# Knowledge, Technology and Innovation Flows across National Boundaries: Developing a Research Agenda

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## 1. Introduction

During, the past twenty years or so innovation emerged as the engine of economic growth in advanced market economies and beyond: seeking advantage in 'putting productive resources to uses hitherto untried in practice, and withdrawing them from the uses they have served so far' (Schumpeter, 1928, 378). The positive contribution of innovation in economic advancement is supported by a growing body of empirical evidence. More specifically, research shows that innovation (measured using various proxies such as levels of R&D intensity, patent activity and others) has significant positive effects on growth in real per capita GDP (OECD, 2003), multi factor productivity (Guellec and van Pottelsberghe de la Potterie, 2001), and productivity growth (Khan and Luintel, 2006).

Knowledge and technology are key enabling factors in the innovation process. At its most elementary the processes of innovation involve using existing knowledge, but often also require generating and acquiring new knowledge and this centrally involves learning. Innovation also involves sharing learned knowledge (Howells, 2002). It is also widely recognised in the literature that technology is a key determinant of innovation and economic performance. This is articulated best in the development studies literature. This shows that there are large technological differences (or gaps) between rich and poor countries. Therefore, engaging in technological catch-up (narrowing the technology gap) emerges as perhaps the most promising avenue that poor countries could follow for achieving long-run growth.

It seems safe to assume that the transfer of knowledge and technology is not a straightforward process across geographical boundaries (Fagerberg et al., 2009). It requires considerable effort and organisational and institutional change to succeed. This revolves primarily around the development of capabilities, including 'social capabilities' (Abramovitz, 1986), 'technological capabilities' (Kim, 1997), 'absorptive capacity of firms' (Cohen and Levintal, 1990) and the development of a strong 'innovation system' (Lundvall, 1992). Rather surprisingly, because of the growing importance of international and global integration (Ohmae, 1990) there is precious little research in this area.

Within this context, *Crossing Boundaries*[1] is setting out to explore how the processes and challenges of knowledge and technology transfer across national boundaries, affect innovation performance. In addressing this overarching aim Crossing Boundaries set out to examine four research objectives:

1. Who are the actors involved in the process of knowledge & technology transfer for the purposes of innovation across national boundaries?

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[1] The Working Paper is the result of collective effort. It was developed during the first project Workshop, organised in Tallinn in June 2013. Whilst the authors are identified it is attributed to the Crossing Boundaries community.

2. What are the processes of knowledge & technology transfer across national boundaries & how do these differ according to the actors involved?

3. How do contextual factors (such as institutional divergence, cultural differences & geographic distance) influence the processes of knowledge & technology transfer across national boundaries?

4. How do organisational factors (such as technological capabilities, & the absorptive capacity of the firm) influence the processes of knowledge & technology transfer across national boundaries?

The advancement of these objectives depends on the development of a clear understanding of the key concepts and flows under examination. This is particularly important as there is precious little agreement about the conceptualisation of knowledge, technology and innovation in the existing body of literature and an acknowledgment that though these concepts are different they also partially overlap. The extent of overlap depends on the scope/broadness of the concepts adopted. Therefore, this Working Paper sets out to introduce these concepts and discuss them particularly in light of the crossing boundaries theme. Challenging clear-cut conceptualisations of knowledge and technology, the paper sets out to examine their transfer across national boundaries, exploring implications for the globalisation of innovation.

The paper is organised as follows. The next section discusses conceptual issues around knowledge, and then focuses on the knowledge transfer literature (also examining proximate concepts such as knowledge exchange). Then it proceeds to explore the implications of Crossing Boundaries. A very similar structure is adopted regarding technology in the subsequent section of this paper. The fourth section explores competing understanding and manifestations of innovations. Key theoretical advances are also identified, whilst the Crossing Boundaries theme is advanced within the globalisation of innovation literature.

## 2. Knowledge

### 2.1. The Concept of Knowledge

There are numerous definitions of knowledge. Most of them agree that there is a distinction between data, information and knowledge. Commonly understood is that knowledge is a complex and almost boundless notion. Knowledge can be defined as "a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories, but also in organizational routines, processes, practices and norms." (Davenport and Prusak, 1998: 5). Nonaka and Takeuchi regard knowledge as "a dynamic human process of justifying personal belief toward the truth." (Nonaka and Takeuchi, 1995: 58). Sveiby describes knowledge as "dynamic, personal and distinctly different from data (discrete, unstructured symbols) and information (a medium for explicit communication). Since the dynamic properties of knowledge are most important for managers, the notion individual competence can be used as a fair synonym to a capacity-to-act." (Sveiby, 2001: 345).

**2.2. Knowledge types**

There are numerous typologies of knowledge. In general, it can be observed in economic literature that knowledge is distinguished in various pair-wise ways. The most used in the literature are the pair codified and non-codified (tacit) knowledge and the pair individual and collective (organisational) knowledge.

The first pair reflects an epistemological dimension (Lam, 2000). Both types of knowledge are directly linked and tacit knowledge is an indispensable component of explicit knowledge (Polanyi, 1966, 1985). Tacit knowledge can be seen as closely associated with skills and knowledge from experience (Nelson and Winter, 1982), practical intelligence and action-oriented (Sternberg et al., 2000, 1995), know-how (Wagner, 1987), it is context-dependent (Sternberg, 1994), includes both technical and cognitive elements (Nonaka and Takeuchi, 1997), and also a social dimension (Leonard and Insch, 2005). Codified knowledge can develop into information, when patents become available on the market or when they are widely communicated in publications.

The second pair reflects an ontological dimension (Lam, 2000). "Individual knowledge reflects individual experiences and constitutes the basis for the development of organizational knowledge. Organizational knowledge is embedded knowledge and comprises belief systems, collective memories, references and values" (Chini, 2005; cited in Thomas & Pretat, 2009). Individual knowledge is often non-codified. According to Spender (1998) and others in the strategy literature (Prahalad and Hamel, 1990) collective knowledge is a core competence and key to an organisation's success.

There are numerous typologies of knowledge in the literature. For example, Blackler (1995) categorises five types of organisational knowledge as:

- **Embrained knowledge** - conceptual skills and cognitive abilities
- **Embodied knowledge** - action oriented, contextual and non-explicit
- **Encultured knowledge** - shared cultural / social understandings
- **Embedded knowledge** - tacit, in systematic routines.
- **Encoded knowledge** - decontextualized into codes of practice; transmission, storage and interrogation of knowledge.

Also Lundvall and Johnson (1994) proposes a useful typology, distinguishing four types of knowledge:

- **Know-what**: information encoded as facts; this kind of knowledge is relevant in specific areas of expertise. It can be stored and provided to the company through consultancy, databases, etc;
- **Know-why**: involves the understanding of basic scientific principles, rules and ideas;
- **Know-how**: involves direct experience, capabilities and practical skills;
- **Know-who**: is specific and selective social knowledge, requiring contact between individuals, trust and the ability to communicate.

In general, the know-what and know-why can easily be formalized, written or reproduced as information encoded, while the know-how and know-who have a greater social dimension, being acquired in social contexts such as the workplace, meetings, conferences, etc. Thus, the latter two forms of knowledge have a strong tacit character.

**2.3. Knowledge production**

Economic literature considers that knowledge can be produced and accumulated and is subject to depreciation, like any other capital good (Soete, 2000, 2001). It also considers that investment in knowledge is cumulative and path dependent (Breschi et al., 2000; Rizzello, 2004). This suggests that new knowledge is created from the novel combination of existing knowledge (Fleming, 2001) and also that previous knowledge management capabilities (search for, access, transfer, absorb, and apply knowledge) influence the ability to create new knowledge (Nahapiet and Ghoshal, 1998).

Knowledge generation and accumulation occur in many forms (Metcalfe et al., 2006) and through the use of various sources (Ancori et al., 2000). In the organisational context, scholars typically distinguish between internal and external sources of knowledge, that is between own generation (for example via in-house R&D) and transfer (for example bought-in or R&D collaborations) (Frenz and Ietto-Gillies, 2009).

One useful perspective on this subject considers that knowledge is socially bound. An organization cannot create knowledge on its own; the organization is dependent on the individuals (Nonaka and Takeuchi, 1995). Beyond, there is another dimension that takes into account that new knowledge in an organization is also created by the combination of knowledge of the individuals. This refers to a creation of knowledge through social interactions within groups of people (Chini, 2005; cited in Thomas & Pretat, 2009).

From a social perspective, knowledge is also understood as constructed in the spaces *between* people and organisations. According to Nonaka et al (2002), "Knowledge is dynamic since it is created in social interactions amongst individuals and organisations. Knowledge is context specific as it is dependent on a particular time and space." The implications are that there is no single holder of knowledge (as truth). Instead, knowledge is tacit (Polyani, 1966; Nonaka, 1994). Working with knowledge in this sense means appreciating knowledge as a practice rather than a possession (Cook and Brown, 1999), negotiated and co-constructed, and produced through communities of practice. Communities of practice accumulate and develop new information through the sharing of knowledge (Nonaka, 1994). These communities of practice tend to develop their own rituals, practices, norms, and values (Von Krogh et al., 2000).

Trust is perceived to be a critical part of this knowledge production process, particularly in the transmission of tacit knowledge. Trust is not a simple concept. For example, Schindler and Thomas (1993) note five key dimensions of trust: integrity, competence, consistency, loyalty and openness. Levin and Cross (2004) also suggest that trust required differs according to the type of knowledge, proposing that benevolence based trust and competence based trust facilitate in different ways the exchange of tacit or explicit knowledge. For this reason, technology-transfer is challenging as private firms and research universities have profoundly different missions and often display mutual distrust (Slaughter and Leslie, 1997; cited in Bercovitz & Feldmann, 2006).

**2.4. The Concept of Knowledge Transfer**

There are many interconnected notions relating to the flow of knowledge. As cited in Locket et al. (2009) these include 'knowledge transfer' (RCUK 2006), 'knowledge exchange' (Schartinger et al., 2002; Swart and Henneberg, 2007), 'knowledge dialogue' (Ruddle, 2000), 'knowledge translation' (Czarniawska and Sevon, 1996; Savory, 2006), 'knowledge sharing' (de Man et al, 2008) and 'knowledge networks' (Huggins et al., 2011). There are multiple definitions of each.

**Knowledge transfer (KT)** could be defined as the use of expert knowledge, resources and services to support new knowledge creation or learning. Knowledge transfer can be said to take place both in the area of explicit and partially also in terms of tacit knowledge. E.g. published research findings constitute codified and explicit, formulated, available knowledge. But not all relevant information is codified in publications and the missing tacit knowledge must be obtained by face-to-face contact. Consequently, social contacts and informal communications became an important part in the process of commercializing universities knowledge (Audretsch and Stephan, 1996).

**Knowledge exchange (KE)** is generally considered to be more fluid and multidimensional than knowledge transfer. It embraces *learning* as well as research and avoids the narrow research—technology push. In many countries there has been a broad policy shift from 'knowledge transfer' to 'knowledge exchange'. In practices of KE, there is less focus on *what* is done, more on *how* it is done.

**Knowledge sharing** refers to "all knowledge processes that enable two or more organisations to access, transfer, integrate or develop knowledge together" (de Man et al, 2008: 8).

**Knowledge networks** can be defined as "a set of nodes - individuals or higher level collectives that serve as heterogeneously distributed repositories of knowledge and agents that search for, transmit, and create knowledge—interconnected by social relationships that enable and constrain nodes' efforts to acquire, transfer, and create knowledge" (Phelps et al., 2012: 117). This concept stresses the collaborative nature of knowledge production and diffusion.

For the purposes of this paper, the term *knowledge transfer* is used as an overarching term for various forms of knowledge diffusion. This is not to reject the nuanced differences between the above (or other associated) concepts but, like Locket et al. (2009), we have chosen to use the KT term as used predominantly in policy and funding to cover university—industry interaction.

However, knowledge transfer is the most widely used perspective in the literature. It assumes that knowledge is forwarded from one actor to another through the process of knowledge transfer (KT). As with knowledge more broadly there is a variety of definitions of KT. In a concise manner it can be said that KT is the process through which one network member is affected by the experience of another (Argote & Ingram, 2000). At its broadest level, the term KT refers to a push for the increase of interactions between universities, the economy, and society and for knowledge to be more 'useful'. However, more detailed definitions of KT are often both elusive and unsatisfactory, because of the multitude of meanings that can be attached to the individual words 'knowledge' and 'transfer' and the term 'knowledge transfer' itself (Wersun 2010).

KT can be characterised by different dimensions, like formal and informal transactions, research, educational and consulting activities, commercial and non-commercial objectives. It is difficult to value and appropriate, as there are transaction costs and spill-overs to other market actors. The contractual mechanisms used to transfer knowledge such as licensing agreements can be seen as market transactions. Although the terms of the transaction are mutually negotiated, however, the value of that knowledge is uncertain. Formal agreements are negotiated prior to the research being complete and the commercial value of the end results known. Thus, negotiations are based on estimates of the subjective expected value of that portion of the knowledge that a firm will be able to appropriate and it may entail a market failure as the contractual price may significantly differ from the social value. (Bercovitz & Feldmann, 2006). Another aspect of KT is that cooperation between universities and industry is characterized by "high uncertainty, high information asymmetries between partners, high transaction costs for knowledge exchanges requiring the presence of absorptive capacity, and high spill-overs to other market actors" (Veugelers and Cassiman, 2005).

In terms of transfer content, universities' relationships with industry are formed through a series of sequential transactions such as sponsored research, licenses, spin-off firms and the hiring of students. Scholars have tended to analyze formal mechanisms such as sponsored research agreements, licenses, or equity swaps when investigating technology transfer. This focus has been found to be too narrow as firm–industry interactions combine formal and informal interactions, and are influenced by firm strategy and industry characteristics, university policies as well as the structure of the technology transfer operations and the parameters defined by government policy. (Bercovitz & Feldmann, 2006).

Reflecting this, there has been a move in the literature away from a rational cognitive perspective on KT that focuses on these linear models, towards a perspective that understands KT as more socially constructed, in keeping with the discussions of knowledge above. Newell et al. (2002), for example, point to the dangers of seeing knowledge as a fixed entity in terms of information and data that can be transferred and 'stockpiled'. A broad critique of policy is that it limits KT to these fixed outputs, based on the success of high profile clusters, rather than embracing the processes through which clusters develop and knowledge creation/development is practised (Leydesdorff 2004). Tacit knowledge in particular – noted above as being of critical importance in areas of knowledge linked to know-how and know-who (and also as prerequisite for explicit knowledge production) - is not easily transferred. According to Duguid (2005) tacit knowledge has a 'sticky quality' around and between organisations making it difficult to communicate or transfer. This stickiness, in turn, is hindered where there is a lack of trust, control or support (Roos and von Krogh, 2002).

All-embracing definitions/characterisations of KT are increasingly accepted. Dosi (1982) and Bozeman (2000) have defined knowledge and technology transfer (KTT) activities more broadly: knowledge and technology transfer between academic institutions and the business sector is understood as any activities aimed at transferring knowledge or technology that may help either the company or the academic institute— depending on the direction of transfer—to further pursue its activities. According to this definition knowledge and technology transfer includes not only research activities (e.g. R&D cooperation projects, contract R&D when one partner is a university) but also informal acquisition and exchange of information (e.g. informal contacts, attending conferences), educational activities (e.g. joint PhDs, hiring scientists with new PhDs in firm R&D), joint technical infrastructure projects and consulting activities (cited in Arvanitis et al., 2011).

Policy documents from different countries emphasise the importance of benefits of KT for the public at large. In Australia, for example, knowledge transfer is seen as the process of engaging, for mutual benefit, with business, government or the community to generate, acquire, apply and make accessible the knowledge needed to enhance material, human, social and environmental wellbeing. Knowledge transfer for commercial benefit, on the other hand, is the process of engaging, for mutual benefit, with business or government to generate, acquire, apply and make accessible the knowledge needed to enhance the success of commercial enterprises. (PhillipsKPA Pty Ltd, 2006, p. vi). In the US, the American Association of State Colleges and Universities finds in its guidelines that there are inextricable linkages with the community which embrace a wide variety of activities. Public engagement is defined as 'direct, two-way interaction with communities and other external constituencies through the development, exchange, and application of knowledge, information, and expertise for mutual benefit' (American Association of State Colleges and Universities, 2002, p. 7). In the UK, these activities are considered to be the third stream of academic work and these "third stream activities are therefore concerned with the generation, use, application and exploitation of knowledge and other university capabilities outside academic environments. In other words, the Third Stream is about the interactions between universities and the rest of society" (Molas-Gallart et al., 2002:p. iii-iv). It follows that KT means the two-way transfer of ideas, research results, expertise or skills between one party and another that enables the creation of new knowledge and its use in: 1) the development of innovative new products, processes and/or services, 2) the development and implementation of public policy (Lockett et al., 2009).

In an attempt to operationalise the term KT, Cullen (2003) has developed the 'outreach to outcome framework' for KT. Cullen's framework is based on the view that universities sometimes act as an agent of local economic development (outreach) and sometimes as a 'venturer' to make financial returns and profit (outcome) (Table 1) (cited in Wersun, 2010).

**Table 1. The outreach to outcome framework**

| | Public good | Academic reasons | Profit |
|---|---|---|---|
| Student placements | Yes | ? | No |
| SME networks | Yes | ? | No |
| Consultancy | ? | Yes | ? |
| Contract research | No | Yes | Yes |
| Licences | No | No | Yes |
| Spin-outs | No | No | Yes |
| Licence to local company | Yes | No | No |
| Licence to global pharmaceutical company | No | No | Yes |
| Venture capital company formation | No | No | Yes |
| Student company formation | Yes | No | No |
| | Outreach ----------------- Outcome | | |

Source: Cullen, 2003, cited in Wersun, 2010.

The above discussion highlights notions of KT as a more engaged and multi-directional practice rather than a linear/sequential, one directional process – in turn based on different characterisations of knowledge itself. Missing from this is the subject of scale or geography, which will have implications for understanding the role of knowledge in innovation across national boundaries. While territory is not homogenous and may be considered a central component of innovation processes, in this project we will be focusing on the crossing of national boundaries rather than specific territorial dimensions although some aspects (for instance rurality) will be investigated as a context in one of the project's work packages.

**2.5 Implications for Crossing Boundaries**

Although most attention has been given to the concept of "national" innovation systems, it is clear that much innovation involves knowledge transfer and exchange across national borders (for example, within transnational enterprises or in the context of European Union research and technology programmes) (Mason & Wagner, 1999). Such transfer of knowledge is facilitated by Multi-National Corporations (MNC), Transnational organisations, International Joint Ventures (IJV), and international projects supported by governments, the United Nations, the European Commission and other national and international funding organisations (Duan et al., 2010). While all knowledge transfer faces some obstacles, cross-border KT faces extra challenges due to cross-cultural, political, economic, and geographical gaps. Knowledge sharing is often seen as resulting in a loss of power, and, as a result, knowledge that should be transferred is often withheld, leading to inefficiency.

There are different dimensions of proximity that include cognitive, organizational, social, institutional and geographical proximity (Boschma, 2005). Each relate to different parameters of how proximity in networks and crossing boundaries can be understood (Table 2).

**Table 2. Features of 5 forms of proximity**

| | **Key dimension** | **Too little proximity** | **Too much proximity** | **Possible solutions** |
|---|---|---|---|---|
| **Cognitive** | Knowledge gap | Misunderstanding | Lack of sources of novelty | Common knowledge base with diverse but complementary capabilities |
| **Organizational** | Control | Opportunism | Bureaucracy | Loosely coupled system |
| **Social** | Trust (based on social relations) | Opportunism | No economic rationale | Mixture of embedded and market relations |
| **Institutional** | Trust (based on common institutions) | Opportunism | Lock-in and inertia | Institutional checks and balances |
| **Geographical** | Distance | No spatial externalities | Lack of geographical openness | Mix of local 'buzz' and extra-local linkages |

Source: Boschma, 2005.

It has been found that if applicable knowledge is available locally, firms and other institutions will attempt to source and acquire it, if not they will look elsewhere (Kingsley and Malecki, 2004; Davenport, 2005; Huggins and Johnston, 2010). In addition, firms with higher absorptive capacity (ability to recognize, transfer and utilise knowledge) are often more connected to global networks (Drejer and Lund Vinding, 2007). The increased reliance on wider spatial knowledge pipelines is reflected by the growing number of firms choosing to work with the best universities regardless of location in order to take advantage of high talent pools, favourable intellectual property rules and government incentives for joint industry–university research (NSF, 2006; Polenske, 2007). However, there are often considerable differences in the capability of universities to effectively transfer their knowledge, and of firms to effectively absorb such knowledge (Di Gregorio and Shane, 2003; Lawton Smith and Bagchi-Sen, 2006; Perkmann and Walsh, 2007, cited in Huggins et al., 2011).

Given the nebulous and socially embedded nature of knowledge, the emphasis is more on knowledge transfer as a fluid, multi-directional process involving broad activities, actors and networks. As the changing landscape of knowledge exchange is increasingly less dependent on geographical proximity, international knowledge flows are affecting *who* and *how* knowledge is transferred and absorbed. The relationship between knowledge and technology is becoming increasingly inter-dependent in this process, which, ultimately, has implications for the incidence and character of innovation exploitation. How these dynamics are operating in relation to the use of technology (in particular information technology) by organisations operating within national boundaries and the *technology transfer across national boundaries* is considered in the next section.

## 3. Technology

### 3.1 The Concept of Technology

The concept of technology has been understood in different ways from different perspectives. Wahab et al. (2012) have produced a comprehensive paper that tracks the development and application of the different definitions of technology. They acknowledge the complexity of the term and its different definitions according to the different disciplinary approaches, a point also emphasized by Lan and Young (1996).

Technology is a collection of physical processes that transform inputs into outputs with procedural techniques and organisational arrangements for carrying out the transformation (Putranto et al., 2003). Technology has also been defined as technical knowledge that could also be associated with a machine, an electrical or mechanical components, a chemical process, software code, a patent, a technique, communication or a combination of different components (Omar et al., 2011: 328).

Examples of technology can be taken from the invention of fire and man's ability to control it, through to the invention of the wheel, the printing press, the telephone, the discovery of radioactivity and man's ability to enhance it for good (nuclear power and x-rays) or evil (the atom bomb). More recent technological developments include the internet and the consequent ability of the technology to inter-connect almost all organic inhabitants and inorganic 'things' on the planet into a collective 'internet of things' (Ashton, 2009). These examples demonstrate the complexity of technology that incorporates the elements of product, process and person operating as a socio-technical ecosystem. The generic term "technology" can also refer to a 'class of knowledge' for making a specific product and also a technical skill necessary to use a production technique and a product.

Institutionalist scholars have considered technology to be a dynamic force in the process of cultural evolution. They do not make functional distinction between 'technology' and science or 'tool' and 'skills' rather they consider them as a cumulative technological life process and of evolving potential, not one of the evolved technologies. Veblen (1908) used the concept of technology 'as knowledge' in a comprehensive way of understanding the material culture of a society. He argued that

> *"whenever a human community is met with [… ] it is found in possession of something in the way of a body of technological knowledge-knowledge serviceable and requisite to the quest of a livelihood comprising at least such elementary acquirements as language, the*

*use of fire, or of a cutting edge[… ]This information and proficiency in the ways and means of life vests in the groups, it is the product of the given group (Veblen, 1908: 519).*

From the above quotation it seems that technological knowledge can also be borrowed from other groups/communities. Thus, there is a transcultural aspect of the technological process that is not evident in other cultural phenomena. Veblen argued that the technological knowledge and the skills to use the tools there is a complete interdependence between the two during the process of technological development. However, Ayres argued that all skills are the part of culture- a body of core from which individual human beings learn whatever they learn in their life. But it is true that all technological behaviour patterns are objectified in tools, instruments, formulas and notations of many kinds; and that fact is vey important, for it is the basis of technological development (Ayres, 1953:282). Technological development is not the result of heroic effort or the genius ills of individual; it is rather the outcome of its inherent logic of development. Ayres argued that

*"since technology is objectified in physical tools and apparatus, it is always capable of progressive development. Every tool contains within itself, the possibility of being applied in new situation or different materials and in different ways from its historical use. This process is the universal pattern of invention and discovery (*Ayres, 1953:282*).*

Thus, Ayres added the 'tool combination principle' to the concept of technological development. He called this principle as a law of progress, which he explained to mean simply that as in a mathematical progression, each member of the series is derived from the preceding member by the same operation (Ayres, 1944, 119-20).

Technology has been defined from a utilitarian approach where technology is considered to be the process of accumulating knowledge, skills and procedures for the making, using and doing of useful things (Merril, 1968; Natarajan and Tan, 1992). Mumford (1996) made a distinction between 'tools' and 'machines' where the user directly manipulates tools, while machines are more independent of the skills of the users. Burgelman et al. (1996) consider technology to be the embodiment of people, materials, cognitive and physical processes facilities, machines and tools. While others focus on technology from a knowledge perspective where knowledge is accumulated and organized in a way to develop and apply tools, machines, materials and processes to solve human problems (Resiman, 2006).

However, the technological development does not require only the knowledge about the precise characteristics of the artifact, but also the social universe in which the artifact would function (Callon, 1986). Technological knowledge is unique and cannot be learned entirely from textbooks or briefings as its uniqueness is marked by its non-transferability and non-tradability (Gusterson, 1996: 156). This kind of 'tacit knowledge' can only be transferred by 'a person-to-person' sharing of technical and managerial experience, attitudes and viewpoints. It is believed that the more complex the technology, the more crucial is the favourable personal chemistry between transferor and recipient. Moreover, both need to be highly motivated for such exchanges (Shelp, 1984: 13-14).

Scientists working on a particular technology share a 'technical frame' (Bijker, 1995), which represents the meanings of technological system for the group members. Hence, transfer of technology involved the transfer of 'technological frame'- a whole way of looking at producing, selling and providing credit for goods. Technological frames, like paradigms, can begin with a research team pursuing a new technology or discovery. Knowledge of a new frame is usually distributed among a small network of innovators. These innovators form communities of interpretation (Brown & Duguid, 1999) in which they develop and collaborate to modify the shared mental model. Only such community of practice could translate a 'shared mental model' into a product.

For the purpose of achieving a common understanding for this project, technology can be broadly defined as:

> *a process of making, modifying, using, applying knowledge related to tools, machines, techniques, systems and methods of organization in order to solve a problem, achieve a goal or perform a function to affect human ability to control and adapt their environments.*

As has been established, technology is not a stand-alone entity but rather is a socio-technical system where transfer of technology is critical and often driven by national and international policies. For this project in particular, the transfer of technology across multi-national and cultural boundaries is especially important and needs conceptual definition.

### 3.2 The Concept of Technology Transfer

Technology transfer has been seen from different disciplinary perspectives: In management, technology transfer is seen as an 'intentional, goal oriented interaction' between two or more persons, group or organizations in order to exchange technological knowledge and / or artifacts and rights (Amesse and Cohendet, 2001: 1460). Since technology refers to a whole range of ideas, know how and logistics, the term technology transfer has become very complex. Before 1980s the idea of technology transfer was seen as a process of transferring the knowledge and technology from developed to less technically developed countries (William & Gibbons, 1990). The current emphasis is more on exchange of ideas, knowledge and technology across national and cultural boundaries. Technology is not a specific tool, artifact or product that is transferred from producers to users. In the context of research organization, technology transfer refers to the processes by which ideas, proofs or concept, and prototypes move from research stage to product development stage (Bozeman, 2000: 629).

Technology transfer could be understood in terms of three core processes: the introduction of new techniques by means of investment in new plants, the improvement of existing techniques and the generation of new knowledge (Hoffman and Girvan, 1990). Many scholars believe that technology and knowledge are so intertwined that any mention of one implies the other; technology is considered a form of knowledge since it  not only consist of machines and mechanical equipment but also comprises technical knowledge and operating skills.

That is why knowledge and technology transfer are considered as an interactive process with a great deal of back and forth exchange among individuals over an extended period of time (Gibson and Smilor, 1991). Sung and Gibson (2005) identified four levels of technology and knowledge transfers: Creation level, Sharing level, Implementation level and Commercialisation level. At each level there are four important factors that affect the process and result of knowledge and technology transfer across the boundaries. These factors are: Communication, Distance, Equivocality, and Motivation (Sung and Gibson, 2005).

Sahal (1981) defined technology as ‘configuration’, transfer of which must rely on a subjectively determined but special set of process and products. However, technology transfer could not be understood only by focusing on a particular ‘product’ because in the process of technology transfer, it is not merely the product that is transferred but also the knowledge of its use and application. From this perspective there is no difference between ‘knowledge transfer’ and ‘technology transfer’ (Sahal, 1982). Without the knowledge base the physical entity could not be put in practice.  Hyden (1992) suggested that technology transfer is nothing but the transfer of knowledge that can be used as inputs, such as patents right, scientific principles and R&D , but which must be able to  be used to make product. Technology transfer is a socio technical process that implies the transfer of cultural skills accompanying the movement of machinery, equipment and tools (Levin, 1993) from one organizational setting to another (Rossener, 1993). When a technological product is transferred, the knowledge upon which its composition is based is also transferred.

However, ‘technology transfer’ and ‘knowledge transfer’ are not the same thing, although some scholars used the these terms interchangeably (Levinson and Minoru, 1995; Oliver and Liebeskind,1998). In fact, technology transfer is much narrower construct than knowledge transfer (Allen, 1984; Corsten, 1987). Technology transfer refers to new tools, methodologies, processes, and products (Tornatzky and Fliescher, 1990) and, as such, is used primarily as an instrument for changing the environment. Knowledge transfer, on the other hand, is a broader concept, embodying comprehensive learning, reflected in the changes in the strategic thinking, culture, and problem-solving techniques used by a firm (Grants, 1996), as described in section 2. Therefore, the transfer of knowledge and the transfer of technology can be seen as two separate processes.

It has also been reported that different types of organizational structures and processes affect technology transfer and knowledge transfer activities differently. Moreover, the factors shaping the external and internal context of the firm also affect the transfer of knowledge as well as technology. The external context of a firm includes the prevailing conditions in a country that affect technological collaboration between universities and firms. The firm’s internal context refers to a firm's capacity to absorb the knowledge and technology transferred from other organizations.

The technology transfer process becomes smooth when there are conducive rules and policies allowing the regular interaction among scientists, technology transfer personnel and managers/administrators of the organizations (Oliver and Liebeskind, 1998). Such interaction, whether it is face-to-face or virtual helps over a period of time in the creation of 'communities of practice'. These tend to develop their own rules and practices, as mentioned in the section on knowledge.

Some scholars have also reported that 'mechanistic structures' and stable and direction oriented culture facilitate knowledge transfer activities more than they did for technology transfer activities. Similarly the 'flexible and change-oriented cultures' and more customized university policies for IPR, patent ownership, and licensing facilitate technology transfer across the organizational boundaries (Gopalakrishnan and Santoro, 2004). However, the trust between Universities and Industries are important for transfer of knowledge as well as technology because trust help cementing industry—university alliances (Pfeffer and Salancik, 1978; Smith, et al. 1995). But trust is a temporal phenomenon; a change in the leadership of university research centre, untrustworthy action by the university or availability of new partnership can quickly change the firm's level of trust in its university partner. Thus, the effect is of both knowledge transfer and technology transfer.

### 3.3 Implications for Crossing Boundaries

Sung and Gibson (2010) reported a range of factors that make the transfer of knowledge and technology across national boundaries successful (p.8): a high degree of interactive communication, a variety of incentives and recognition for transfer of knowledge and technology, cultural proximity among developers and users, and unambiguous nature of knowledge and technology and their application. However, the success of technology transfer depends on the absorptive capacity of the recipient firms, organizations or institutions (Sazali et al., 2009). The absorptive capacity of a firm is basically a function of the recipient firm's level of prior related knowledge which includes basic skills, a shared language, positive attitudes towards learning, relevant prior experience and up to date information on knowledge domain as all these are essential for an organization to assimilate and exploit new knowledge (cited in Sazali, et al., 2009).

Therefore, an organisation's absorptive capacity does not simply depend on the organization's direct interface with the external environment, but on the transfer of technology which include knowledge, skills and tools, across and within sub-organizations (Cohen and Levinthal, 1990). Information Communication Technologies (ICTs) have been very effective in bringing internationally dispersed R&D teams together and facilitating the transfer and sharing of codified knowledge. But ICTs have not been successful in transferring related sensory information, feelings, intuition and non-verbal communication that were important to the ultimate implementation of knowledge (Boutellier et al. 1998). Sanjay Lall (2000) also suggested that knowledge embodied in technology 'can be used at best practice level only if (it is) complemented by a number of tacit elements that have to be developed locally.

ICTs bring to the fore a second element to consider for investigation in the relationship between technological capabilities and innovation systems across national boundaries: the identification of a specific technology (one of the drivers of the 5th Long Wave of Techno-Economic development (1960-2020) (Lynch, 2003) that crosses multi-national boundaries and becomes a relatively standard technological platform) that itself facilitates access to other technologies. By enabling "social integration capacity" (Joshi et al., 2010), ICTs can provide a capability to help augment firms' social capital and support direct interactions among actors (Srivardhana, Pawlowski, 2007).

ICT capabilities have been broadly and consistently defined as a combination of ICT-based assets and routines that 'support business conduct in value adding ways' (Sambamurthy & Zmud, 2000; King, 2003; Chang & King, 2005; Ravichandran & Lertwongsatien, 2005). Many studies have investigated the effect of IT on firms' performance and the majority of them conclude that IT has a direct and positive effect on a firm's performance and its competitive advantage (Wade and Hulland, 2004; Pavlou and El Sawy, 2006). Fink's (2011, p. 18) classification of ICT capabilities, which included IT human capabilities (technical, behavioural, business) and ICT infrastructure capabilities (physical, managerial) are particularly relevant in this case. Combined with organizational capabilities, ICT can then lead to the development of electronic networks of alliances that can facilitate knowledge integration and ultimately innovation. However, the links between ICT capabilities and innovation and/or innovative projects across national boundaries are rare and will be a rich area of investigation in this project.

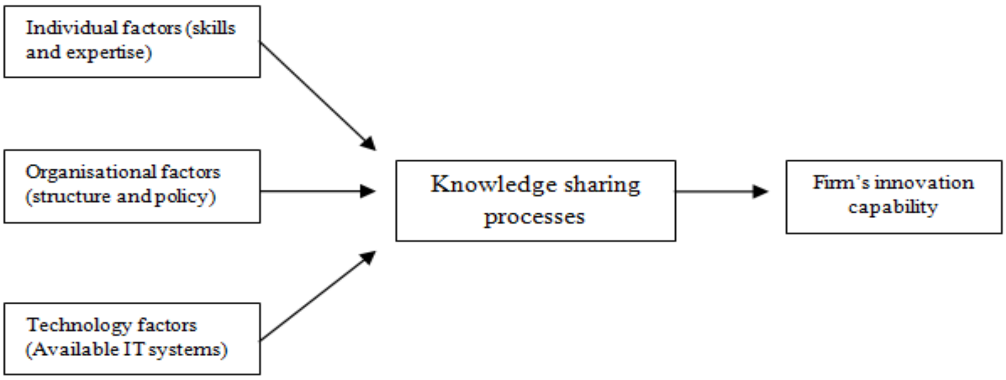
As the range of information (communication) technologies have developed, we use the term digital technologies to incorporate the additional technology (including mobile). Consequently, we will be building the concept of digital capabilities, which is adapted from the term ICT capabilities widely used in information systems literature. The term has already been used by public entities. In the UK, the term digital capabilities has been used in its digital strategy policies to define the internal government departments to be able to interact digitally by sharing information and data. MIT and CapGemini (George Westerman, Didier Bonnet and Andrew McAfee, 2012) have also used the term very specifically to define a:

- Unified digital platform: *a digital platform of appropriately integrated data and processes.*
- Solution delivery: *the ability to modify their processes or build new methods onto the data and process platform. Such solution delivery requires effective methods and strong skills.*
- Analytics capabilities: *Combining integrated data with powerful analysis tools is seen as a way to gain strategic advantage over competitors.*
- Business & IT integration: *With trust and shared understanding where IT executives can help business executives meet their goals, and are willing to be flexible in creating new governance mechanisms or digital units without feeling threatened.*

Digital capabilities will be further defined in this project as a catalyst for innovation or as a means of developing strategic policies for being able to compete in the digital age. Thus for this project, there is a need to develop a new concept around digital capabilities that incorporates the capabilities that are required to enhance and capitalise on the digital technology/ies that currently prevail.

This section has established the importance of technology – both in terms of technology transfer and also as a unit of analysis that enables knowledge sharing, transfer and innovation. Hsui (2007) identified the relationship between these three broad actors and their inter-relationships (illustrated in figure 1) highlighting the connection between knowledge sharing enablers (human, organization and technology) and a firm's innovative capability, focusing on the function of technology as a key part of these processes.

**Figure 1. A general framework for understanding the relationship between knowledge, technology and innovation at the firm level**.




Adapted from Hsiu (2007)

The *Crossing Boundaries* project focuses on the connection between knowledge, technology and innovation processes and flows across national boundaries. The next section will draw out in more detail an understanding of innovation and its processes and the implications of knowledge and technology flows across boundaries for globalization of innovation.

## 4. Innovation

### 4.1 The Concept of Innovation and the Schumpeterian Divide

Innovation is invariably perceived as one of the means by which firms can enhance their competitiveness and improve their performance (Akçomak and ter Weel, 2009). However, its definition (like those of knowledge and technology) is far from clear. In a rather narrow definition Schmookler (1966) associates innovation with the first enterprise to produce a good or service, or use a new method or input, whilst all subsequent firms that do the same thing are deemed as imitators. However, the boundaries between innovation and imitation are blurred as imitators in their pursuit of the leader may do things differently (in many instances intentionally so as to gain competitive advantage) from the way they were done by the first firm (Hall, 1994). In a much broader definition Brown-Kamn (1987) identifies innovation with the process of generating ideas that are new to their source and making decisions about these ideas that result in something useful.

Probably the most influential scholar in the field of innovation studies is Joseph Schumpeter. His definition of innovation focuses on the introduction of new combinations: i.e. the introduction of a new product or new quality of product, a new method of production, a new market, the conquest of a new source of raw materials; the creation of a new type of industrial organisation. However, there is an interesting divide in his works that is reflected in contemporary research in the field. In the *Theory of Economic Development* (1934 [original 1912]), he emphasised the role of entrepreneurship for novel value-generating activities which would expand (and transform) the circular flow of income. Drawing from Say's tripartite division of labour Schumpeter identifies a clear division between invention and entrepreneurship: the latter being the remit of economic agents who get things done (Say's application) whilst the former of those engaged with the production of new (scientific) ideas (Say's abstract labour). The ideas generated by inventors are not by themselves of any importance for economic activity (Schumpeter uses the example of ancient Greeks, who had produced all that is necessary to create a steam engine but actually did not build one), whilst not all innovations need to embody something that is scientifically new (Schumpeter, 1947). In some cases invention and entrepreneurship are combined within the same economic agent, however, they remain distinct analytical categories. Nevertheless, for many types of early Schumpeterian combinations, leading to significant economic gains, 'inventions' rarely exist.

Later works of Joseph Schumpeter (1942) however, advance the notion that large firms provide a more stable platform to invest in research and development and that perfect competition is not necessarily the most efficient market structure to promote R&D. The Schumpeterian view that large firms and concentrated market structures promote innovation is the subject of a voluminous theoretical and empirical literature. Penrose (1959) identified herself clearly with the later works of Schumpeter: focusing on productive experimentation and novel creativity, rather than in coordination, exchange and market power. She focused on innovation as the source of profits, which would be achieved through learning to develop new applications of the current resource base of the firm, as opposed to profits due to the market positioning of the firm or the rents achieved through market power. Since innovation is rooted principally in internal learning within the firm, technological competence evolves gradually and changes much less dramatically than the composition of downstream products or markets. Penrose claimed that each successful firm had a continuity which was provided by its capabilities or resources.

### 4.2 Innovation in Different Empirical Contexts

The implications of diversity in the conceptualisation of innovation can be shown readily through empirical illustrations from different empirical contexts. In this paper we will focus on innovation in rural areas and innovation in the informal sector.

One commonly identified innovation within the former context revolves around organic farming: 'an innovative way of envisioning and practicing agriculture... It does not affect production techniques exclusively, it rather influences farm management in its entirety' (Pugliese, 2001). The emphasis here is on changes in the processes and management of agriculture, and an elimination of technological innovations. However, activities that could be viewed as invention (and R & D) are used in this context. Not very dissimilar are 'traditiovations', defined 'as those expressions of forms of integration of informal local knowledge and formal scientific information generated locally linked to local traditions and history' (Cannarella and Piccioni, 2011). A totally different illustration emerges in the case of indigenous innovation described by Uddin (2006) as 'due to farmer-artisan interaction the local blacksmiths could … start producing blades' (Uddin, 2006). The element of novelty in this setting is very localized: i.e. including something that existed for a long-time but introduced (without any incremental changes) by a new producer, whilst the emphasis is on the role of entrepreneurs in creating new, value-generating, activities. A similar illustration of a localized solution, but different in terms of the value being generated and used solely by a user is provided by Glover (2012) who quotes a rural inhabitant: 'I use a shower scraper to clean the window on the old ford4000 as the window wipers no longer exist'.

Despite a phenomenal growth in the literature on innovation in recent years, innovative activities in the informal sector have remained outside the scope of academic research as well as policy discussion. Two terms that have appeared to represent the notion of informal sector innovations are '*jugaad*' (which literally means collection of, or obtaining, something through search and effort) and 'grassroot innovation'. For Birtchnell (2011), *jugaad* refers to improvised vehicles assembled by hand from carts, old cars, and spare parts used by Indian farmers. Heeks (2009), in a report to the Organisation for Economic Co-operation and Development (OECD), identifies its characters and argues that *jugaad* innovations are "lower in price, lower in capital, lower in skill intensity, make greater use of local material, and are more adaptable to sporadic availability. In sum, they close the 'design-reality gaps' that other innovations suffer, and demonstrate that poverty can drive innovation (p.51)." Successful *jugaad* requires alertness of mind, knowledge about existing possibilities available in the immediate environment, and a dedication to solve every problem one confronts in his business/surroundings.

In comparison to '*jugaad'*, 'grassroot innovation' is a relatively newer term, but has received major attention among academic scholars and policy makers in India and elsewhere. Such innovations are outcomes of efforts to solve long persisting (at times, suddenly emerged) problems at the local level. These problems are diverse in nature, such as agriculture related problems (new seed, new technology for harvesting, new methods of agriculture), agriculture allied activities related problems (e.g. processing technology, equipment used in the activities), daily life problems (e.g. washing cum exercise machine, sanitary napkins), hardship faced by family members (e.g. Pochampalli sari making machine), problems of differently abled persons (mobility equipment) and problems of electricity and water. For Gupta (2011) such efforts demonstrate an "inverted model of innovation". Furthermore, Hanna (2010) characterises such innovations as "simple, low cost, easy to apply, and replicate, and such products have large social impacts on the livelihood of the marginalised (p. 212)." Often, many grassroot innovations are not made for markets, but they respond to the gaps market may have created. Thus, neither the motive to enhance private property, nor accumulation of capital that motivates mainstream innovations seems to be the prime driver of grassroot innovations.

This Section does not only reiterate key conceptual issues identified earlier: such as how new is new (is the revival of traditional techniques innovative) and to what extent does innovation rest with invention or new value-generating activities? It poses questions around the focus of value generating activities: i.e. do they derive from the solution (see Glover) or the exploitation of the solution (Udin)? And what about innovations that respond to gaps created by the markets but are not made by the markets (such as grassroots innovations)?

### 4.3 External Influences on Innovation: Learning, Systems and Beyond

*4.3.1 Innovation and Learning*

Firms' learning may be linked to knowledge developed *internally* to the firm in activities such as production and R&D or sourced *externally* by the firm through its interactions with other firms operating in the same industry, with suppliers and/or customers as well as from science and technology advancements. The firm's internal learning understood as a collective process in the sense that individual contributions to advances in learning are developed through interactions among firms' workers (Pin & Santangeno, 2002). The introduction of specific innovation types (namely incremental and radical innovations) shows specific patterns of R&D organisation and employees' competences as a result of different underlying learning processes (Pin & Santangeno, 2002). Drawing on Malerba (1992), it can be distinguished in three types of internal learning processes according to different sources and types of knowledge: 1) *learning by doing* related to production activity, 2) *learning by using* related to the use of products, machinery and inputs, and 3) *learning by searching* mainly related to formalised activities (i.e. R&D) aimed at generating new knowledge. If the first type of learning dates back to Arrow's (1962) seminal work, other scholars (i.e. David, 1975, Rosenberg, 1976) have emphasised its cumulative character. Similarly, cumulative effects of learning by using and learning by searching have been extensively acknowledged (i.e. Rosenberg (1982), and Nelson and Winter (1982) and Dosi (1988).

An interactive view of innovation (focusing on R & D externally sourced) has been developed within the framework of a learning economy, in which innovation is seen as a technical and social process based on the complex interaction between firms and their environment (Asheim and Isaksen 1997). Within this context, new models of innovation highlight the interactive character of the innovation process, suggesting that innovators rely heavily on their interaction with lead users, suppliers, universities and other research organisations, venture capitalists, government and with a range of institutions inside the innovation system (Lundvall, 1992; Brown and

Eisenhardt, 1995; Szulanski, 1996). These organisations generate and exchange knowledge, financial capital, and other resources in networks in relationships that are embedded in institutional networks at the local, regional, national and international level (Beckman ja Berry, 2007; Belussi, McDonald, and Borrás 2002; Svetina & Prodan, 2008; Mierlo et a 2010). The interaction between stakeholders in an innovation process is regarded as an interactive learning process in which the wishes and expectations on the one side and the possibilities on the other may align the network of involved stakeholders, possibly leading to a successful innovation or to reduced uncertainty about future developments (Vandeberg, Boon & Moors 2005).

Firm's in-house expertise for R&D has a considerable positive effect on the absorptive capacity of firms. This means that continuous improvements in its internal knowledge base are also important for increasing a firm's capability to assimilate and transform external knowledge and information into new products, services, and processes. As firms' learning capacity is context dependent on the institutional set-up of its business environment (Lorenzen 1998; Tomassini and Sarcina 2005), cultural, social, and organizational proximity (Lundvall 1992; Belussi and Pilotti 2000; Steiner 2006) are also influencing factors. It has been concluded that internal learning and interactive learning with firms and institutions in a wider business environment mutually reinforce each other and bring optimal results in terms of innovation performance (e.g. Love and Mansury, 2007; Svetina & Prodan, 2008) that verify the importance of external sources and imply that innovations come from a number of sources and develop in a number of ways (Willoughby and Galvin 2005).

Openness in terms of external linkages generates learning effects, which enable firms to generate more innovation outputs from any given breadth of external linkages. Such activities are likely to be subject to a learning process, as firms learn which knowledge sources and collaborative linkages are most useful to their particular needs, and which partnerships are most effective in delivering innovation performance *(*Love, Roper Vahter 2013). Sources of innovation are commonly found in the interstices between firms, universities, research laboratories, suppliers, and customers (Powell, 1990). Consequently, the degree to which firms learn about new opportunities is a function of the extent of their participation in such activities (Levinthal and March, 1994). Brown and Duguid (1991: 48).

*4.3.2 Systemic Approaches to Innovation*

The main idea of the concept of innovation systems is that the overall innovation performance of an economy depends not only on how specific organizations like firms and research institutes perform, but also on how they interact with each other and with the government sector in knowledge production and distribution (Gregersen 1996). Innovating firms operate within a common institutional set-up and they jointly depend on, contribute to and utilize a common knowledge infrastructure. For system innovation, actors need to change not only their own current thinking and practices, but also their practices vis-à-vis each other and underlying social institutions (Mierlo et al 2010). Technical, organizational, and institutional diversity in the economy affects and feeds interactive learning that creates and distributes new knowledge subject to different kinds of selection.

In interactive innovation processes both demand and supply of knowledge and technology play a role (Mowery and Rosenberg, 1979); Nelson and Winter describe it as a "backing and forthing" between the demand and supply side in the selection environment (Smits and Kuhlmann, 2004; Blume, 1992). In such iterative process, innovation is the result of the combination of a heterogeneous set of actors, the relations between them and the institutional surrounding. These components form the *Innovation System* (IS). This "systems of innovation" approach was introduced by Freeman (1987), Lundvall (1992), Nelson (1993) and Edquist (1997). Although the definitions differ from each other; however, they all encompass the same elements: a network of stakeholders; interactions between the stakeholders in which knowledge and information is transferred; institutions; and a 'purpose' (i.e. innovation success, reduction of uncertainty, economic growth and welfare) of the Innovation System. The activities in the IS can be described as *learning activities*, where users have their particular role and interactions in the innovation process. The concepts of knowledge and learning are important in all the different contributions to the analysis of innovation systems. In Lundvall (1992) it was proposed that ''the most fundamental resource in the modern economy is knowledge and, accordingly, the most important process is learning''.

Other contributions referring to systems and operating at the national level refer to ''social systems of innovation'' (Amable et al., 1997), ''national business systems'' (Whitley, 1994), ''technological systems'' (Carlsson and Stankiewicz, 1995), ''regional systems of innovation'' (Cooke, 1996; Maskell and Malmberg, 1997) and ''sectoral systems of innovation'' (Breschi and Malerba, 1997). Some of the crucial ideas inherent in the innovation system concept (on vertical interaction and innovation as an interactive process) appear in Porter's industrial clusters as well as in Etzkowitz and Leydesdorff's Triple Helix concept (Etzkowitz and Leydesdorff, 2000).

In a dynamic context this means that we need to understand systems as being complex and characterized by co-evolution and self-organizing (Lundvall 2007). For the innovation system as a whole, in the short and medium term, it is important for performance that there are effective interactions between firms and the knowledge infrastructure. In the long run it is important that the knowledge infrastructure is allowed (stimulated) to evolve with the population of firms but also with some autonomy so that it can give rise to radically new technologies. The interaction and communication are key both within the population of firms and between firms and knowledge infrastructure. A key to understand interaction and communication is to make a distinction between knowledge transfer and learning through respectively information flows (codified knowledge exchange) and body–body contact (tacit knowledge exchange). A key difference between firms, sectors, regional and national systems is the role played by respectively codified knowledge and tacit knowledge in the innovation process (Lundvall 2007).

### *4.3.3 Open Innovation*

Research regarding the interactive, distributed, and open nature of innovation can be seen in Chesbrough's 'open innovation' model (Chesbrough, 2003a, 2003b). This model suggests that the advantages that firms gain from internal R&D expenditure have declined. Accordingly, many innovative firms are able to successfully innovate by drawing in knowledge and expertise from a wide range of external sources. Chesbrough argues that open innovators commercialize external ideas by deploying outside (as well as in-house) pathways to the market (Chesbrough, 2003b). This process redefines the boundary between the firm and its surrounding environment, making the firm more porous and embedded in loosely coupled networks of different actors, collectively and individually working toward commercializing new knowledge.

### 4.4 Innovation and Crossing Boundaries

The increased importance of contextual influences (such as systemic views and open innovation) was combined with changes in the real world that opened up the scope for research into innovation across national boundaries. More specifically, low cost and global proliferation of ICTs enabled more open and distributed innovation processes (Serger and Wise, 2010). Increased internationalization of science through rapidly growing numbers of international co-publications, cross-border patenting, and human (scientific) capital mobility (OECD, 2008), alongside offshoring of corporate R & D facilities (Karlsson et al, 2006) enable the emergence of global innovation networks. Within these, the value chain is broken up and research, innovation and production do not occur necessarily in the same geographic location (Serger and Wise, 2010). Lastly, the nature of the challenges currently confronting the world (that could be overcome through the introduction of innovative solutions) is becoming increasingly global (in the sense that they transcend national boundaries). Climate change, pollution, natural resource depletion, and potential pandemics require resources that are international in nature – and offer opportunities at a global scale. There is a considerable body of empirical evidence supporting the global character of the exploitation of innovation and the collaboration of innovation (Chesnais, 1988; Gugler and Dunning, 1993; Hagerdoorn and Schakenraad, 1990; Lukkonen et al., 1993).

The handful of studies exploring the cross border innovation advance differential taxonomies. In a suggestive contribution Archibugi and Iammarino (2002) identify three main types of cross border innovation (see Table 3 below). The first comprises the international exploitation (or diffusion) of innovations developed within a defined geographic setting: attained through exports of innovative goods, cession of licenses and patents, and foreign production of innovative goods developed nationally. The second comprises the generation of innovations across national boundaries: through R&D and innovative activities taking place in different countries, the acquisition of existing R&D facilities or greenfield R&D activities in different countries. The third revolves around global technological and scientific collaborations occurring either between universities (i.e. joint projects, staff and student visits) or enterprises (joint ventures). Interestingly, this taxonomy does not include collaborations between different types of actors (i.e. between universities and enterprises) across national boundaries. Moreover, the typology focuses heavily on multinational corporations at the expense of networks of smaller firms. These three types of cross-border innovation can be viewed as the outcome of two different strategies: asset exploiting and asset seeking (Castellani and Zanfei, 2006; Dunning and Lundan, 2009).

**Table 3. Taxonomy of cross-border innovation**

| Categories | Actors | Forms |
|---|---|---|
| International exploitation of nationally-produced innovations | Profit seeking firms and individuals | Exports of innovative goods<br>Cession of licenses and patents<br>Foreign production of innovative goods internally developed |
| Global generation of innovations | Multinational corporations | R & D and innovative activities both at home and internationally<br>Acquisitions of existing R & D facilities<br>Greenfield R & D investments |
| Global techno-scientific collaborations | Universities and public research centres<br>National and multinational firms | Joint research projects<br>Staff and student visits<br>Joint ventures for specific projects<br>Productive agreements with exchange of technical information |

Source: modified from Archibugi and Iammarino (2002).

A more inclusive and abstract taxonomy emerged from Platon plus (2009). This comprises of three types: i) buying or selling technology from the global technology market (e.g. licensing or outsourcing R&D), ii) collaboration between businesses and universities, and iii) off-shoring own R&D activities by MNEs in their foreign subsidiaries located elsewhere in the world.

More recently, from a developing country point of view, Plechero and Chaminade (2013) identify three different modes of globalisation of innovation: the global sourcing of technology, the global collaboration in research projects and the global exploitation of innovation activities. These three modes of globalisation of innovation point to a certain direction of the knowledge flow: from firms in the developing country region to the rest of the world, from firms in the rest of the world to the region, and bidirectional cross-border knowledge flows involving firms in the developing country region and firms and organisations in the rest of the world.

The taxonomies developed in the globalization of innovation literature are undoubtedly linked with late Schumpeterian views regarding the conceptualization: more closely linked to R & D activities rather than their commercial exploitation. Thus, if implemented in their original form in the *CrossingBoundaries* project they would exclude many of the illustrations of innovation identified in the rural and informal economy context: as for example traditiovations, or indigenous innovations and *jugaad* rarely – if ever – involve explicit R & D investments. Innovations of this type remain hidden from existing research on the globalization of innovation.

Another implication of the views prevailing in the globalization of innovation literature is the emphasis placed on multinational corporations feature, at the expense of smaller, entrepreneurial ventures. This is because, whilst the importance of different actors is acknowledged, the emphasis is invariably placed on linkages among the same type of actor (for example between universities) rather than between different types of actors.

## 5. Emerging Analytical Instruments and Research Agenda

### *5.1 Analytical Instruments*

The previous Section began with diverse conceptualisations of innovation and the identification of the Schumpeterian divide (i.e. the relative divergence between his early and late views) and concluded with a discussion of the globalization of innovation literature, and its shortcomings. Our point of departure in this Section is the use of early Schumpeterian views in order to overcome the narrow conceptualisation of innovation (closely linked with R & D activities) and the relative neglect of different types of actors. This is attained through the development of a more complex taxonomy of innovation crossing boundaries (see Table 4). Two categories are identified using early Schumpeterian views: whereby the emphasis is on novel value generating activities (invariably driven by entrepreneurial actors). The first comprises the global exploitation of nationally produced inventions, and has been explored fairly extensively in the context of the international business and international entrepreneurship literature. However, much less attention has been paid in innovations linked to the flow of technologies across national boundaries (that may occur in an informal context setting - such as some of the grassroot innovations discussed earlier in the paper). This paper also advances the notion of global exploitation of globally produced new value generating activities – that may for example be particularly relevant in rural contexts (where both local knowledge and technology inputs as well as output markets may be constrained). The taxonomy advanced here also includes the two existing categories advanced by Archibugi and Iammarino (2002) that are linked with late Schumpeterian views: global techno-scientific collaborations and global generation of inventions. However, it also introduces on novel form of global techno-scientific collaboration revolving around university-industry knowledge transfer.

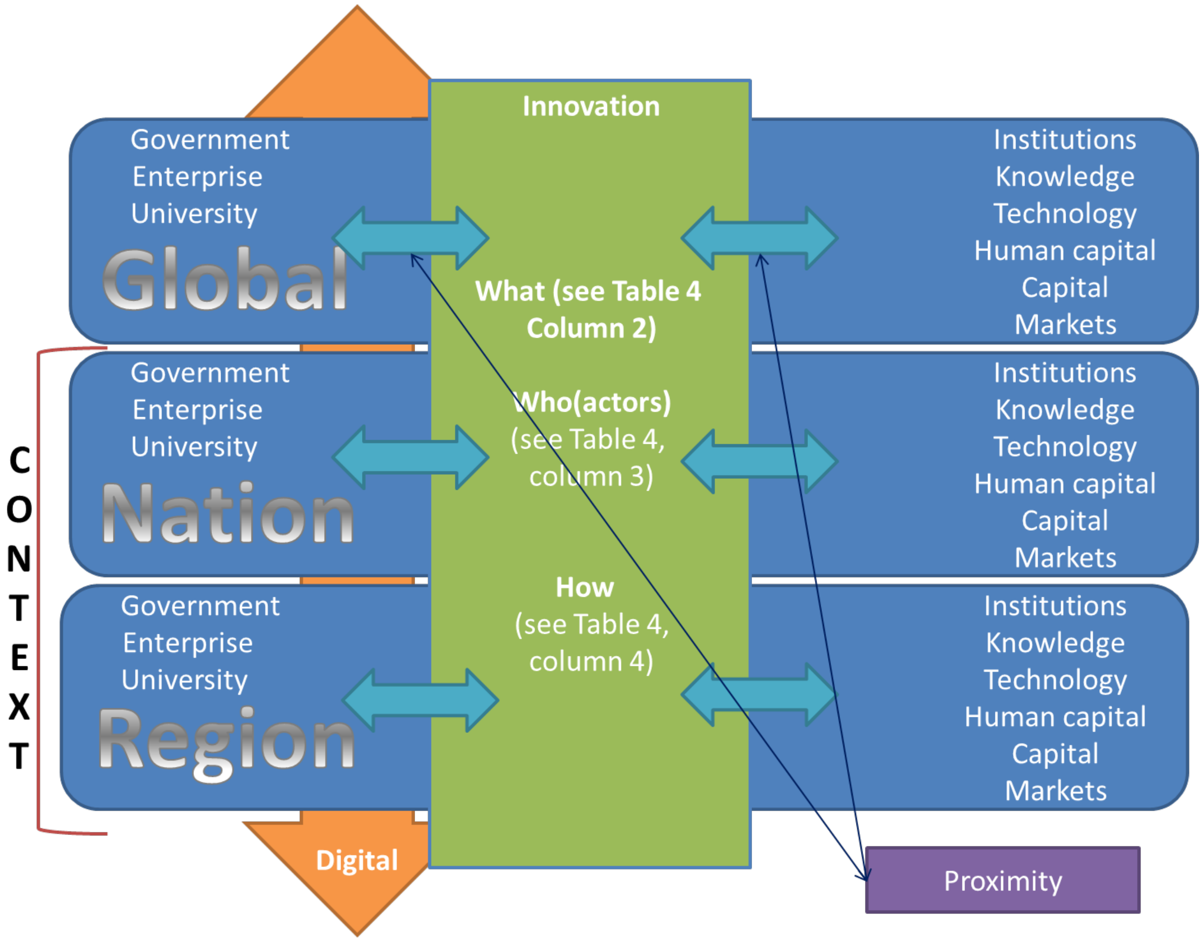
**Table 4. Taxonomy of Innovation Crossing Boundaries**

| Conceptualisation | Categories | Actors | Forms |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Early Schumpterian | Global exploitation (innovation) of new value-generating activities | Enterprises and individuals | Exports of innovative goods<br>Cession of licenses and patents<br>Foreign production of innovative goods internally developed |
| | Global exploitation (innovation) of globally-produced new value-generating activities | Enterprises and individuals | Exports of innovative goods<br>Cession of licenses and patents<br>Foreign production of innovative goods internally developed<br>International sourcing of knowledge and technology<br>International flows of capital to finance innovation<br>International flows of human capital in order to implement innovation |
| Late Schumpeterian | Global techno-scientific collaborations | Universities and public research centres, & universities and enterprises | Joint research projects<br>Staff and student visits & secondments<br>University-industry knowledge transfer |
| | | Enterprises | Joint ventures for specific projects<br>Productive agreements with exchange of technical information |
| | Global generation of inventions | Enterprises (particularly but not solely MNCs) | R & D and innovative activities both at home and internationally<br>Acquisitions of existing R & D facilities<br>Greenfield R & D investments |

In order to implement this taxonomy in the empirical context of the Crossing Boundaries project an analytical framework informed by the existing body of literature is developed. This is presented in Figure 2 below. The taxonomy of innovation crossing boundaries (Table 4) captures the main thrust of the innovation process (green column) and involves the questions of what, who and how. This taxonomy is embedded upon a multiscalar space. The lower two scales (rows) provide the context: i.e. the specificities of the place (i.e. the region and/or the nation) where the innovators are located (in accordance with systemic views of innovation). These scales constitute arenas for sets of actors (government, enterprises – viewed broadly to include civic society organisations - and universities) who may drive (enterprises and civic society organisations) or support/facilitate (government) the introduction of innovation. Their actions are influenced by the prevailing institutional setting, and set out to exploit context-specific tangible and intangible resources (and for the purposes of the globalization of innovation key resources include knowledge, technology, human capital, capital and markets). However, the focus of this Working Paper and the Crossing Boundaries project revolves around the interface between the taxonomy of innovation crossing boundaries (main column) and the global scale (top row). Actors, institutions and resources are also present at this scale: however, issues of proximity (viewed here broadly to include cognitive, organizational, social, institutional, and geographical proximity) are of particular importance. Within this framework technology is viewed here both an input (identified at different scales) as well as a facilitator of innovation. The latter focuses particularly on digital technologies, and is captured as a vertical influence underpinning innovation.

**Figure 2. Analytical Framework**




Overall, this Working Paper has reconsidered the relationship between knowledge, technology and innovation in the specific context of crossing national boundaries. It has suggested that the scope for innovation across national borders will be determined in part by the changing landscape of knowledge exchange; flows are dependent less and less on geographical proximity – yet still ultimately dependent on firms' and institutions' differing capabilities and capacities. Technology transfer has a clear connection with this. As a set of more clearly defined technology transfer processes that are also subjective, constructed and interwoven with knowledge, have an overtly changing relationship to international innovation, both directly and as an enabler/driver. ICT and digital technologies/capabilities are posited in this paper as essential developments for studying i) how knowledge and innovation interact and ii) as a catalyst for innovation directly. The final concept under discussion, innovation itself, appears equally contingent on definition, social practices and a range of contextual influences that are opening up innovation at the global scale. Recognising the need for more inclusive definitions and taxonomies of innovation, the Working Paper has demonstrated the conceptual limitations of existing work for understanding how the three concepts converge across boundaries.

### 5.2 An Emerging Research Agenda

This Working Paper explored diverse conceptualisations of knowledge, technology and innovation in the light of the crossing boundaries theme. In doing so it focused particularly on issues around knowledge and technology transfer and the globalisation of innovation. It concluded with the development of a broad taxonomy of innovation in the crossing boundaries context, as well as an analytical framework. Whilst the latter remains informed of theoretical advances in a broad body of literature it offers a coherent instrument for analysis. The taxonomy and the analytical framework developed here can be usefully deployed in different empirical contexts, and address a number of areas for further research identified in this Working Paper.

It is apparent from the voluminous body of literature explored in this Working Paper that all three concepts at the heart of the *Crossing Boundaries* study are viewed as dynamic elements, driving change not only economically but also socially. However, rather perversely time, either historical or sequential, has not been a key consideration of the existing body of literature. Thus, whilst existing research provides numerous illustrations of how innovation (for example) changes society, it provides precious little insights into how historical time may influence the innovation process. The conceptualisation of knowledge, technology and innovation as socially constructed has been examined in this Working Paper. This has implications about how their transfer can be effected both within, and more importantly across national boundaries, that merit investigation.

A key issue that emerges in this context revolves around the identification of actors that are best placed to benefit from such global flows (tapping into the literature on absorptive capacity). Existing research around the globalisation of innovation assumes that MNCs may be able to tap into these global processes more than smaller entrepreneurial ventures. The dual role of digital technologies both as a technology to be transfer as well as a facilitator of further technology transfer merits particular consideration in further research. Finally, section 4 considered the need for broad definitions of innovation that allow consideration of contextual influences. Unanswered here are questions around what international dimensions of innovation or innovation flows look like in the sorts of contexts not conventionally considered as sites of innovation, such as grassroots or rural contexts. How are rural innovation processes and outcomes influenced by the ability of actors to exploit international resources? Specific research questions arise, including: How are developments in digital technologies and capabilities opening up opportunities for and access to innovation at an international scale?

The *Crossing Boundaries* project will address these by conducting research in three distinct settings. The first revolves around the process of knowledge transfer between universities and enterprises (where the geographical divide is complemented with a sectoral one) across national boundaries. This goes beyond (in fact excludes) university-industry knowledge transfer within the national context: focusing squarely on the rarely explored, in the literature, international dimension. Whilst universities and enterprises, and particularly their interaction, are at the heart of this context, they can not be examined in isolation from the actions of regional, national and transnational policy bodies as well as other organisations (such as intermediaries). Appendix 1 illustrates diagrammatically how the framework (presented in the previous sub-Section) will be used in this empirical context. The second task adopts a national innovation system perspective, exploring the implication of openness of the system both at the macro and the organizational level. This does not involve merely a comparative study of innovation systems but actually a blurring of the often marked boundaries between them. Of particular emphasis in this context will be issues of intellectual property protection and their implication for the flow of innovation. The third task revolves around the process of global exploitation of globally produced inventions where the main actor is based in a rural area. The importance of rurality rests with resource scarcity, which in turn prompts enterprises to tap into external (and often geographically distant) resources. Within this setting, the research will not focus on rural innovation or the territorial dimension in general but on how innovation crossing boundaries takes place in this contextual setting. Whilst enterprises (private and in the civic context) and entrepreneurs drive innovation, their actions are influenced by local and regional authorities, as well as local knowledge providers. Appendix 3 illustrates diagrammatically how the framework will be used in this empirical context.

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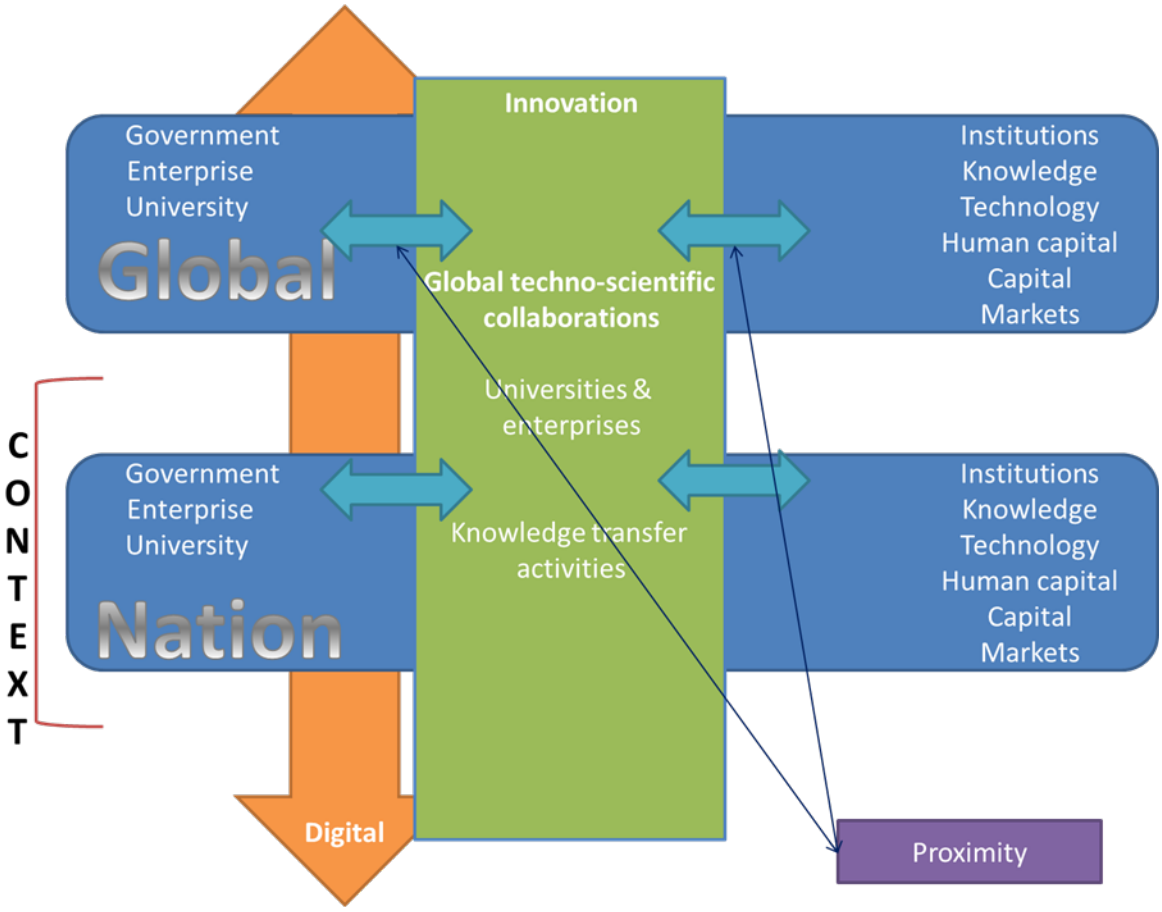
Appendix 1



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Human capital
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Markets
Global techno-scientific collaborations
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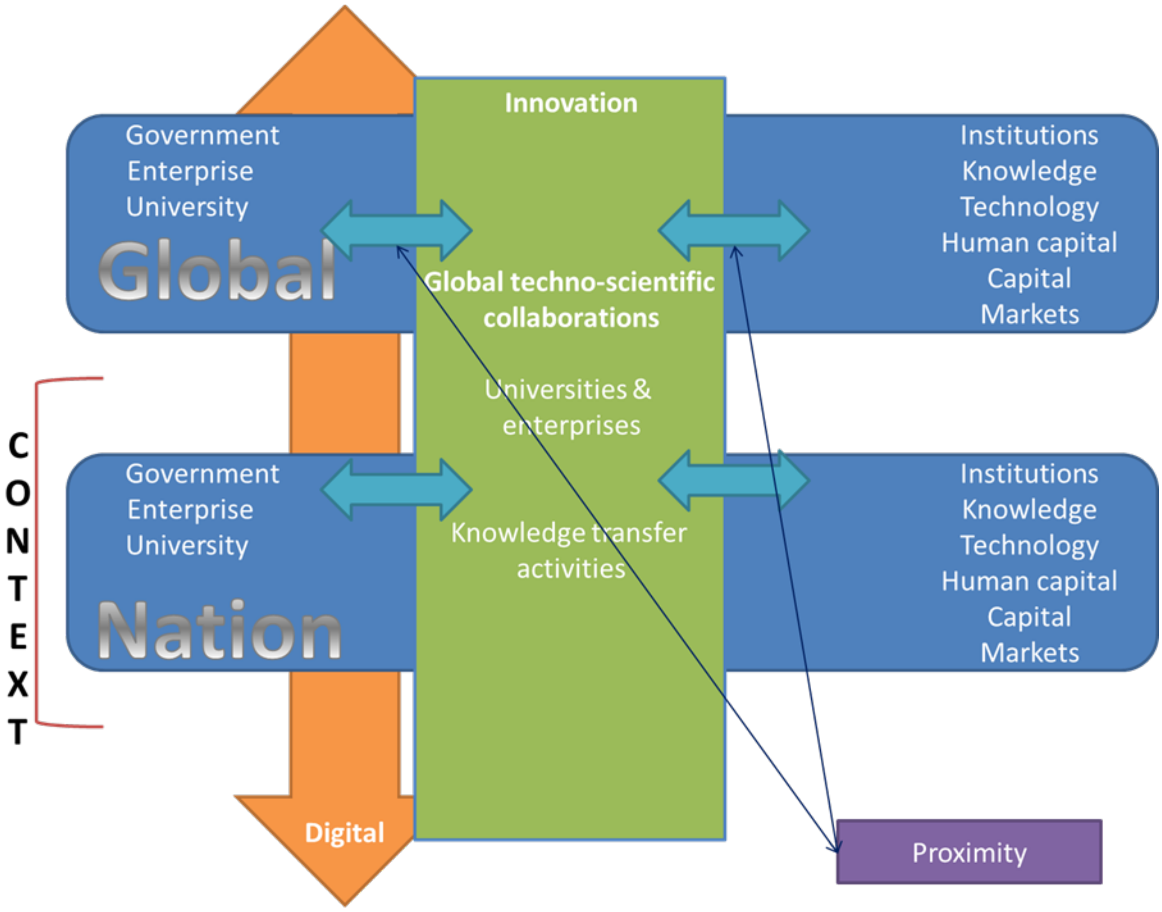
Human capital
Capital
Markets
Digital
Proximity

Appendix 2



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Human capital
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Markets
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Universities & enterprises
C O N T E X T
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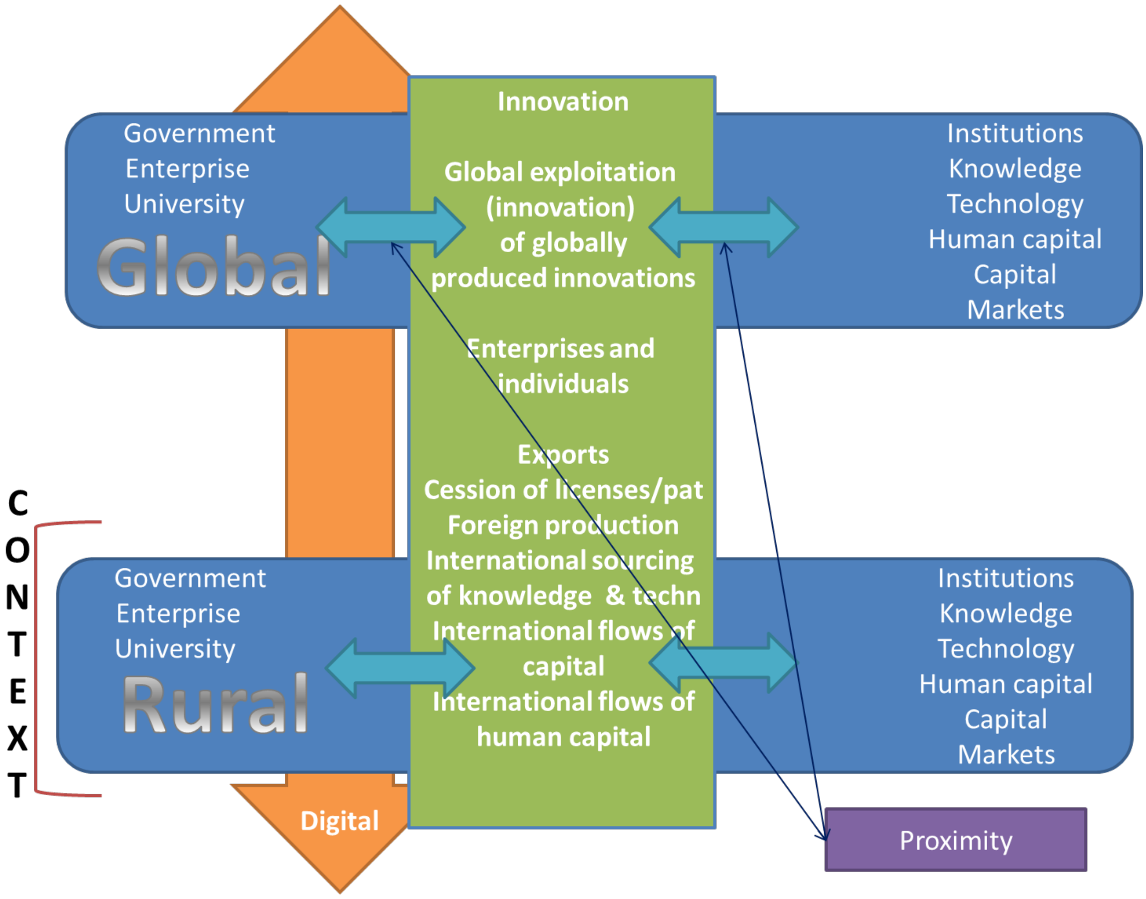
Digital
Proximity

Appendix 3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Global exploitation (innovation) of globally produced innovations
Enterprises and individuals
Exports
Cession of licenses/pat
Foreign production
International sourcing of knowledge & techn
International flows of capital
International flows of human capital
Government
Enterprise
University
Global
Institutions
Knowledge
Technology
Human capital
Capital
Markets
Government
Enterprise
University
Rural
Institutions
Knowledge
Technology
Human capital
Capital
Markets
CONTEXT
Digital
Proximity