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NATIONAL INNOVATION SYSTEMS, DEVELOPING COUNTRIES, AND THE ROLE OF INTERMEDIARIES: A CRITICAL REVIEW OF THE LITERATURE

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National innovation systems, developing countries, and the role of intermediaries: A critical review of the literature

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Abstract:
Developed over the past three decades, the national innovation system concept (NIS) has been widely used by both scholars and policy makers to explain how interactions between a set of distinct, nationally bounded institutions supports and facilitates technological change and the emergence and diffusion of new innovations. This concept provides a framework by which developing countries can adopt for purposes of catching up. Initially conceived on structures and interactions identified in economically advanced countries, the application of the NIS concept to developing countries has been gradual and has coincided – in the NIS literature – with a move away from overly macro-interpretations to an emphasis on micro-level interactions and processes, with much of this work questioning the nation state as the most appropriate level of analysis, as well as the emergence of certain intermediary actors thought to facilitate knowledge exchange between actors and institutions. This paper reviews the NIS literature chronologically, showing how this shift in emphasis, while offering insights to how new technologies are selected, developed, and diffused, has also diminished somewhat the importance of both institutions, particularly governments, and the process of institutional capacity building. In doing so, the paper suggests that more recent literature on intermediaries such as industry associations may offer valuable insights to how institutional capacity building occurs and how it might be directed, particularly in the context of developing countries where governance capacities are often lacking, contributing to less effective innovation systems, stagnant economies, and unequal development.

Key words: *national innovation systems, development, institutional capacity, knowledge exchange, intermediaries, industry associations*

Introduction

Innovation, understood as the recombination of existing ideas or the generation of new ideas into new processes and products (Freeman & Soete, 1997; Gordon & McCann, 2005) is widely viewed as the main driver of growth in modern capitalistic economies (Rodriguez-Pose & Crescenzi, 2008). Further this, Metcalfe and Ramlogan (2008: 436) state that "successful economic development is intimately linked to a country's capacity to acquire, absorb, disseminate, and apply modern technologies, a capacity embodied in its NIS [National Innovation System]". In most accounts, the NIS concept is described as that set of national institutions which contribute to generation and diffusion of new technologies and which provide the framework within which government and firms negotiate policies to influence the innovation process (Metcalfe, 1997).

Although notions of technological 'catch-up' and economic growth have always been central to the NIS concept (see Lundvall, 2007), the idea was conceived on institutional structures and activities identified in already developed countries (e.g. Japan, USA, Germany, Sweden) with developing countries largely absent from the early literature. Shortly thereafter, however, the NIS concept was applied to so-called newly industrialised countries (e.g. South Korea, Taiwan, and Singapore) and countries of Latin America (e.g. Mexico and Argentina), and has, more recently, been applied to developing countries, both the emerging powers of India, China, and South Africa, and more limitedly to less developed countries in Sub-Saharan Africa and elsewhere (Metcalfe & Ramlogan, 2008). The gradual inclusion of developing countries within the NIS discussion has coincided with several interrelated shifts in the NIS literature occurring over the past three decades: (1) a move away from macro institutional explanations to a focus on specific system processes, (2) a more recent emphasis on the role of intermediary and non-governmental actors in this regard, and (3) the increasing internationalisation of the NIS concept.

The aim of this paper is to provide a comprehensive review of the NIS literature, seeking to characterise and explain these changes and their implications within the context of a limited yet growing body of work on the role of intermediaries, particularly industry associations, in developing countries. In doing so, it suggests that an emerging emphasis on such intermediaries in developing countries offers valuable insight on linkages between the often disconnected processes – within the NIS literature – of technology creation and diffusion and processes of institutional capacity building and governance.

This paper is structured chronologically, although there is considerable overlap between the approaches and themes described here. Section 2 reviews early concepts of NIS, revealing their macro-level perspective and narrow focus on industrialised countries of the global North. Section 3 examines a second wave of NIS literature, identifying new conceptual boundaries and process dynamics. Section 4 focuses on the more recent move of literature towards internationalisation of the NIS approach, showing the increasing emphasis on intermediary institutional actors such as industry associations. Section 5 concludes by summarising the three major shifts in the literature of NIS and their significance for conceptualising the role of industry associations in innovation of developing countries in the global South.

NIS: early concepts and approaches

Derived in part from the ideas of List (1841) and his concept of *national systems of production*, the NIS concept was first proposed by Freeman (1982, 1987) as a response to the *Washington consensus* and to the neoclassical approaches to growth. In this way, the NIS concept has always been intrinsically linked to public policy (Sharif, 2006). Drawing on the work of Nelson and Winter (1982) and their Schumpeterian inspired theory of economic growth through evolutionary technological change, Freeman, along with Lundvall (1985, 1988) and again Nelson (1990), argued that neoclassical growth models are inadequate as they ignored the role that technological change and innovation play, particularly in economies that are science and technology driven and which are increasingly shaped by competitive global forces. For Freeman and others, technological change and innovation are central to economic growth – a notion Freeman pointed to as obvious since the industrial revolution and already well established by Schumpeter (1939, 1942). Furthermore, innovation, in this view, is understood as not only the work of individual firms, but as a collective endeavour, requiring diverse and substantive sets of knowledge, resources and expertise. As such, different countries will have different capacities for innovation (Patel and Pavitt, 1994). Unlike the neoclassical view of growth, therefore, the NIS concept argues that governments and collective activities can and do play a central orchestrating role in the generation and diffusion of innovation in a national economy. Freeman (1987) made this point quite clear in his analysis of Japan's post-war 'catching up' policy. In other words, institutions matter: they can create and support an environment through which collective knowledge and resources can be more easily exchanged for the pursuit of new ideas and opportunities, in what are increasingly complex and inherently uncertain enterprises (Freeman and Soete, 1997).

Institutional actors and interactive learning

Early work on the NIS concept set out to first identify the institutions and system interactions that characterise economically successful countries (OECD countries in particular). As an institutional construct, the core institutions comprising the NIS identified in the early literature are (1) *governments* and related agencies supporting innovation through regulation, standard setting, public-private partnerships, and funding of basic research, (2) *sectors and industries* comprised of *firms* which generate commercial innovations through experimentation, R&D, and product improvement, (3) *universities* which conduct basic research and train a technical and scientific workforce, and (4) other *public and private organisations* that engage in education oriented activities (Patel and Pavitt, 1994). Key to this structure are interactions within and between institutions which Lundvall (1992) and others describe as a variety user-producer linkages that facilitate information sharing leading to cumulative knowledge and collective learning – *learning by doing* as Arrow (1962) described, being central to both innovation and institutional capacity building (Lundvall, 2007; Nelson & Winter, 1982). The NIS concept also draws upon other ideas from innovation theory that posits learning and subsequent innovation as a non-linear and recursive process that relies on effective feedback loops between actors and institutions – recursively informing stages of invention, research and development, and commercialisation (e.g. early marketing and product testing informing product development efforts). In this way, the NIS concept places considerable emphasis on the evolutionary and path dependent nature of technological change. Understanding innovation, therefore, requires a degree of historical context and analysis – differing again sharply from neoclassical economics (see Freeman, 1995).

Importantly, this early conceptual NIS framework, being focused on first identifying institutional structures, was initially concerned in capturing the NIS at the macro level of analysis: conceptualising and understanding the 'system' as a whole rather than the underlying system processes (Lundvall, 2007). An unintentional and somewhat contradictory result of this initial macro-approach, though, was to frame the NIS as a structurally static system, particularly when applying the concept as a policy tool.

Early work on the NIS concept centred on firms (both small and large) as the core institution through which innovations are developed and commercialised (Patel and Pavitt, 1994). In this view, the other main institutional actors play an essential yet supporting role. In general, governments provide incentives and regulatory support for innovative firms, while universities cultivate new ideas and talent that repopulate the entrepreneurial ecosystems and R&D divisions of high-tech sectors and industries. Somewhat later work would challenge the firm centred NIS approach, with related concepts such as Mode 2 and Triple Helix placing greater emphasis on universities as central to a country's research infrastructure (see Etzkowitz & Leydesdorff, 1998; Leydesdorff & Etzkowitz 2001). For these concepts, however, crucial interactions between the primary institutions, particularly between universities and industry, still predominate, as does, for the most part, the national character of the innovation system (Lundvall, 2007).

Interestingly, while the institutional role of government in providing a stable, supportive, and appropriately competitive environment for innovation is almost overarching in the early literature, how such an environment, through interaction with other institutions, is informed is largely absent – government as a necessary yet almost passive player in the NIS' dynamics. Again, much of this is probably due to the macro level focus of this early work and the dominant emphasis on university-industry linkages and collective collaboration and feedback between firms. Another possibility, however, is the omission of politics from the early NIS concept. In other words, the early NIS concept omits, to a large degree, the political processes through which governments are both informed and through which governments exert influence on the NIS. In doing so, this early NIS literature does not consider organisations (e.g. industry associations) within the NIS that work with the state to inform and negotiate conditions and incentives for innovation and growth.

Institutional intermediaries

Also missing from the main NIS literature at this time was any real attempt to identify and then clarify the activities of those institutions described as *other public and private organisations* beyond their supposed and rather vague 'educational' role. Inspired by the network possibilities that notions of collective learning offered, a nascent strand in the innovation systems literature – technology innovation systems – began looking at particular actors and organisations from an intermediary perspective: firms and organisations that might facilitate information exchange by linking (i.e. bringing together) common and complementary actors, and in the process, facilitating the development of networks (see Lynn et al., 1996). Carlsson and Stankiewicz (1991) proposed the existence of intermediary firms which act as 'bridging institutions' within specific industries whose function is to draw upon collective knowledge in solving problems for individual firms. More broadly, Stankiewicz (1995) and Leyn et al., (1996) write of superstructure organisations that link and shape network relationships within an innovation system and provide collective goods to members. These intermediary institutions, though, are not well defined or identified. A strand within this literature, however, looks at intermediary institutions as facilitating knowledge flows between policy makers and innovators (see Callon, 1994; Van der Meulen & Rip, 1998;

Cash, 2001; Kelly, 2003). In this case, examples identified are research councils, various funding bodies and universities. Equally important here is that these intermediaries are described as *institutional actors* that likely contribute to the shaping of the overall innovation system (institutional environment and governing structure).

In this way, these early studies correspond to work that looks at the role of intermediaries, but not from an innovation systems perspective. Looking primarily at firm based collaboration, this work views intermediaries as performing three primary functions (see Howells, 2006). First, the function of *information collection and information exchange* through respective networks. In this role, intermediaries scan for network related information (e.g. actors, activities, and trends within a network and possibly outside it), collect and package this information, and then share it with network members (see Hargadon and Sutton, 1997). Such information might include current and emerging technologies, new products and processes, changing regulation, and potential partners and competitors (see Aldrich and von Glinow, 1992; Turpin et al. 1996; Wolpert, 2002). Second, in sharing information with network members, intermediaries can directly contribute to the *construction or development of a said network* (Kogut et al., 1992). By bringing similar and/or complementary actors together, the intermediary acts as an important network selection mechanism, both in determining, to some degree, which actors can enter and maintain a position in the network and, in doing so, facilitating the technological transfer and diffusion of certain technologies within the network over alternative technologies (Rosenfeld, 1996). In this construction role the intermediary can also contribute to the collaborative culture and structural characteristics of the network (Rosenfeld, 1996), encouraging certain network norms (e.g. frequency and modes of interaction between members).

Finally, once a collaborative relationship between network members are established, intermediaries can then help *manage and develop* those relationship, *facilitating the collaboration process* (Davenport, Davies & Grimes, 1999). They may do this by recognising the changing collaborative needs of the parties and facilitating both parties in identifying and meeting those respective needs, thus furthering the development of the relationship. In doing so, the intermediary may become both the point of contact and venue for initiating and conducting meetings between the respective parties as collaboration becomes more direct and/or complex (see Luukkonen, 2005).

As eluded to earlier, absent from this early discussion on intermediaries industry associations. This absence is surprising given to how intermediaries are discussed above in terms of collecting information, providing collective goods, and informing policy makers – activities that are very much today associated with such organisations. In addition to the important omission of politics from the early NIS concept, the absence of industry associations from this early innovation systems literature may well be due to the negative connotations ascribed to industry associations. The latter are considered to be controversial actors of innovation and development. Several economists and political scientists express distrust in them. For instance, as early as the 18th century, Adam Smith, in his *The Wealth of Nations*, accused industry associations of playing a negative role in the economy, conspiring against the public or raising the prices of goods. More recently, industry associations have been viewed as special interest groups that pursue narrow rents for a limited number of members at the expense of the wider sector and economy – discouraging competition and thus curtailing collective innovation within an industry (see Olson, 1982; Schmitter & Streeck, 1999). In addition, Cawson's work on corporatism suggests that industry associations in certain political contexts can even threaten democracy (Cawson, 1982).

Different institutional incentives and competencies

As mentioned previously, early frameworks of the NIS were derived primarily from successfully developed countries. While looking at the OECD countries of the time, however, this early work identified some differences regarding incentives and competencies between these countries. For example, Freeman (1987, 1988) showed that Japan's NIS placed considerable emphasis on government-industry partnerships that focused on providing regulatory protection for and funding applied research in specific industries (e.g. automobiles and consumer electronics) with less funding going to basic research – placing considerably less emphasis on university led research more generally. In contrast, the supposed resilience of the US economy – seen as declining at the time – was attributed to a NIS that provided strong government support for basic research, high levels of defence spending leading to research spin-offs, and a university research system that was able to effectively connect basic research activities to emerging technological industries (e.g. semiconductors), as well as supporting a regulatory environment and culture conducive to entrepreneurialism and risk taking (see Nelson, 1988, 1993). At the same time, the NIS of countries such as Germany, Sweden, and Switzerland were shown to be particularly robust and effective in their support for private sector financing of R&D with an industrial base dominated by large firms engaged in chemicals and advanced machinery (manufacturing and defence) (Ray, 1989). In contrast, OECD countries such as Italy and Portugal showed relatively weak NISs compared to other west European countries (Patel & Pavitt, 1994).

This early work on the NIS concept, however, was not limited solely to OECD countries. Again, the NIS concept first emerged amidst growing questions regarding economic growth and potential templates for the less developed countries of the South to catch-up with the developed North (see Nelson, 1993). With Freeman's description of Japan's NIS as an example of effective economic catch-up and then, at the time, overtaking the economies of the US and Western Europe in many technological areas, work on the NIS concept quickly turned to the rapidly emerging economies of East Asia, particularly South Korea, Taiwan, and Singapore (see Freeman, 1995; Kim, 1993; Nelson, 1993; Mowery & Oxley, 1995). Studies on these three countries showed differences between NISs (see Wong, 1999), but certain NIS characteristics were common. These included government intervention in and championing of key industries, along with carefully crafted policies to support reverse engineering of foreign technology and subsequent technological leapfrogging by latecomer firms, support for patent protection, as well as an emphasis on public education and the building of a technical workforce (Nelson, 1993). All of this, coupled with initially lower labour costs, allowed these countries to experience significant economic growth and emerge as global leaders in several high tech industries, ranging from automobile design and manufacturing, computer electronics, software, semiconductors, and business services (see Chang, 1999).

What is particularly striking about the NISs of these East Asian countries was that they supported and directed national innovation strategies that effectively balanced protectionism for key indigenous industries with a degree of system openness – allowing these industries to adopt, exploit, and improve upon technology and organisational practices from the advanced economies, particularly those of Japan, the US, and Western Europe. While these practices represent primarily *inward flows* of technology and knowledge, their prominence in the early NIS literature gave rise to notions that effective innovation systems required a degree of openness and receptivity to external ideas and information: this openness would come to be recognised as the primary mechanism through which NISs react to ongoing competitive forces, and in doing so, how these systems develop and evolve over time. As such, Bell and

Pavitt (1993) argue that effective government policy toward building national capacities for innovation (e.g. effective university-industry linkages) is what separated the so called Asian Tigers from the less performing industrialised economies of Latin America (Argentina, Mexico and Brazil) whose NISs were also studied at this time (see Alcorta & Peres, 1998; Viotte, 2002). They go on to argue that the economies of many Latin American countries lacked capacities for sustained growth and competitiveness due to inefficiencies brought about by decades under ineffective socialist regimes.

Arocena and Sutz (2000) suggest that more than just a lack of institutional capacity is at play, however, when applying the NIS concept to developing countries. In their work on NISs in Latin America, they propose that while many developing countries have specific technological competencies and excel in various industries, that these often operate in isolation to anything resembling an integrated system of institutions as described by the NIS concept. Further this, they argue that the preponderance, central to the NIS concept, of relational interaction between actors and institutions is often missing, writing at the time that "In Latin America, it is a relatively easy task to create organisations to foster innovation, but it is quite difficult to make them operate as bridges between people" (Arocena & Sutz, 2000: 56). Application of the NIS to developing countries is also complicated by what they argue are the overly normative tendencies of the NIS concept that confer an innovation system as continually, and often rapidly correcting inefficient pathways toward the advancement and maturing of industries (i.e. there are good and bad NISs), and that the emphasis is on technology based manufacturing (e.g. automobiles and computer electronics) and high tech industries (e.g. ICT and biotech). In doing so, the application of the NIS concept to developing countries may very well miss existing innovation systems in these countries that are based on more slowly developing, less technology driven industries (e.g. agriculture and craft industries) – possibly hindering the application of the NIS concept as a development tool and strategy.

That being said, in capturing the diversity of NISs across developed and newly industrialised countries, and emphasising interactions between institutional actors as facilitating collective learning toward innovation, this early literature offered some alternatives to how successful innovation systems might be constructed for purposes of both catching up and for sustained economic growth. For developing countries, this provided both a potential policy roadmap for development, while at the same time laying bare the stark institutional disparities between the developed north and much of the developing south.

New conceptual boundaries and process dynamics of NISs

While the NIS concept took hold as a policy prescription for catching up and was further bolstered by the popularity of Porter's (1990) theory of 'the competitive advantage of nations', early concepts of the NIS came under increasing criticism for being too vague, open to misinterpretation, and too inclusive to the point of being impractical, as well as concerns that the national emphasis of the concept missed what was felt as the more important underlying processes through which innovations actually come about (see Miettinen, 2002). As a result, several concepts were developed that while ground in innovation systems theory, and ideas of collective learning and path dependency, considered innovation "at other levels of the economy than the nation state" (Lundvall, 2007: 100). As mentioned previously, the first of these was the *technology systems* approach proposed by Carlsson and Stankiewicz (1995) which begins with a particular technology and looks at what actors and institutions influence its development and diffusion (Bergek et al., 2008). The second was the sectoral systems of innovation approach developed by Breschi and Malerba (1997) who argued that

innovation could be best understood by looking at a set of products and a distinct set of agents who interact through networks in the development, production and sale of those products. These agents hold sector specific knowledge and their interactions are influenced by institutions that may have both local and international dimensions. Importantly, Breschi and Malerba argued that looking at innovation at the sector level offered greater insight to how sectors and thus sets of technologies interact and change over time.

The third approach was the regional innovation systems (RIS) concept proposed by Asheim and Isaksen (1997) and Cooke et al. (1997) which proposes that innovation is best understood as a local or regional phenomenon where interactions, knowledge exchange and learning occur between geographically proximate actors and institutions which are bounded to a particular location. The RIS concept is based on the observations that high-tech innovative activity tends to agglomerate in a select number of high capacity metropolitan regions – home to high tech industries, research universities, financial and legal institutions, government agencies, and highly skilled labour – and that the tacit and asymmetric knowledge flows that characterise innovation are best communicated through face-to-face interaction which co-location facilitates.

While these approaches emerged as critical responses to the NIS concept, Lundvall (2007: 100) proposes that "these are not alternatives to the analysis of national systems. They have important contributions to make to the general understanding of innovation in their own right", and should be seen as complementing and contributing to the NIS concept: "To compare sectoral, regional and technological systems across nations is often an operational method for understanding the dynamics at the national level" (Lundvall, 2007: 100). That being said, while these approaches garnered new found insights to how innovations emerged and diffused within a systems context, they focus primarily on how the interactions within an innovation system influence the development of new ideas and technologies rather than on how these interactions influence and shape the innovation system itself. In other words, these approaches, at least initially, do not sufficiently connect processes of technological change and innovation to processes of institutional capacity building and governance.

Functions, process dynamics, and politics

Moving beyond the mainly structural framework offered by the NIS concept, approaches to innovation systems such as those above looked to not only how innovation systems facilitate the emergence and diffusion of innovation, but the extent to which such systems are effective in doing so. To this end, Jacobsson and Johnson (2000) proposed a *functions approach* to innovation systems which set out to first identify the primary functions of an effective innovation system and to then determine the relative importance of various functions and related interactions pertaining to both the innovation process and the growing capacity of a particular innovation system. What was somewhat novel about this approach is that while it was applied primarily to *technology* innovation systems (i.e. the micro systems level), the set of functions eventually identified can potentially be used for understanding innovation systems at different levels of analysis, from technology and sectoral systems up to the regional and national systems of innovation (see Markard & Truffer, 2008). Based on a number of previous studies that have taken a functions approach to innovation systems (e.g. Jacobsson & Bergek, 2004; Edquist & Johnson, 1997; Bergek et al., 2005), Hekkert et al., (2007) propose a list of seven primary functions that effective innovation systems support: (1) entrepreneurial activities; (2) collective learning; (3) knowledge diffusion through networks; (4) technology selection/promotion; (5) market formation; (6) resource mobilisation; and (7) technology legitimacy/overcoming resistance. Importantly, positive

fulfilment of these functions and interactions between them are viewed as leading to virtuous cycles of innovative activity, whereas a lack of any one function fulfilment or interactions can lead to system inefficiencies and failure (e.g. an inability to overcome incumbent resistance to a new and improved technology).

In verifying the set of above functions, studies by Bergek, Hekkert, and Jacobsson (2008) and Hekkert and Negro (2009) employ a historical event analysis method as developed by Van de Ven and colleagues (2000, 1999) to essentially map the events, interactions, and processes involved in particular technology innovation systems in the successful development and commercialisation of various clean technology innovations in Germany (e.g. biofuels and solar cell technology). Both of these studies found similar trajectories and patterns regarding system functions and interactions: (1) responding to exogenous events and trends (e.g. global warming and competitive forces), governments introduce incentives (e.g. tariffs, subsidies, funding) to encourage investment in particular technology areas; (2) these incentives stimulate entrepreneurial activity resulting in experimentation, knowledge exchange, and the development of nascent technologies and production systems – from which an initial yet limited market emerges; (3) aiming to improve viability and expand markets for these new technologies, entrepreneurs and industry, through the auspices of *industry associations and advocacy groups*, successfully lobby government for more incentives and institutional changes; (4) this success decreases uncertainty which encourages further investment, resource mobilisation, and subsequent market growth. In some cases, virtuous cycles are punctuated by vicious cycles (e.g. initial regulation proves ineffective) requiring additional industry lobbying and subsequent policy correction (Hekkert & Negro, 2009).

From these technology innovation system case studies, three important notions regarding institutional interactions within innovation systems can be derived. First, the successful emergence, development, and commercialisation of new technologies is the result of interactions and linkages between micro firm level processes and macro-level institutions: interactions that both purposively, and recursively link firm level processes to broader industry activities and government policies – demonstrating that technology innovation systems both shape and are influenced by a broader yet highly active national innovation system (see Kaiser & Prange, 2004). In these case studies, it is government, at the national level, that initially stimulates entrepreneurial activity and then responds to the needs of nascent technology producers and the demands of a fragile yet emerging market. Second, while not the focus of these studies, it is *industry associations* that are identified as lobbying government on behalf of entrepreneurs and industry for greater incentives and advantageous market conditions – although not identified as such, these are industry associations playing the role of *institutional intermediaries*. Finally, the presence and interplay of both virtuous and vicious cycles demonstrates that politics and negotiations between institutions, as evidenced by the activities of industry associations, are both inevitable and central as processes through which institutions are informed, policy adjustments are made and incentives gained, industry standards are set and favourable market conditions created.

Innovation intermediaries

The case studies above are some of the first in the innovation systems literature to identify industry associations as playing a central role in the innovation process and to position them as institutional intermediaries. This follows a limited yet growing body of work that looks at the role of so-called *innovation intermediaries* in knowledge and technology transfer between partner firms (e.g. joint R&D projects) and along increasingly complex production and supply chains (see Howells, 2006). These actors include technology and industry specific

consulting firms and business service providers, more general management and strategic consulting firms, and sources of risk finance such as venture capital firms. Case study research by Howells (2006) looks at a number of these intermediaries in the UK, focusing on the variety of functions they provide. In addition to intermediary functions mentioned earlier, including information collection and packaging, knowledge and relationship brokering, and technology selection, Howells identifies a number of additional functions performed by these intermediaries, including, but not limited to: industry and business forecasting; technology testing, diagnostics and other validation work; standardization work; services regarding the protection of intellectual property and the commercialisation of new innovations; and technology and business evaluation services. Also mentioned, but to a lesser extent, is work involving regulation and arbitration (Howells, 2006).

Given the diverse set of functions identified here, particularly those not normally associated with direct technology transfer and diffusion activities (e.g. standardization work, intellectual property protection and regulation work), the absence of industry associations from the mix of potential innovation intermediaries is interesting, if not all that surprising. Again, studies that have considered the role of intermediaries in the innovation process tend to focus on how those intermediaries facilitate directly the process of information exchange and technology diffusion at the micro-level of analysis, and not, rather, the processes by which the conditions that facilitate innovation are negotiated and created. Further this, Dalziel (2006) suggests that the omission of non-profit organisations such as industry associations from most of the empirical and policy literature on NISs is based, in part, on the secondary consideration that this literature, in contrast to the more theoretical treatments of the NIS concept, gives to social interactions, i.e. actors processes and actors that are involved in creating opportunities for interaction and social relations that then may lead to more formal business relations (e.g. industry associations).

In one of the few studies at the time that purposively connects industry associations and innovation, Dalziel (2006) looks at the role of industry associations in Canada and argues that industry associations enable innovation by bringing member firms together (e.g. legitimising member firms through industry directories and facilitating collaboration through network activities) which allows information and new ideas to be exchanged. An earlier study by Damsgaard and Lyytinen (2001) looks at the role of industry associations in the adoption of electronic data exchange technology in three countries: Denmark, Finland, and Hong Kong. Their work demonstrates that industry associations play a critical role in the diffusion of new technology, particularly regarding technology adoption/training, and standard setting. They argue that effective knowledge diffusion requires industry associations to bridge and negotiate the varying customs and practices of different national and local environments. In a later study, Kautto (2007) shows how companies, in this case Nokia, worked with prominent European industry associations to build coalitions among large companies to directly lobby the European Commission and influence the preparation of the 2005 EuP directive which placed new environmental and efficiency requirements on electronic equipment. Not only does this study demonstrate the negotiating role of industry associations in the policy process, but it also provides an example of industry associations as ‘umbrella organisations’ that span nation states and lobby supranational regulatory bodies.

Applying NIS to rapidly emerging economies and less developed countries

While the majority of studies on innovation systems during this period looked at different levels of analysis other than the nation state (technology, sectoral, and regional innovation

systems), and focused primarily on such innovation systems in the advanced economies of the North, a concerted shift toward the application of the NIS concept to developing countries was also occurring. Much of this involved studies that moved away from the newly industrialised economies of East Asia to focus on the large and rapidly emerging economies of China, India, and to a lesser extent Brazil (see Lundvall, Intarakumnerd, & Vang-Lauridsen, 2006). These three countries, particularly China and India, emerged rapidly as global economic powers following consecutive government policies toward greater economic liberalisation: China's 'open door' policies of the late 1970s and market reforms in the 1980s and 1990s, and India's liberalisation policies beginning in 1991 (see Mathews, 2009). Although the actual policies employed by these two countries differed somewhat due to different historical and national contexts, the strategies employed for 'catching up' purposes were very similar. These included: greater openness to foreign trade and foreign direct investment, the denationalisation of certain industries (China), the opening up of indigenous industries to global competition, and greater support for private enterprise and entrepreneurial activity; along with co-current policies toward the technological development, maturation, and the global orientation of indigenous industries (see Krishnan, 2003; Motohashi & Yun 2007). These liberalisation policies, Mathews (2009) argues, are very reminiscent of the catching up strategies employed earlier by Japan and the newly industrialised countries of East Asia.

In the case of China, such policies included programs and incentives for the aggressive adoption of foreign manufacturing technology, the gradual decentralisation of national R&D efforts from government institutes and universities to commercial enterprise, the encouragement of partnerships between indigenous and foreign companies, and the establishment of numerous enterprise zones and science parks which have become increasingly populated by MNCs (see Leydesdorff & Guoping, 2001; Sun, 2002). On the one hand, these policies have led China to almost unparalleled economic success and rising living standards across its population. On the other hand, Gu and Lundvall (2006) argued, at the time, that China's decades long focus on modernising its indigenous manufacturing industries had led to several weaknesses in its national innovation system, particularly weakened capacities for basic research and high tech entrepreneurial activity. They go on to argue that a lack of systemic capability for interactive learning within organised markets has hurt China's ability to absorb advanced foreign technology and to create and develop domestic high tech industries. In contrast, India, while following a similar approach to China, was able to capitalise on its historically strong science and engineering base (robust research universities and expertise in areas such as aerospace) and already burgeoning indigenous industries in computer electronics and pharmaceuticals to develop a world class and global oriented ICT industry and to become an emerging leader in medical equipment and biotech (Krishnan, 2003; Herstatt, Tiwari, Buse & Ernst, 2008). Unlike China, however, India has struggled to translate this success into a widespread rise of living standards, with much of India's population remaining in poverty.

In looking at the economic liberalisation efforts and subsequent NISs of China and India, several points are worth further consideration. For both China and India, the state has played a significant role in carrying out reforms and shaping the innovation system. It might be argued however, that China's innovation system, the product of a single political party and a tendency toward central planning, relies very much on downward streams of information (i.e. the government acting upon macro generated information and the institutional strengths and bureaucratic biases of the state and its agencies), whereas India's innovation system, residing within a far more pluralistic state and devolved regional powers, might rely much more on

upward streams of information (i.e. the government acting more upon information from both industry and civil society). As a result, China might be less capable than India in meeting the needs of rapidly changing and increasingly complex industries such as ICT and biotech, hampering its efforts to establish and grow such industries domestically. On the flipside, however, India's pluralism may allow certain industries or actors to dominate upward streams, influencing government policy to their benefit, yet to the disadvantage and underdevelopment of the wider economy.

These structural and political differences may have implications for how China and India engage and react to external flows of knowledge, capital, and commerce. Along the lines of Gu and Lundvall's argument above, it is possible that China's more top-down NIS may better protect the interests of indigenous industry at the expense of absorbing and developing radical innovations from abroad, whereas India's NIS, while possibly more capable of integrating global R&D flows, may do so at the expense of its indigenous industries. This raises questions as to how and to what extent the integration of foreign knowledge and technology into a NIS is informed and negotiated, particularly given the prominence of global interactions and interdependences exhibited by most high-tech sectors.

In this context, Brazil is another interesting case of an emerging economy. A small number of studies on Brazil's NIS during this period captured a large, emerging economy that despite its size and vast resources struggled to develop its capacities for innovation. Viotti (2002) argued at the time that Brazil's struggles were the result of its relatively weak education system that had produced a labour force whose skills were largely inadequate toward the widespread absorption and improvement of foreign technology. For example, Brazil followed a policy strategy that focused on encouraging foreign direct investment, particularly policies that made it easier for MNCs to set up operations in the country. In this aim, Brazil was very successful: "Foreign subsidiaries were estimated to be responsible for 33% of whole industrial sales in the Brazilian domestic market, and for 44% of industrial exports, during 1990" (Viotti, 2002: 670). Viotti argues, however, that MNCs' operations in Brazil were almost exclusively production oriented and remained so due to Brazil's mostly low skilled workforce. Furthermore, Brazil's intense focus on incentivising MNCs came at the expense of indigenous producers who were essentially crowded out. It was not until later, following a more focused and somewhat protectionist export strategy (e.g. steel and agribusiness) that Brazil emerged as a global export leader in raw commodities, agriculture, and more recently aerospace and biofuels leading to significant economic gains over the past decade (Mathews, 2009).

Brazil's success in agriculture and biofuels is informative, with Hall (2005) suggesting that less developed countries, particularly those in sub-Saharan Africa, might find success in developing nascent NISs around their strength in agriculture to build indigenous biotechnology industries (see Hall, 2005). With this in a mind, a study by Lall and Pietrobelli (2005) looks at NISs in sub-Saharan Africa including Ghana, Uganda, Kenya, Tanzania, and Zimbabwe, noting that in some of these countries, government institutions that focus on agriculture seemed 'potentially' better positioned than other institutions to support viable R&D efforts (better funding, knowledge capacities, and linkages to industry). They go on to conclude, however, that most R&D institutions in these countries "generally lack the facilities (physical and human) to provide meaningful support to industrial enterprise . . . they have no means of assessing the technological needs of industrial enterprise or of diffusing to them the few technologies they have created [or adapted]" (Lall and Pietrobelli, 2005: p. 334). Because of this, "the institutions carry little credibility with the private sector" (ibid). Hall (2005)

examines policy initiatives by a number of sub-Saharan African countries to develop their own indigenous agriculture biotechnology industries (agriculture and healthcare). While pointing to some success in institution building around these initiatives, particularly in linkages between national institutions (e.g. R&D institutes and universities) and institutions from the developed North, Hall (2005) points to continued systemic weaknesses, particularly the lack of effective linkages between government institutions and industry at the local level. In other words, a lack of effective diffusion and feedback channels from the national to the local and vice versa tend to impede the development of indigenous industry.

Interestingly, at the transnational level, Hall (2005: p. 621) suggests that international organisations and associations "have played an important role in brokering partnerships" between research institutions in developing countries "and both public and private organisation" in the developed North. For developing countries, this raises questions as to whether NGOs and various types of associations might play a similar role in facilitating knowledge exchange and diffusion between the national government and local entities (e.g. industry and civil society), and in doing so, better linking and integrating local interests and development needs with global knowledge and technology.

Internationalisation of NISs and industry associations in developing countries

The concurrent ideas that NISs exist within and interact with an increasingly global economic system and that, within this context, different NISs will exhibit different capacities for innovation and competitiveness go back to the earliest iterations of the NIS concept (see Niosi & Bellon, 1994). Within the NIS literature, the term internationalisation or the globalisation of the NIS concept is used in three ways, and these often interchangeably. The first is the notion that the NIS concept, conceived initially on frameworks identified in already developed countries can be transferred to the context of developing countries. While transferability is a long standing notion, its application to developing countries is a more recent trend. The second notion refers to the related and common practice in the literature of comparing the NISs of different countries – much of this between countries of the developed North. The third notion concerns the extent to which a country's NIS is characterised by global linkages and interactions (i.e. open to external knowledge flows) (see Carlsson, 2006). An example in the early literature is international interaction and global standard setting between leading research universities (see Pietrobelli, 1996). More prominently, however, are studies that focus on the global R&D activities of MNCs (see Patel and Pavitt, 1991, 1999; Pavitt 2002). The overarching sentiment in the NIS literature, however, is that while international linkages have become increasingly important, the institutions that govern these interactions are largely national (Carlsson, 2006).

These convergent notions hold relevance when applying the NIS concept to developmental contexts. First, it is increasingly recognised that effective NISs require substantial inward knowledge flows and linkages to innovation capacities located in other countries. Therefore, pursuing global linkages would appear to be an obvious path, as capacity building mechanisms, toward the *development* of an effective NIS. Second, for developing countries, the processes by which external flows are negotiated into the NIS framework are bound to be not only important, but contentious. In other words, politics of development will play a central role in shaping the emerging innovation system in these countries. Politics of development engage in certain relations with innovative industries, often forming 'growth coalitions' (Leftwich, 2009). Third, in the face of institutional weaknesses, intermediaries such industry associations are bound to be important actors that work/negotiate with

governments to create stable business environments for industry growth and innovation. This section proceeds by looking more closely at how more recent literature treats the role of both MNCs and industry associations in the shaping of NISs in developing countries.

MNCs and developing countries

Earlier studies identified MNCs and their activities as one mechanism by which developing countries can link to external knowledge and technology and, through partnerships and spillovers, absorb and then build indigenous innovation capacities. It is only more recently though, that a very limited yet growing number of studies have examined more critically the processes and conditions that govern the integration of MNCs into the emerging innovation systems of developing countries (see Fu, Pietrobelli & Soete, 2011). In doing so, these studies characterise a learning process dominated by activities in which indigenous firms and entire industries connect into MNC led global value chains (GVCs) consisting of producers, suppliers, marketers, and R&D operations; from these linkages, indigenous firms can learn about not only global market needs, standards, and practices, but also technological and organisational competencies. In this way, learning through GVCs opens opportunities for indigenous firms to 'move up the value chain' from manufacturing to more advanced functions such as marketing, designing, and R&D. Building innovation capacities, however, is not just about increasing capabilities and functions along the value chain, "but is often about deepening the specific capabilities to explore new opportunities offered" (Pietrobelli & Rabellotti, 2011: p. 1262) through spillovers from the value chain, e.g. recombining new and existing knowledge to improve manufacturing processes, allowing for the production of more sophisticated and complex products (see Morrison et al., 2008). An example of this is India's biopharmaceutical industry were significant partnering between Indian pharmaceutical companies and MNCs has allowed these Indian companies to not only better serve global market demands, but to also make commercial inroads into increasingly complex areas of biotech and life science (Rezaie et al., 2012).

That being said, the challenges for developing countries to emulate the success of countries such as India, China, Brazil are great, in part because few countries have the large domestic markets that these countries have which allow them to both build indigenous industries upon and to attract the production and supply operations of MNCs (i.e. MNCs want better access to these large markets and to take advantage of lower production costs). Furthermore, attracting MNCs and other forms of FDI in ways that facilitate knowledge absorption and diffusion within developing countries takes a number of other conditions. First, developing countries must be relatively open to inward investment and trade, with Aiken and Harrison (2008) arguing that "heavy restrictions on foreign investors and import substitution policy provide foreign affiliates with low incentives for technology transfer" (Fu, Pietrobelli & Soete, 2011: p.1207). Second, developing countries need to have strong and investment friendly regulatory policies, and well defined intellectual property right regimes: "Foreign firms will not bring core technology into their subsidiaries in developing countries with weak IPR production" (Fu, Pietrobelli & Soete, 2011: p.1207) Third, as mentioned previously, technology transfers will only occur when there are substantive linkages between indigenous firms and foreign subsidiaries. Finally, such policies and organisational practices will need to be implemented, supported, and governed by capable and informed institutions (e.g. government science and technology policy agencies) that can work with both indigenous industry and MNCs to facilitate standard setting, workforce training, and resource allocation to promising, but not yet commercial ideas and practices (e.g. funding of basic and applied research).

Without some combination of these factors, MNCs will either forgo investing in a developing country, or their engagement in a developing country will not result in sufficient technology transfer and the development of indigenous industries (i.e. produces a captive relationship as exemplified by the early liberalisation efforts of Brazil). Even under so-called optimal policies and conditions, studies have noted that MNCs and their GVCs can essentially crowd out indigenous firms and/or act as a disincentive for indigenous firms to pursue technological change and innovation (see Fu & Gong, 2011). Fu and Gong (2011) go onto argue that in China it is geographically clustered and well-connected indigenous firms, rather than those that partner exclusively with MNCs, that are more likely to engage intensively in the process of technological change and produce innovations. Furthermore, studies on China and India indicate that it is new firms and more high tech oriented industries (e.g. biopharma, software, and ICT) that benefit most from linkages with MNCs, with the rest of the indigenous economy benefiting little. In other words, these indigenous high tech industries are growing, yet in isolation to the rest of the indigenous economy. As Fu, Pietrobelli and Soete (2011) suggest, the success of some high tech industries in developing countries may be coinciding, and be the result of R&D and policy institutions that have become increasingly adept and focused at facilitating substantive linkages between indigenous high tech firms and MNCs, yet these institutions may lack the capacities and incentives to support indigenous industries that are less globally oriented and which employ a far greater number of the domestic workforce. In other words, it is possible that those government institutions, and perhaps much of the NIS of a developing country, can become captive to the interests of MNCs and their foreign subsidiaries.

Industry associations and developing countries

As discussed previously, literature that purposively connects industry associations to NIS is limited and remains desperate among many existing threads; even though studies on technology innovation systems have identified industry associations as playing a prominent role in the innovation process (see previous sections). In applying the NIS concept to developing countries, however, it is apparent, as Kshetri & Dholakia, (2009) argue, that (1) governments are subject to considerable structural changes (i.e. these are not static institutions), (2) governments will be stretched to meet the growing needs of a relatively poor but increasingly upwardly mobile population (see Frankel, 2006), and as a result (3) governments will often "lack resources, expertise and legitimacy required in developing new templates and monitoring industry behaviour". In such contexts, they argue, industry associations "are likely to be more effective and efficient institutions" in articulating industry needs, mobilising resources and working with government to develop and implement new regulatory frameworks (Kshetri & Dholakia, 2009: 227).

As such, a recent study by Kshetri and Dholakia (2009) looked at the role of industry associations in India, explaining how India's National Association of Software and Services Companies (NASSCOM) facilitated the development of India's offshoring industry. According to this study, NASSCOM was particularly effective in articulating, both to the Indian government and the public, the supposed economic benefits of the offshoring industry by establishing a dissemination and diffusion network involving government agencies, policy makers, member companies, and various social organisations (i.e. legitimising the industry). NASSCOM also leveraged this network to actively participate in the development and enforcement of industry standards and practices (i.e. setting industry norms and behaviour), gaining industry favourable tax incentives, and played a significant role in shaping India's intellectual property right laws. Kshetri and Dholakia argue that central to NASSCOM's success was the positioning and use of 'elite' members and officials (highly experienced and

visible members of industry with deep government connections) to lead outreach and lobbying efforts, and an effective strategy of working with the Indian judicial system and courts – rather than central government agencies – "to enforce the substance of legal claims" (Kshetri and Dholakia, 2009: 234). In the case of working directly with the courts, NASSCOM supposedly did this due to the perceived weaknesses of the courts regarding commercial and copyright law, and the probable lack of judicial oversight by a resource stretched central government; a prominent example of an industry association stepping in to fill a regulatory void, and initiating institutional reform.

Another study on industry associations in India by Athreye and Chaturvedi (2007) also looked at the role and effectiveness of NASSCOM, but in comparison to the early efforts of industry associations promoting India's burgeoning biotech sector. According to this study, the biotech industry associations played a similar role to what NASSCOM did for outsourcing and ICT, including lobbying for tax incentives, working with government to strengthen the regulatory environment, setting industry standards, and shaping intellectual property laws. For knowledge diffusion among members, like NASSCOM, the biotech industry associations organise "seminars, workshops, fact sheets, participating in trade fairs and registering presence in key markets of export interest like the US etc." (Athreye and Chaturvedi, 2007: 169). Athreye and Chaturvedi argue, however, that the major biotech industry associations at the time, the Association of Biotechnology-Led Enterprises (ABLE) and the All India Crop Biotechnology Association (AICBA) suffered early on from competing interests within their memberships and between the two associations, with ABLE viewed as representing only the interests (tax, regulatory, and export) of a select number of pharmaceutical companies located in Bangalore to the expense of the broader industry. As a result, the biotech industry was not as effective, initially, as the ICT industry, led by NASSCOM, in lobbying for incentives and in delivering benefits to a majority of its members. Despite differences, both case studies reveal strong politics of development. It is clear that NASSCOM and ABLE work closely with the state to promote innovation policy reforms which will have positive impact on their members' activities. Liberalisation and integration with the world economy are two of these reforms.

Conclusion

This paper has sought to critically review the literature of NIS, focusing on industry associations. In doing so, it has identified three major shifts which can guide our conceptual understanding of the role of such associations in innovation and development. First of all, an early yet extensive body of work that captures the structures of national innovation systems and the interactions between various actors. During this period, ideas from innovation and evolutionary theory such as collective learning and path dependency were applied, although most studies at this time present innovation systems as presently comprised (static) and from a macro-level perspective. While looking almost exclusively at developed countries, NIS studies on both developed countries and newly industrialised countries at the time showed insightful differences between countries regarding incentives and competencies. While some reference is made to intermediaries as institutional actors, their role and function in the NIS is not concretely identified.

Secondly, a later wave of NIS literature questioned both the macro-approach of earlier studies and the importance of innovation systems as a solely national concept. As such, this literature developed concepts of technology, sectoral, and regional innovation systems. This diverse work placed a growing emphasis on processes, relation and spatial dynamics between actors leading to insight as to how new technologies arise, develop and diffuse and to how

innovation systems evolve over time. In this literature, the role and contribution of industry associations begins to emerge, particularly regarding advocacy and lobbying. This period also saw an increasing number of studies looking at the NISs of emerging economies such as India, Brazil, and China along with developing countries such as Indonesia and the Philippines, although much of the emphasis here is on sectoral systems of innovation.

Thirdly, a subset of more recent literature shows a growing emphasis on the internationalisation of innovation systems, looking more closely at the role and activities of MNCs and the prominence of global knowledge flows and markets. For developing countries, this raises questions and opportunities concerning global linkages as mechanisms for building innovation capacities, as well as questions of autonomy, influence, and control. This coincides with a growing literature on innovation within certain high-tech sectors such as ICT and biopharmaceuticals occurring in emerging powers such as India and South Africa. Within this literature, there is increasing yet limited work on the role of industry associations in developing countries (e.g. ICT in India), but a significant gap remains as to the diverse set of functions and activities that these industry associations actually perform.

In conclusion it might be said that although the NIS literature has so far paid little attention to the role of industry associations in innovation, the current shift towards emerging economies and less developed countries requires more systematic investigation of these institutional intermediaries and their role in influencing politics of development. Only this way we can achieve better understanding of innovation institutions in developing countries.

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