry and other relevant groups, should encourage expansion of environmental labeling and other environmentally-related product information programs designed to assist consumers to make informed choices" [UN, Agenda 21, Chap. 4, paragraph 21 (1992)]. Since that decision, research has shown that labeling can be a powerful tool for promoting technical change and innovation.

Muller (2002) studied the German "Blue Angel" program, which began as early as 1971. The basic idea she notes (p. 6) is to improve the environmental quality of consumer goods and other products by providing an economic incentive to manufacturers to develop products whose choice of raw material, production, use and disposal, through all stages of the product life cycle, should ensure that these products would be less harmful to the environment. Products whose life cycle conformed to this requirement were granted the Blue Angel logo, the symbol of the UN Environmental Program. Muller concludes, in her evaluation of the Blue Angel program, that "the Blue Angel has helped promote innovation in some cases and has significantly promoted the diffusion of 'best available technology' to reduce product-related environmental problems in quite a number of product categories. This happened primarily when it was accompanied by additional tools and when, in the view of industry, regulatory measures were in the 'political pipe-line'" (p. 33). Her findings are consistent with the German culture concern for the environment as mention above by Peters *et al.* [2007].

2.3. *Lead markets*

Countries can create competitive advantage by imposing standards that drive technological advances, making it a "lead market" (pioneer) and generating exports. This too is closely related to national culture. Why do some innovative products and services "catch on" fastest in one country or another, and not in others? Such countries are known as "lead markets". Japan, for instance, was a lead market for cell phones. Countries where innovative products are adopted much later are "lag markets". What are the key factors that determine whether a country will be a lead or lag market, for innovative products?

Beise [2004], in his article, models "lead market potential" as a function of five key factors: cost advantage (ability to produce the product at low cost), demand advantage (eagerness of the country's consumers to buy the product), export advantage (ability of firms in the country to profitably export the product to other nations), market structure advantage (the agile, competitive structure of a country's markets, that foster introducing innovative products), and finally, transfer advantage (the ability of a country to transfer a successful lead-market product to other nations, by adapting its characteristics to that nation's preferences and culture).

Several studies by Beise [2004]; Beise and Cleff [2004] and Beise and Rennings [2005] explore this issue and show how to assess lead-market potential. By examining environmental regulations, they found that when supported by global demand or regulatory trends, strict regulation results in the creation of lead markets. Edler and Georghiou [2007] link lead markets to public procurement. Their study discusses public procurement as one of the major components of a demand-oriented innovation policy. They claim that recent public discussion, especially in Europe, has revived this concept. In their study, the authors define "public procurement" and place it in the context of the full range of innovation-promoting policies. They examine the various pros and cons of procurement policies to spur innovation, and provide a series of examples and case studies. They note the danger that World Trade Organization Government Procurement Roles limit the ability of the EU to favor local companies in procurement, while nations like China are not bound by such rules.

Industry-specific studies of lead markets include Denmark's fabricated metal industry [Hansen (2010)], intra-ocular lenses [Metcalfe and James (2001)] and the earliest business computer [Land (2000)]. Hansen finds that "the ability to create tailor-made solutions is central to the competitiveness of these medium-low-tech firms" (p. 65). However, he warns that there is no guarantee that this will be the case in future, because Asian nations continue to move up the value chain, producing large numbers of skilled laborers in metal-working, while Danish youth are not encouraged to pursue metal-working careers.

Saviotti and Pyka [2008] build a model of economic development through creation of new (leading) sectors, and show that optimal development occurs "when a suitable ratio of inter-sector and intra-sector competition is achieved" (p. 323). According to this paper, Schumpeterian and classical competition can be considered the extremes of a range within which fall all the competitive situations existing in a real economic system, varying from the multidimensional analogue of perfect competition to monopolistic competition. But economic development needs both classical and Schumpeterian competition whereas the balance between these two types is extremely important. Classical competition alone would not sustain the creation of new sectors, while a prolongation of the temporary monopoly involved in Schumpeterian competition would reduce the scope of each sector and the rate of creation of subsequent ones. Krafft [2003] analyzes the info-communications industry, itself a lead market, showing how this key industry does not conform to observed optimal vertical structures in dominant economic models.

There are major advantages for global firms in successfully identifying and exploiting lead markets; such markets "signal" to firms which set of product characteristics are most likely to succeed, thus reducing the risk of failure in new product launches. National technology policies should also take into account the advantages that "lead markets" confer.

2.4. *Demand attractiveness* (*private sector*)

Increasing demand for technological development in the private sector has significantly contributed to the strengthening of innovation and entrepreneurship. In this context, Finland's innovation ecosystem is widely admired. A study by Breznitz *et al.* [2009] reviews the role of user-driven innovation in Finland. Contrary to many other studies that stress the key role of markets and demand, Breznitz finds that new technologies arise from direct government intervention and funding. The drivers of R&D and start-up innovation are the topics of papers by Falk [2006] and by Gans *et al.* [2002], the former focused on OECD nations. His findings suggest that tax incentives for R&D have a large and positive impact on business R&D spending in OECD countries. Expenditures on R&D performed by universities are significantly positively related to business enterprise sector expenditures on R&D indicating that public sector R&D and private R&D are complements. Finally, direct R&D subsidies and specialization in high-tech industries also contribute significantly to business-sector intensity.

Griliches' [1995] landmark book shows the high rate of return, in terms of higher productivity, to investment in research and development, with R&D pulled by market demand. Ortega-Argiles *et al.* [2010] and Paff and Watkins [2009] study empirical aspects of R&D in terms of their effectiveness and cost. The former confirm that the relationship between R&D stock and productivity is positive; R&D is found to be significantly linked to productivity in the high-tech sectors and to a lesser extent in the medium-tech industries. As a result, firms in high-tech sectors not only invest more in R&D, but also achieve more in terms of the productivity gains connected with research activities. Consoli [2008] does a case study of UK retail banking, showing how changes in knowledge and structure combine to foster a "paradigm of service innovation". He uses theory and case studies to show how UK retail banking has become "more contestable as a result of the combined effect of technological progress and the changing regulatory framework" (p. 478).

Nesta and Saviotti [2006] study 84 biotechnology firms active during the 1990s. Using panel data, the authors seek to place a monetary value on the degree to which biotech firms "integrate knowledge" and thereby create "knowledge capital" (capital that reflects the value of the knowledge acquired and integrated by the firm in its operations and products). They provide two main findings. First, the firms' market value (the value of the firms' shares on the stock market, mainly NASDAQ) is influenced strongly by the degree of "knowledge integration" within firms. Second, knowledge integration grows in importance over the lifetime of the firm, in terms of its contribution to, and impact on, market value. They do note, however, that this finding may well be specific to biotechnology, and to sectors within biotechnology.

3. Market Dimension

This dimension covers aspects of innovation that relate to how the forces of demand interact in the marketplace, including the forces of competition. Research on the market dimension reveals a variety of ways in which innovative businesses and start-ups can determine the existence of unmet needs and wants, define those wants, and seek ways to satisfy them in a sustained profitable manner. It includes research to help less-developed nations, where market forces are less powerful, strengthen their demand-driven innovation.

Saviotti and Pyka [2011] build a model showing how widening development gaps among countries emerge when countries face entry barriers that hamper efforts to imitate advanced countries' technologies. The role of co-opetition (collaboration with competitors, for instance in R&D) is the topic of another study that found that the more that a technological change makes the capabilities of a firm's suppliers or customers obsolescent, the less well the firm performs [Afuah (2000)]. This underscores the importance of using the network as the lens when exploring the impact of a technological change on the firm's competitive advantage. In that case Afuah concludes: "a firm that is sufficiently short-sighted to emphasize only the effect of technological change on its own abilities can lose a competitive advantage that it gains from its relations with collaborators ("co-opetitors") (p. 399).

Aghion *et al.* [2005] find a complex U-shaped relationship between competition and innovation. They have three main findings. First, when product market competition is low, there is what they call an "escape-competition" effect. Second, at higher levels of "neck-and-neck" product market competition, an inverted U-shaped curve exists for industries, which is steeper than the higher the level of competition, and third, firms facing the threat of bankruptcy encounter greater "escape-competition" and hence, on average, are more innovative.

Cervantes [2009] addresses the role of policy in demand-led innovation, as does Edler [2007]. Edler provides a useful definition of demand-led innovation policy, as a "set of public measures to increase the demand for innovations, to improve the conditions for the uptake of innovations or to improve the articulation of demand in order to spur innovations and the diffusion of innovations" (p. 1). Edler explains that market failure makes demand-based policy necessary. Such failures include information asymmetries (buyers and sellers have different information), switching costs, and barriers to entry. Based on OECD work from the last 10 years Baland and Francois [1996] relate innovation to monopoly and poverty and provide a broad-brush overview about good policy practices for innovation and highlight recent changes in innovation processes and patterns.

Some researchers apply the economic theory. Lauga and Ofek [2009] examine innovation in the context of duopoly (two competitors). Leflaive [2009] addresses policies that build demand for innovation in environmental areas in OECD countries, while evolutionary economists Malerba *et al.* [2007] link market structure to innovation through two key aspects of the market: experimental users, and diversity of buyer preferences. They use the framework of evolutionary economics, to model market behavior under introduction of new technologies (generally, disruptive technologies, in Christensen's terminology, which initially are inferior to established technologies but ultimately, improve so rapidly that they come to dominate). At times, new firms specializing in the disruptive technology prevail. At other times, established firms switch from old to new technologies and dominate. The model in their paper shows that in order for new firms to displace old ones, through new technology, a key role is played by "fringe markets" (markets not served well by the old technology) or "experimental users" (markets of customers eager to try new technologies, even those not yet perfected). The reason for the crucial importance of these two markets, for new firms, is that such firms generally cannot compete with established, incumbent firms. Fringe markets and experimental users give new firms sufficient time to survive and perfect new technologies, to the point where they are competitive with the old technologies. Lack of such markets implies the rapid disappearance of new firms, well before the disruptive technology is sufficiently strong to replace established technology.

Hansen and Birkinshaw [2006] explore the innovation value chain. They stress that in order to improve innovation, executives need to view the process of transforming ideas into commercial outputs as an integrated flow. They indicate three phases in the chain: generate ideas, convert ideas, or, more specifically, select ideas for funding and developing them into products or practices, and diffuse those products and practices. Consoli [2005] takes a long (1840–1990) perspective on the UK retail banking industry to show how three factors: technology developers, service suppliers and customers contribute to structural change in the industry. Mowery and Rosenberg [1979] provide researchers with an invaluable survey of empirical research on the link between market demand and innovation. They recommend that wise policies: (a) encourage interaction between users and producers, (b) interactive interaction between basic and applied researchers, and (c) focus on provision of information.

Michael Porter's landmark book on competitive strategy [1990] presents his famous five-forces model for market dynamics, and offers a theory of competitiveness based on the causes of productivity with which companies compete. Moving back to the sources raised by Schmookler [1966] and Schumpeter [1934], both provide sweeping book-length analyses of the role of inventions, and the role of innovation, respectively, in economic growth. Schumpeter places innovation at the focus of economic change, noting that economic change revolves around innovation, entrepreneurial activities, and market power. Schumpeter argued that innovation-originated market power (restraint of competition, in part through intellectual property) could create more economic value than Smith's "invisible hand" and price competition. According to Schumpeter, technological innovation often creates "temporary monopolies" which permit super-normal profits soon be competed away by rivals and imitators. Schumpeter's view, that capitalism is a process of creative destruction, was later echoed by management expert Peter Drucker, whose pioneering course on innovation at New York University was titled "innovation and destruction", reflecting the fact that some businesses and products must disappear if new ones are to appear.

The Market Dimension in the generic innovation ecosystem map (see Fig. 1) is inter-related to three key processes. Among them labeling and awareness, and lead market are also inter-related to the previous culture dimension and have been discussed above. The last process, cluster strategies, is also inter-related to the context and infrastructure dimension and is presented below.

3.1. *Cluster strategies*

One of the processes related to innovation is that of agglomeration, or creation of "clusters" of innovators in the same area, city or region. Lockett *et al.* [2009] study knowledge transfer from universities to small firms, in a regional context. They describe in detail the advantages that SMEs derive from a locale within a university. Quatraro [2009a] uses a Schumpeterian approach. He joins business cycles, "creative destruction" and growth retardation theory, to show how regions that engage in early industrialization advance faster toward a knowledge-based economy, compared with regions where industrialization occurs late. He shows that for Italian regions, innovation capabilities diffuse faster in late-industrialized regions than in early-industrialized ones [Quatraro (2009b)].

The production of knowledge and how knowledge production is organized industrially is a central issue in innovation. Many studies have shown extremely high social rates of return to investment in knowledge production, especially among universities. However, this categorical finding has been qualified, somewhat. Benhabib and Spiegel [1994] show that the high rate of return on investment in human capital is related less to its contribution to developing local innovation, and far more to the ability to adapt and employ foreign technology.

Concomitantly, knowledge production is the result of complex processes. Knowledge itself is complex, defined as "tacit" (unwritten) and "overt" (written), and "internal" (to the firm) or "external" [Antonelli (1999)]. The author describes four modes through which knowledge of all kinds is created: entrepreneurship, institutional variety, vertical integration and technological cooperation. Which mode is most efficient for society? Antonelli suggests that four key factors determine how efficient each mode of knowledge production is: the structure of incentives (such as the wealth that accrues to entrepreneurs); access to resources for knowledge production (as for large organizations with R&D budgets); private efficiency of knowledge production (the difference between private and social returns on investment in knowledge production); and connectivity among agents engaged in knowledge production (externalities and spillovers, the extent to which knowledge diffuses). Further, he uses the nature of the communication processes to explain how innovations cluster innovations in particular regions [Antonelli (2000)]. Recently, Antonelli and associates employed economic theory to explore these key aspects of innovation in the context of regions and clusters [Antonelli *et al.* (2011)]. They used the concept of monetized knowledge externalities to gain insights into the gains and the losses linked with the regional concentration of knowledge.

Boschma and Iammarino [2009] study regional growth as a function of two types of regional "variety" — "related variety", that is, diversity of products and industries all linked to one another, as a kind of "cluster", and "unrelated variety", diversity of products and industries without links or connections to one another. Prevailing theory suggests that variety strengthens regional growth through "spillover effects" between products and industries, as one firm builds innovation on the activities of another. Boschma and Iammarino distinguish between the two rather different types of "variety" and study the link between them and regional growth, for a number of Italian regions, during 1995–2003. Their findings show that "related variety" is positively associated with regional growth. However, "unrelated variety" does not contribute to regional growth. This strengthens the finding that clusters of firms working within related industries can successfully capture "spillovers" in their innovative activities.

Krafft [2004] proposes "a knowledge-based industrial dynamics", to explain how a cluster decreases barriers to knowledge on the part of clustered companies. A useful review of the literature on RSI's (regional systems of innovation), show (for the case of Italy) why historical perspectives are vital for understanding regional development [Iammarino (2005)]. Later, Iammarino and McCann [2006] integrate two approaches, that of transactions costs and of knowledge-based clusters, to explore the nature and evolution of "clusters".

4. Institution Dimension

Institutions are defined as durable systems of established and embedded social rules and conventions that structure social interactions. In other words, institutions are the "rules of the game" that define the context in which innovation occurs. Some institutions are defined precisely, as laws and regulations, while others are unwritten and tacit. Institutions play a key role in the initiation and evolution of innovation.

How regulation can impact the market for innovations? Regulation may be employed to spur technological change for health, safety, and environmental purposes as well as to implement a reconfiguration of the industrial process. In addition, regulation crucially shapes new markets for innovative products [Ashford *et al.* (1985); Blind (2004)]. Blumenthal [2010] provides a case study of regulation for electronic health records. Danzon and Epstein [2008] examine the important role of regulation in drug launches, analyzing data cover launch experience in 15 countries in EU for drugs that experienced significant innovation during 1992–2003. They found that both the timing of the launch, and the prices of innovative drugs, are affected by the prices of well-established existing products in the marketplace. So, if the regulation of drug prices lowers prices, it may contribute to delaying launches in the home country.

The study on "red tape", an enemy of innovation, and its role in delaying entry into a market, defined red tape as the collection or sequence of forms and procedures required to gain bureaucratic approval for something, especially when oppressively complex. The term originates with the red ribbons used by governments to bind documents [Ciccone and Papaioannou (2007)]. The study raised the question whether reducing bureaucratic red tape can encourage entrepreneurship and growth. The study examined 45 nations, using as a key independent variable the time between registering a new company and entry to market, across 28 different industries. As expected, among the main findings was the red tape in registering start-ups which caused countries to lag in reacting to global trends. The authors suggest that reduction in bureaucratic red tape could possibly come at the expense of workers' rights. They examine this contention and find it has no basis — workers' rights are not enhanced by "red tape", and protection of workers' rights does not slow growth.

Freeman's classic book [1974] provides comprehensive analysis of pro-innovation policies and regulations. In 1995, he published an overview on the national system of innovation from historical perspective and shows that historically there have been major differences between countries in the ways in which they have organized and sustained the development, introduction, improvement and diffusion of new products and processes within their national economies.

The Gallup Organization [2009] has an "Innobarometer" providing useful survey data on innovation. Their report focuses on innovation spending, on the role of innovation in public procurement tenders, the effects of public policies and private initiatives to boost innovation, and other strategic trends. It provides information on characteristics of innovative enterprises, innovative activities, and the role of R&D in innovation, innovation transfer and policy support for innovation. The role of intellectual property, as opposed to open (unpatented) innovation, is the topic of another study that shows that the corporate intellectual property portfolio constitutes a major determinant of opening up the innovation process [Lichtenthaler (2010)]. In 2005, Malerba takes an evolutionary perspective in analyzing industrial innovation. Evolutionary economics itself evolved from "institutional" economies, which stressed the role of rules, regulations and conventions. Sutton [1991] seeks to explain cross-industry differences in the degree of concentration, by a model that combines three key principles: "survivor" (firms do not pursue loss-making strategies), "arbitrage" (if an opportunity for profit exists, some firm will grab it), and "symmetry" (strategy pursued by a new entrant to a market depends neither on who the entrant is, nor what the entrant has done in other markets).

Taylor *et al.* [2005] show how regulation of sulfur dioxide emissions induced technological innovation in the US. They claim that both regulation itself, and even the anticipation of regulation, can spur invention. However, technology-push tools are far less effective at promoting invention than are demand-pull tools. Moreover, tight stringent regulations can guide inventive activity along well-defined technology paths.

One key process is inter-related to the Institution Dimension: development attractiveness in the private sectors (see Fig. 1). This key processes are also inter-related to the Culture Dimension, hence discussed above.

5. Context Dimension

The Context Dimension refers to the scientific, technological and physical infrastructure in which innovation thrives, with "infrastructure" broadly interpreted to mean any framework that relates to innovative activity. Several studies dealt with this issue. Dumas [2008] examines the link between research and innovation, terming it "alchemy" and stressing the need for "catalytic rather than controlling" government intervention. Feller *et al.* [2002] surveys how engineering research centers (ERC) sited in universities impact industrial innovation. Their study points to problematic continuation of industrial support for ERCs following the ending of National Science Foundation funding, when the maximum number of funding years under the program is reached.

Acworth [2008] in his paper on "knowledge integration community" (KIC) gives an excellent example of such "alchemy" which Dumas mentions. He coins the term (KIC) to describe the interesting ecosystem surrounding the Cambridge University (UK) and Massachusetts Institute of Technology (MIT, in the US) and concludes "it is something other university, government and industry-based research institutions could embark upon" (p. 1241). Under this approach, the two universities collaborated, through CMI (Cambridge–MIT Institute), to create what it called a KIC "Knowledge Integration Community". This approach arose when Cambridge University approached MIT and sought to learn why and how MIT has been uniquely successful in collaborating with industry. Starting in 2003, seven such experimental communities were built. These communities involved complex systems for exchange of knowledge between faculty and industry, processes for review of findings, structures for decision-making and management, and mechanisms for supporting joint research activities. The author offers an interesting case study of a project comprising one of the KICs, on the "Silent Aircraft" (an aircraft with vastly reduced noise levels, to overcome the problem of aircraft noise in urban airports). The conclusion is that the KIC model is one that other universities and countries could well adopt, after suitably adapting it for local conditions.

The Context is a major dimension in our generic innovation ecosystem map (see Fig. 1). This dimension is inter-related with four key processes: two demand-driven innovation processes and the remaining two with both supply-side and demand-side processes. Of the four key processes, demand attractiveness in the private sector and cluster strategies are also inter-related to the previous three dimensions that were discussed above. We now turn to describe the remaining inter-relations as depicted in our ecosystem in Fig. 1.

5.1. *Public–private cooperation*

One of the most important factors that accelerates innovation is the process in which public and private cooperation exists. This process often relates to the manner in which knowledge and technology are transferred from the public sector — perhaps, publicly-funded universities — to private-sector organizations, perhaps companies and start-ups. Allen *et al.* [1983] study such transfers and compare technology transfer to small manufacturing firms in three nations: Ireland, Italy and Spain. They found that all three nations developed reasonable technology bases in their universities and research institutions, but this system operates largely independent of the industries which it could potentially support. Audretsch *et al.* [2005] link technology "spillovers" to firm location. Based on dataset from German high technology start-up firms they found that new knowledge and technological-based firms have a high propensity to locate close to universities, presumably in order to access knowledge spillovers. A study on technology transfer in services in the UK has shown that "environmental pressures alone in a firm's selection environment are not sufficient to ensure receptivity to product service systems". The authors claim that "it is clear that that existing technological regimes/paradigms are not delivering the socially optimal solution for society in the light of the requirements for improved sustainability" [Cook *et al.* (2006, p. 1464)].

Empirical study of technology transfer in Spanish universities examines the role of university policy in the success of its technology transfer, using a Spanish database [Caldera and Debande (2010)]. In the study, technology transfer data is measured by three variables: R&D contracts between universities and industry, licensing of technologies, and creation of commercial firms (start-ups). The authors find that university technology transfer policies strongly influence success in technology transfer. Spanish universities that have science parks succeed better in technology transfer than universities without them.

A great deal of research on technology transfer has been focused on the Bayh–Dole Act and on its impact in America. This Act passed on Dec. 12 1980 by the US Congress gave US universities, small businesses and non-profit organizations intellectual property control of their inventions even when they resulted from public funding. The Act reversed the presumption that the government owns the inventions it funds and is widely thought to have stimulated a vast amount of entrepreneurial activity. But, Grimpe and Fier [2010] note that relatively little research has been done on "informal" technology transfer based on how university faculty interact with industry experts. The study by Grimpe and Fier focuses on a comparison of Germany and the US. In Germany, an Act similar to Bayh–Dole was passed in 2002. Using a sample of more than 800 university scientists in America and in Germany, the researchers find that the two countries are similar in how technology is transferred by person-to-person contact. Moreover, this important "informal technology transfer", in contrast to more formal licensing and collaborative agreements, is predicted by the extent to which faculty quality (promotions, etc.) is based on patent applications, at least in part, rather than solely on pure "publish or perish". The two researchers conclude with a rather dire warning — until universities in both the US and

Germany make "patents" an important criterion for academic achievement and promotion, their intellectual property will continue to leak "out the back door", through informal contacts between university faculty and their colleagues and friends working in industry.

Another interesting study that refers to public–private cooperation, presented in a paper by Frenkel and Shefer [2012], examines the factors that help and hinder technology transfer from universities to industry. The underlying motivation is that the enormous gap between basic research (universities) and product development (industries) is not being adequately closed. Part of the reason is that faced with shrinking revenues, universities battle to protect their intellectual property rigidly, which tends to deter industry from even attempting to exploit basic research findings. The researchers surveyed scholars in three Israeli universities — Hebrew University, Technion and Tel Aviv University. They found considerable openness among the scholars for engaging in collaboration with industry. Scholars do believe that collaboration with industry is part of the social obligations of university and those who do research within them. However, and against Grimpe and Fier's recommendation, in general they do not believe that collaboration with industry should be among the criteria for their academic promotions. They do believe that at times collaboration with industry forces them to compromise on the kinds of research they undertake, focusing on topics for which resources are available rather than those they are passionate about. The scholars recommend making university conditions for collaboration with industry — especially related to patents and royalties — more flexible, and recommend increasing the royalties accruing to researchers.

Another study focuses on Israeli R&D networks and defense conversion, in the context of Israel's national innovation system [Vekstein (1999)]. The author urges: "above all, to expand the concept of national security so as to include social and economic aspects at individual and collective levels" (p. 615). Another study focuses on US–Israel R&D cooperation employing data on American–Israeli research alliances in order to investigate the success of R&D projects [Bizan (2003)]. The findings have shown that such bi-national projects may contribute to the "success of research alliances by offering non-financial support. For example: "at the formation stage, R&D programs may be designed to assist collaborators to better integrate their project-related activities" (p. 1639). Dill [1995] studied technology transfer units' operation in American universities and their ties with industry and pointed to a number of individual and managerial variables such as: "years of experience, technical orientation, and frequency of managerial communication that were found to be significantly correlated with perceived unit performance" (p. 382).

In a similar manner, Chanan *et al.* [2009] explore alliances between local governments and colleges. They find that: "there is a general lack of appreciation among council staff of the value of collaboration with universities and vice versa"... (p. 111), while Chakrabarti and Dror [1994] research how US defense firms interact through patent citations. Collaboration across industrial sectors and between academic and government researchers in Australia was examined through interviews with participants from various Australian Cooperative Research Centers (CRC) [Garrett-Jones *et al.* (2005)]. The authors study how researchers reconcile the various requirements of their double role, as a government researcher or academic, and as a committed participant in an industry-collaborative research center. Their work suggests that Cooperative Research Centers develop their own identities, quite different from those of the participants (government and industry).

An interesting case study is the development of a hepatitis B vaccine in Korea, emerging from public–private collaboration [Mahony (2005)]. The author stresses that the most important factor to foster the development of products in developing countries is the creation of international procurement funds to bridge the gap between real needs and effective demand. Patzelt and Shepherd [2009] draw on academic entrepreneurs to help assess innovation policies and show that availability of financial resources increases academic entrepreneurs' perceptions that they can capitalize more on other, non-financial resources such as networks and business knowledge. Finally, an interesting comparison of the impact of government policies on new product development was done in four countries: US, UK, South Korea and Taiwan [Schoening *et al.* (1998)]. The findings show that in America and Britain, government policies do not have any direct effect on private sector's new product innovation activities. In contrast, the South Korean and Taiwanese governments have had an important impact in increasing their countries' new product innovation activities. They achieved this, by means of tax credits, direct and indirect grants, low interest loans, intellectual property regulations and other mechanisms.

With respect to university spin-off, Van Burg *et al.* [2008] choose to study creation of university spin-offs, as does Vincett [2010] who argued that the impacts of spin-off stemming from academic research show incremental contributions to Canadian GDP, a consequence that probably would not have been occurred without the academic research. Based on a case study of spin-off creation at a Dutch university, Van Burg *et al.* came to the conclusion that in order to build and increase capacity for creating spin-offs, universities should create strong awareness of entrepreneurial opportunities, support start-up teams, set clear supportive rules, and create a network of advisors, investors and managers (p. 123).

Finally, empirical studies have attempted to quantify knowledge transfers from academic research, through various proxies such as patents, spin-off activities and licensing of university innovations [e.g. Debackere and Veugelers (2005)]. The influence of geographical knowledge spillovers in the US was estimated by employing a three-equation model involving patenting, industrial R&D, and basic university research [Jaffe (1989)]. Using patents as a proxy for innovative output, the author examined the relationship between patents assigned to firms in 29 US states, industrial R&D, and university research. The results of the research demonstrate the existence of spillovers from university research and industrial patenting. University research was found to have a positive effect on industrial R&D, but not vice versa.

5.2. *Standards and standardization*

Standardization is the process through which a variety of innovative technologies gradually converge to a single well-defined one, generally through market forces, and standards, whether formally or informally defined, is the definition of the converged technology. Some studies explore various aspects of standards [Bryden (2010); OECD (2010c); UK Dept. of Trade (2005); Swann (2000)]. Their finding shows that surveys of innovating firms find that standards are a source of information that helps many enterprises in their innovation activities. Moreover, while many argue that regulations also constrain their innovation activities, these constraints do not necessarily prevent innovation.

In his study, Stango [2004] surveys the economic literature regarding standards and puts the question (p. 1) "Is public sector involvement in standard-setting justified?" His survey reveals that when there are "wars" between competing standards, the research literature reveals a conflict between those who find standards change too quickly, and those who believe standards change too slowly. Both can create inefficiencies. In either event, public sector involvement is indeed indicated. By using data from four European countries: UK, France, Germany and Italy and 12 sectors, Blind and Jungmittag [2008] confirm that both the stock of patents and the stock of technical standards were significantly linked with economic growth in the 1990s. They find that in more mature, less R&D-intensive sectors, existence of standards are significantly more important for growth to occur. In contrast, measures related to new knowledge (e.g. patent applications) are more relevant for growth, in sectors that have relatively high R&D intensity and make wider use of high technology.

Finally, to conclude the aspect of Standards and Standardization we note the UK Dept. of Trade Report [2005] which is based on various studies and counts five major ways in which standards might help innovation (p. 9): (a) Standardization helps to build focus, cohesion and critical mass in the formative stages of a market. (b) Standardization of measurements allows innovative producers to demonstrate to the satisfaction of the customer that products are as innovative as they claim to be. (c) Standardization codifies and diffuses state-of-the-art technology and best practice. (d) Open standards are desirable to enable a competitive process of innovation-led growth. (e) The report concludes that standardization is an essential part of the microeconomic infrastructure since it enables innovation and acts as a barrier to undesirable outcomes.

6. Summary and Conclusion

Innovation is widely regarded as an art, not a science. This follows from a popular definition of innovation — "breaking the rules to create value in novel ways". If innovation itself is breaking the rules, it would be internally contradictory to define such rigid rules for the innovation process.

The bulk of innovation and technology policies have been designed by relying on a supply-side perspective while the demand-side has long been neglected in innovation policy. Our review of the literature was tailored around generic structure of innovation ecosystems that we built. Through this process we identified the four major dimensions that foster innovation processes, among them processes that present the demand-side of innovation and highlight relevant issues. In our review, we introduced four demand-driven components igniting the innovation processes which are crucial for policy implications.

First, Market-Driven Forces were introduced as demand-side, interacting with the Culture Innovation dimension. Key terms such as "disruptive technologies" and "open innovation" systems show that market-driven forces tend to enhance the emergence of new markets, technologies and innovation processes. But market-driven forces are sometimes characterized by a kind of chaotic and unorganized management process, as when, for example, firms are required to kill their mainstream business in order to realize a new technology's full potential. Past experience shows that there is no one exceptional recipe for successful innovation processes, but rather a variety of mixtures related to diverse cultural contexts.

One insight, however, is clear here. The capitalist system underpins demand-driven forces, providing financial incentives to sometimes unclear technological trajectories. Under capitalism key aspects of demand are eminent, such as the prospect of new markets and information about user needs. Business networking in mitigating risks and enhancing access to new markets and technologies are most welcome in free markets, whose demand aspects sometimes coerce "routinization" of innovation at the organizational level.

But from the literature review, it seems that classical competition alone would not sustain the creation of new technologies or innovation paths. Rather, national policy, strict regulation and governmental procurement are most important in this context. National policy is essential, for example, in creating lead markets, which are pioneer markets in their particular industries, and are crucial apparatuses in generating exports and enhancing economic growth. Lead Markets is the second demand-driven component discussed, connected to the Market Dimension, while interacting simultaneously with the Cultural Innovation Dimension. It is not clear which key factors determine whether a country will be a leading market or a lagging market. Although some scholars tried to cope with this challenge by suggesting a set of factors, one thing is evident. Global firms are major players in benefitting from leading markets, as the latter act as beacons that illuminate the set of product characteristics that are most likely to succeed, thus reducing the risk of failure in new product launches.

The third demand-driven component is Demand Attractiveness (private sector), which is also bidirectional, and connected with Context and Culture Dimensions, concentrating on the firm's knowledge stock, mainly its R&D activity. The experience summarized here shows that the relationship between R&D stock and productivity is mostly positive. That is, the larger the proportion of R&D activity (whether it characterizes the government, a university or a private firm), the larger will be the impact on business intensity. Although this is most relevant to high-tech industry rather than other sectors, it is a key factor in the development of a variety of activities in the market. Spatial location in that context is well-documented, as agglomeration clusters (the fourth component) in the same area (city or region) act as a source of regional development contributing to the general welfare.

One prevailing theory in the "Cluster Strategies" aspect suggests that related variety strengthens regional economic growth through "spillover effects" between products and industries, as one firm builds innovation on the activities of another. In global markets, "distance is dead", it is claimed. But distance in this context is not "dead" at all, but lives when proximity enhances connectivity among agents which are working within related industries, capturing "spillovers' in their innovative activities. Factors involving the variety of knowledge, its geographical source and the nature and evolution of clusters are crucial in understanding regional systems as part of a general ecosystem of innovation.

But our literature review also introduced three components that represent both key demand and supply processes. These three elements are: Labeling and Awareness, Public–Private Cooperation and Standardization.

Labeling and Awareness which interacts both with Culture and Market Dimensions explores measures for educating and protecting consumers, without hampering the introduction of innovative products. This ethical aspect of market development and innovation processes is becoming more and more significant, as especially youngsters are evolving to be the focus of consumerism, and in cultural trends, in which the demand-side underpins modern and highly innovative economies. Education is a major aspect to be contended but there is no clear answer to which direction it should be taken. Though it is a confusing and complex theme, it seems that treading the fine line between critical consumerism and further consumption should be the goal of consumer education.

Another aspect of education in this key process of both demand and supply relates to higher education driven by universities and research institutions. It is labeled here as the Public–Private Cooperation. This ecosystem component interacts with the Context Innovation dimension, and concentrates on technology transfer from the public sector to the private one. In this regard, universities that represent publicly funded institutions are evolving to play a major role in the research of innovation. The relationship linking the private sector to universities is not trivial since the former are driven by their nature directed toward academic research and far less, if at all, to market satisfaction of demand. But the enormous innovative potential of universities (especially in the formation stage of an innovative process or product) has turned them to a main research theme, directed toward shaping more effective tools for public–private cooperation.

Initially, it is often asked whether geographical proximity benefits both universities and private firms. Though the literature shows mixed and indecisive results, it is obvious that both sides expect to reach a positive relationship, in order to enjoy reciprocal "spillovers". This expectation can be seen, for example, in the industrial parks being formed in many developed countries. However, this growing cooperation between private sector firms and public universities raises several issues that pose serious challenges. Some of them were reviewed here, with regard to intellectual property, the leakage of scientific knowledge and the sensitive topic of rewards, royalties and institutional loyalty of many scientists involved. It is found that university technology transfer policies can be a decisive factor in contending with these matters, and in guaranteeing successful technology transfer.

Innovation, whether its origin is in academe or elsewhere, must follow a standardization process in order to converge into a well-defined technology. Standards and Standardization is the third component that comprises a key aspect of both demand and supply. Standards are a source of information that helps many enterprises in their innovation activities. For instance, it helps them to build focus, cohesion and critical mass in the formative stages of a market. Standards and Standardization codifies and diffuses state-of-the-art technology and best practice, acting as an essential part of the microeconomic infrastructure that enables innovation on the one hand and reduces undesirable outcomes on the other.

This is perhaps as it should be. If there are indeed wide diversities in national innovation systems, then we should also find equally wide diversity in the battery of innovation policies that nations adopt. And we do find such diversity. One implication is that those engaged in research on innovation policy should regard the literature as a wide variety of social experiments that need to be carefully evaluated as far as possible under controlled circumstances, as Banerjee and Duflo have done in their study of policies to mitigate poverty, described in their path-breaking book: *Poor Economics* [2011]. The art and science of innovation policy is a work in progress, as this literature survey attests and proves.

Our review has also uncovered a key paradox in innovation policy. Demand-driven innovation policies permit maximum flexibility and resilience of market forces and remove bureaucratic regulations and red tape as far as possible. When questioned, entrepreneurs often say this is precisely what they seek. Supply-side innovation policies are the opposite and feature direct and indirect interventions by government agencies. Balancing such interventions, while creating open free-market entrepreneurship, is an art.

The validity of our literature review rests in part on the validity of the framework in which it is set (the generic innovation map shown in Fig. 1). This map is admittedly based on a limited subset of innovation ecosystems. But we have made a major effort to select polar opposites (Greater Toronto versus Shanghai Zhangjiang Science Park) and innovation systems on several continents. We based Fig. 1 on ecosystems that are driven primarily by government policy and intervention (Singapore), and ecosystems that are mainly market-driven (Israel). Hopefully, when new innovation ecosystem maps emerge for additional countries, we can re-evaluate Fig. 1, extend and improve it, and revisit our review of demand-driven innovation research.

A large theoretical and empirical literature on innovation policy exists. In this review, we have surveyed only a small sampling of it focusing on the demand-side of innovation that has long been neglected in the literature on innovation. Our findings reveal that each nation must adapt its arsenal of innovation policies to its own culture and history, learning from other nations and pioneering with its own experiments, building on what is known and at times, even, experimenting with what is not known. We wish to stress that our literature survey has not sought to critically evaluate the quality or sufficiency of theoretical and empirical research on demand-driven innovation or identify gaps in this research as, for instance, Bozeman [2000] has done for technology transfer. We seek to organize and integrate a very large literature on demand-driven innovation, within a comprehensible framework, to advance both future research and policy consensus across nations.

We conclude with a suggestion for future research. In our judgment, crucial innovation policies suffer from absence of a vital first step: reaching consensus on how the existing system, and policies, work. It is not unlike two mechanics asked to repair a vehicle, when one brings tools to repair a car and the other, tools to repair a bus. Perhaps, innovation scholars can improve and perfect our ecosystem methodology, with a view to beginning pragmatic policy debates with a consensus view on how existing innovation systems work, including the key anchors and processes and the feedback links among them. This could even contribute to better theory — e.g. by constructing empirical simulations of innovation ecosystems, in order to better identify "high impact levers", policies that can exert major positive influence on innovation. The two foundations of policy consensus are a common understanding of how innovation works along with a deep knowledge of the research foundations scholars have built. We have tried to make modest contributions to both.

Acknowledgment

The research leading to these results has received funding from the European Union Seventh Framework Programme FP7/2007-2013 under Grant Agreement No. SSH-CT-2010-266959.

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