8. THE GLOBAL DIMENSION OF INNOVATION SYSTEMS

Linking Innovation Systems and Global Value Chains

Carlo Pietrobelli and Roberta Rabellotti

8.1. Introduction

In these days nobody would resist the contention that learning and innovation are key determinants of competitiveness and growth of nations, regions and firms. Sometimes, more refined observers would stress that competitiveness is affected by firm-specific attitudes and actions together with the meso and macroeconomic contexts in which firms operate. In advanced countries, the concept of National Innovation System (NIS), introduced by Freeman (1987) has accounted for the role played by the institutions (the rules of the game) and the organizations that systemically interact and have an effect on the creation and diffusion of innovations in any national economic system. As it has been discussed in the previous chapters of the Handbook the most useful definition of innovation systems might not necessarily coincide with national borders and therefore other concepts have been introduced, such as 'technological systems' (Carlsson and Stakiewicz, 1991), 'regional innovation systems' (Cooke, 1992) and 'sectoral innovation systems' (Breschi and Malerba, 1997).

Moreover, in recent years it has increasingly been stressed that the innovation system approach needs to be enriched by the international dimension (Asheim and Herstad, 2005; Bunnel and Coe, 2001; Carlsson, 2006; Fromhold-Eisebith, 2007). The point made in these contributions is that the Innovation Systems (IS) literature has underemphasized the crucial impact of international information exchange and collaboration on the generation and diffusion of knowledge and innovation through different channels, as for example inter-firm, intra-firm and individual networks.

In less developed countries (LDCs), the extra-national influences on the innovation process are particularly crucial given that linkages with foreign firms and organizations play a central role to help operate Innovation Systems, as new frontier innovation is scarcely created and the bulk of knowledge and technology is imported.

Different strands of literature have analysed the impact of foreign firms in the process of innovation and learning in LDCs; these range from the exploration of the learning and efficiency-improving potential offered by exports ("learning from exporting", see Wagner, 2007 for a survey) to the focusing on the role of Foreign Direct Investments (FDI) through spillovers, imitation and direct innovation efforts (Barba Navaretti and Venables, 2004; UNCTAD, various years; see also Chapter 10 by Marin and Arza in this Handbook).

Another channel to access knowledge and enhance learning and innovation in firms located in less developed countries are Global Value Chains (GVC). Recent wide empirical evidence shows that firms in LDCs are increasingly involved in GVC as providers of inputs or specialised suppliers and through their participation they may build up their production, technological and innovation capabilities (Gereffi, 1994 and 1999; Giuliani *et al.*, 2005; Kaplinsky, 2000; Humphrey and Schmitz, 2002 a and b;

Pietrobelli and Rabellotti, 2007. See also Chapter 3 by Cozzens and Kaplinsky in this Handbook). According to this literature, the extent to which firms might acquire new capabilities through the insertion in the GVC is highly contingent to the different pattern of governance dominating the chain (Gereffi *et al.*, 2005).

As we study the international dimension of Innovation System, it becomes crucial to understand how different patterns of GVC governance influence learning and innovation of firms. This implies addressing two main groups of research questions:

- How does the learning mechanism operate in different chains? In which chains are lead firms promoting learning through increased pressure? In which ones are they supporting the innovation process through deliberate knowledge transfer and direct involvement in the learning and innovation process? In which type of chains is learning instead resulting from unintended knowledge spillovers?
- What is the role of the innovation systems, at national, regional or local level, in this GVC-driven learning and innovation process? How can innovation systems foster (hinder) the efforts of developing countries' firms to gain a profitable entry into, and interaction within GVCs?

This chapter addresses these questions, being organised as follows. Next section briefly discusses the appropriateness of the concept of IS, developed having in mind advanced industrial countries, for LDCs, and reviews the literature adapting/introducing new concepts. Section 8.3 reviews the main issues analysed in the GVC literature, with special reference to the different patterns of governance and introduces a detailed discussion of the different mechanisms of learning prevailing in the various types of

chains. Then Section 8.4 explicitly links the literature on GVCs and their governance with the notion of IS. Section 8.5 concludes.

Box 8.1 The Global dimension of Innovation Systems: main terms used in this chapter

Value Chain = the full range of activities that firms do to bring a product from its conception to its end use and beyond. This includes activities such as design, production, marketing, distribution, support and after-sale services to the final consumer.

Global Value Chain = when the activities above are divided among different enterprises located in different countries.

GVC Governance = the process of co-ordinating activities in a chain. Governance may occur through arms' length market linkages or non-market relationships.

Upgrading = innovation to increase value added.

Product upgrading = moving into more sophisticated product lines in terms of increased unit values.

Process upgrading = transforming inputs into outputs more efficiently by reorganizing the production system or introducing superior technologies.

Functional upgrading = acquiring new, higher-value-added functions, such as design or marketing, abandoning lower-value-added functions, such as assembly.

8.2. Innovation Systems in Less Developed Countries

The idea that innovation occurs in a 'system' – a set of interacting enterprises, institutions, research bodies and policy making agencies that share knowledge and jointly and individually contribute to the development and diffusion of new technologies – is by now widely accepted. The notion of Innovation System is rooted in List's concept of 'National Systems of Production' (List, 1841) and in more recent times was introduced by Freeman in his 1987 book to account for the outstanding process of economic growth of Japan in the post war period. In the following years many other scholars have contributed to elaborate this concept.[1]

The introduction of the IS concept in LDCs is more recent, but it has rapidly diffused, as discussed in the introduction and several chapters in this Handbook. This follows the realization of the need for conscious and purposive innovation effort and capacity building in less developed countries, even if relying primarily on imported technology. It is likely that there are similar – to developed countries - systemic elements that affect LDCs' ability to innovate and to access, master, adapt and improve upon imported technologies (Freeman, 1995), and to build the required competences (Lundvall *et al*., 2002). And it is also likely that these elements differ across countries – this is vital to explaining the widening gap between a small group of successful emerging countries and the rest of the less-developed world, what Abramovitz (1986) terms the 'forging ahead', 'catching up', 'falling behind' of economies.

There are a number of reasons why the application of the concept of IS in a developing country's context is not at all straightforward. First, the processes of innovation are of

different nature with respect to developed countries: incremental innovations and absorption of knowledge and technologies new to the firms are more frequent and relevant than radical innovations that are new to the world. While the analysis of IS in industrialized economies has increasingly focused on R&D and frontier innovation, in most LDCs, the nature of innovation is quite different. However, since the nature of technological needs and the market failures[2] that surround technological effort differ between developed and developing countries, the innovation system differs in some respects as well: developing countries have a greater need to build the initial base of capabilities and so need to support their industry learning processes; their markets and support institutions are less developed, and so less responsive to enterprise needs; information networks and clusters are thinner; the macroeconomic framework for industrial and technological activity is less conducive; the entrepreneurial capacity to undertake risky technological effort may also be less developed and the financial system less geared to supporting such effort.

Second, key science and technology organizations of the innovation system often analysed in developed countries, such as universities, R&D laboratories, and research institutes, in some developing countries are missing or may be inadequate, and linkages among them and with local firms are inexistent or rather weak; indeed, the organizations that often matter more in such "systems" in developing countries are organizations dealing with technology diffusion and extension (metrology, standards, testing, quality – MSTQ).

Third and key for the scope of this chapter, the inflows of knowledge and technology from external sources are essential components in the innovation and learning processes in LDCs. From this it follows that policies and institutions affecting international flows

of equipment and services, human capital and foreign investments, as well as global value chains also matter.

In this regard, a caveat is due to stress that within less developed countries there are increasingly differences in terms of innovation and technological capacity. A small number of developing countries (often referred to as emerging countries) have begun to make the difficult transition from being economically successful in industrial production to building up innovation capabilities. The depth and width of this transition is not yet clear, and although it has attracted a lot of attention among policymakers and in the media, there is not much research available on it (Schmitz and Strambach, 2008). Nevertheless, it is clear that in countries like China and India the IS or some parts of it are very similar to developed countries' innovation systems and in some sectors even of world class standards (Altenburg *et al*., 2008).

While acknowledging the very differentiated reality hidden by the sketchy and simplistic definition of "less developed countries", we still argue that, due to the reasons listed above the analysis of the innovation systems in LDCs has to be different from that of mature industrialized countries. Since the bulk of technological activity in the former concerns the absorption and improvement of existing technologies rather than innovation at the frontier[3], For most firms in developing countries the ability to use existing technologies at competitive levels of cost and quality is what really matters. This follows from the bi-dimensional nature of the process of technological change in developing countries: the absorption of technology and knowledge produced elsewhere and the local generation of incremental innovation. This implies a shift in the focus and a renewed interest on different organizations: more MSTQ and less basic research and frontier innovation. This view of the system as open and deeply inserted in global flows

of knowledge and technology is shared by other scholars such as Ernst (2002), who believes that NIS theory fails to address the disruptive changes imposed by globalisation on the geography of innovation systems.

Moreover, it is by now widely agreed that there is a need to adopt a broader notion of innovation system that includes economic, social, educational and political institutions that can affect learning and technology and knowledge diffusion (Arocena and Sutz, 1999; Cassiolato *et al*., 2003; Chaminade and Vang, forthcoming; Edquist, 2001; Gu, 1999; Intarakamnerd et al., 2002). In developing countries – to a larger extent than in industrialized countries - this includes the policies governing the macroeconomic framework, international trade, migration and foreign direct investment flows, cross-border operations of trans-national corporations and global value chains, as well as education and technical training, and technology diffusion.

To conclude, the literature on IS in less developed countries unanimously agrees on the crucial role played by foreign sources of technology, knowledge and innovation, but it fails to understand how these global learning processes take place or what are the mechanisms that might enhance or hinder the transfer of knowledge within firms participating in global value chains. The literature of GVC might shed some light on these issues..

8.3. GVCs in developing countries

8.3.1. The patterns of governance

It is by now common knowledge that enterprises outsource a number of activities which they had previously handled internally, keeping in-house those activities on which they do have core competences. Different parts of the production processes are therefore increasingly dislocated in different developed and developing countries according to their specific endowments of factors and capabilities, or to additional strategic considerations (e.g. fiscal incentives, market access, local physical and technical infrastructures, etc.)

A common feature in this new global division of labour is that lead firms, often from developed countries, engage in coordinating the activities of their business partners upstream and downstream. Altenburg (2006a) explains the engagement in coordination of lead firms with their needs to compete on innovation and costs not only in their own operations but in all external activities, which impact on the innovativeness and cost of the final product. Moreover due to increasing pressure from consumers, lead firms are not only required to prove the tangible and intangible quality features of their final products, but also to trace them back to the individual suppliers participating in the production process.

Over the past two decades, this form of coordinated trade has given rise to a new line of research: the Global Value Chain (GVC) analysis. The value chain describes the full range of activities that firms do to bring a product from its conception to its end use and

beyond. This includes activities such as design, production, marketing, distribution, support and after-sale services to the final consumer. Indeed, rarely do individual companies alone undertake the full range of activities required to bring a product from conception to market. The design, production, and marketing of products involve a chain of activities that are divided among different enterprises, often located in different places and sometimes even in different countries, hence the term global value chain.[4]

An important contribution of the GVC literature is the shifting of the analytical focus from manufacturing alone to include all the other activities involved in the supply of goods and services, including "intangible" phases such as distribution, marketing or innovation (Kaplinsky, 2000; Wood, 2001). All activities contribute to total value, but some add more value than others, and therefore it becomes crucial to identify which activities are providing higher returns (i.e. "premia") along the value chain. These differences among activities are relevant in order to understand the global distribution of value added - and, to our aims, the opportunities open to LDCs firms' competitiveness and upgrading.

The focus of value chain research is on the linkages through which information and knowledge, as well as goods, flow among the various actors involved in the chain and on their implications for development (Humphrey and Schmitz, 2002b). The concept of governance is central to the analysis of the relationships among actors in the chain that might, in turn, facilitate or hinder the transfer of knowledge between the different actors.

In 2005 Gereffi *et al.* (2005) have introduced a useful typology which identifies five different GVC governance patterns, discussing under which conditions these types can be expected to arise. According to the authors, three factors determine the lead firm's

choice between one of the different patterns: the complexity of information involved in the transactions, the possibility to codify information and the competence of suppliers along the chain. The five analytical types, represented in Table 8.1, are:

- Market-based chains characterised by low complexity of transactions, simple and easily codified product specifications and capable potential suppliers.
- Modular chains characterised by highly codified links simplified by technical standards, where suppliers make products to a customer's specifications and take full responsibility for process technology.
- Relational chains characterised by complex transactions and highly idiosyncratic relationships which are difficult and time-consuming to re-establish with new value chain partners (i.e. “switching costs” are high). In these chains mutual dependence is regulated through reputation, social and spatial proximity, family and ethnic ties, where trust plays a central role.
- Captive chains characterised by suppliers with low capabilities, dependent on larger, dominant buyers, who exert a high degree of monitoring and control.
- Hierarchy is a governance form implying vertical integration when transactions are complex and not easy to codify and the competence of suppliers is low.

The GVC literature also stresses the role played by the leaders of the chain in transferring knowledge to their suppliers. For small firms in less developed countries, participation in value chains is a crucial means of obtaining information on the type, quality of products and technologies required by global markets and of gaining access to those markets. However, this information needs to be blended with local technological capabilities and this requires substantial technological and learning efforts (Morrison *et*

al., 2008). What role the leaders of the GVCs actually play in fostering and supporting this process is one of the focus of this literature (Giuliani *et al*., 2005). In this sense, empirical evidence suggests that insertion in different types of chains may offer different opportunities for upgrading. Humphrey and Schmitz (2002a) show that process and product upgrading is often supported by GVC leaders, who may instead hinder functional upgrading to protect their core competences. Relational value chains[5] offer ideal conditions for all forms of upgrading, but they are the least likely to occur among producers in developing countries.

Table 8.1- The Gereffi-Humphrey-Sturgeon Theory of Value Chain

Governance Type	**Complexity of transactions**	**Codification of transactions**	**Competence of suppliers**
Market	Low	High	High
Modular	High	High	High
Relational	High	Low	High
Captive	High	High	Low
Hierarchy	High	Low	Low

Source: adapted from Gereffi *et al*., 2005

Within this framework Pietrobelli and Rabellotti (2007) add the sectoral dimension and provide empirical evidence on a wide variety of GVCs in Latin America. The need to take into account sectoral differences is based upon the consideration that industrial sectors differ in terms of their technological complexity and in the modes and sources of

innovation and upgrading.[6] As innovation studies have shown, in some sectors vertical relations with suppliers of inputs may be particularly important sources of product and process upgrading, as in the case of textiles and most traditional manufacturing. While in other sectors, the major stimuli for technical change may be provided by technology users, organizations such as universities or the firms themselves as, for example, in software or agro-industrial sectors (Pavitt, 1984). In turn, considering that in traditional manufacturing sectors technology has important tacit (Polanyi, 1967) and idiosyncratic elements, upgrading is expected to depend on the intensity of technological externalities and cooperation among local actors (e.g., firms, research centres, technology and quality diffusion centres). From this it follows that global buyers are forced to be more involved and interested in their providers' upgrading if the technology required is mainly tacit and needs intense interaction. Moreover, in traditional manufacturing industries, characterized by a low degree of technological complexity, firms are likely to be included in global value chains even if they have low technological competences. Therefore, tight supervision of and direct support to suppliers becomes a necessary condition for global buyers who face high "switching costs", and want to reduce the risk of suppliers' non-compliance (Humphrey and Schmitz, 2002b).

An additional point made in the GVC literature is that chain governance is a dynamic process. According to Schmitz (2004), a dynamic perspective helps to recognize why the limits to upgrading met in some chains might be temporary and overcome when governance patterns evolve. The dynamics of governance patterns is certainly crucial to understand the opportunities of suppliers "to go up the value ladder", moving away from the "low road" to competitiveness in which competition is mainly based on price and squeezing wages, and barriers to entry are low (Pietrobelli and Rabellotti, 2007).

Nevertheless, LDCs small suppliers face wide opportunities for upgrading also building and deepening their technological capabilities at each (same) stage of the value chain. As argued in Morrison *et al.* (2008), the key issue is not always moving into more advanced functions "along the value chain", but often deepening the specific capabilities required to explore new opportunities offered "on the side" of the stage of the value chain where the firm is currently engaged. Moving from natural resources to their exploitation, manufacturing, packaging, distribution and branding is very important and can be described as somehow "climbing the ladder". But deepening capabilities to explore new original features and varieties at each stage of the GVC (e.g. from new flower varieties via biotechnological research to new packaging with original highly-valued characteristics) is indeed also important, and clearly requires creation and deepening of higher skills and more complex technological capabilities.

8.3.2. The learning mechanisms within GVCs

As seen above, integration in GVCs is increasingly common among small firms in LDCs, which get access to knowledge, learn and innovate thanks to their participation in these chains. To satisfy the requirements in terms of product quality, delivery time, efficiency of processes, environmental, labour and social standards imposed within the chains, firms specialised in the different phases of the chains have to learn and innovate. In the previous section, we stressed the relevance of making the distinction among the different patterns of governance proposed by Gereffi *et al.* (2005) and in this section we

explore the main mechanisms of learning and innovation which prevail in the different chains. Let us discuss them in a sequence (Table 8.2).

Table 8.2- The learning mechanisms in GVC

Governance Type	**Learning mechanisms**
Market	• Knowledge spillovers • Imitation
Modular	• Learning through pressure to accomplish international standards. • Transfer of knowledge embodied in standards, codes, technical definitions
Relational	• Mutual learning from face-to-face interactions
Captive	• Learning via deliberate knowledge transfer from lead firms confined to a narrow range of tasks – e.g. simple assembly.
Hierarchy	• Imitation • Turnover of skilled managers and workers • Training by foreign leader/owner • Knowledge spillovers

In *market-based GVCs,* only firms holding adequate capabilities can eventually become suppliers in the chains. The inclusion in the GVC offers an open window – and the related information - on the global market's requirements in terms of products, processes, technology and standards. The main mechanisms of learning are spillovers and imitation through which small LDCs firms capture the knowledge needed for

adaptive change and innovation in order to stay in the chain. Schmitz (2004) provides some examples of market-based chains sharing a common characteristic: the small size of buyers. In Brazil, buyers selling in the domestic market purchase ready-designed shoes and either sell them under their own labels or under the supplier's own brand. Similarly, in Ludhiana (India) the knitwear firms selling to small foreign traders develop their own products (Tewari, 1999). Based on this empirical evidence, Schmitz (2004) concludes that advances in functional upgrading (see Box 8.1) seem to be facilitated by dealing with small rather than large customers. It is the different capabilities of firms to make the required investments in design, product development and marketing that may explain why some firms succeed and others do not.

In *modular chains* the suppliers learn how to produce components and modules with fully specified technical standards. The need to accomplish these standards is an important channel inducing learning; lead firms impose on their suppliers the pressure to innovate and to keep up with technological advancements, but they are not directly involved in the learning process. In other words, the lead firms represent a crucial external stimulus for the learning and innovation process of suppliers, being a spectator and a final judge of this process.

Firms involved in modular chains need to undertake highly specific investments, build specific production capabilities and constantly update them to enter and stay in the GVC. Nevertheless, they need to exert their learning efforts by themselves, as they are hardly supported by GVC leaders. As reported by Quadros (2004), in Brazil in the GM and Volkswagen GVCs local suppliers have improved their quality standards of production and achieved ISO 9000 certification, but leading firms in the chains have spent minor efforts to assist suppliers in the adoption of these standards. Instead, firms

received technical support mainly from consultancies and accredited certification institutions. Similar evidence is also observed in the automotive sector in Argentina (Albornoz *et al.*, 2002) and Mexico (Dutrénit *et al.*, 2002).

Given the high complexity of tacit information and knowledge transferred, in *relational chains* the linkages are very tight, often implying a lot of face-to-face interactions and mutual learning. In this type of chains, firms have highly complementary competences. LDCs suppliers should hold and be able to strengthen their production and linkage capabilities to interact with the lead firms in the GVC. The learning efforts needed imply (sunk) costs and take time, and this binds the parties to continued interaction, i.e. switching costs are higher.

The apparel firms in East Asia which have been able to upgrade from mere assembly to "full package" production, implying the capability to interpret designs, make samples, monitor product quality and meet buyer's price and time conditions are a good example of a relational value chain (Gereffi, 1999). According to Gereffi *et al.* (2005), the main opportunity of learning in such a kind of chain is that "….it allows local firms to learn how to make internationally competitive consumers goods and generates substantial backward linkages to the domestic economy." (92).

Another interesting case of local suppliers that have progressed from producing to the specification of their buyers to their own design manufacturing is presented by Kishimoto (2004) in his study on the Taiwanese computer industry. Analysing the same case, Guerrieri and Pietrobelli (2006) emphasize that from MNCs to local suppliers the knowledge is mainly transmitted through the supply of blueprints, the interaction of personnel and the transfer of tacit dimensions of technology creation. Besides, the relevant technology and technical expertise acquired in manufacturing in a GVC is

transferred in the products done for other multinationals and/or in the production for their own designed and branded products. Thus, Taiwanese firms often participate in more than one GVC. This is what Schmitz (2006), quoting Lee and Chen (2000) names "*the leveraging of competences across chains*" (561).

In Latin America another example of learning in a relational chain can be found in the Brazilian State of *Espírito Santo*, where local SMEs have benefited from interacting with larger firms, acting as "anchors" for the local cluster. This process has been fostered by the activities of intermediate institutions – match-making the interests of small and large firms – and by the active role of the local government, enjoying the authority and credibility to negotiate with large firms better linkages and collaboration with SMEs (Villaschi *et al.*, 2007).

In *captive chains*, lead firms actively intervene in the learning process of suppliers that lack the competences required. Their support is usually confined to a narrow range of tasks – for example simple assembly. However, there are risks of lock-ins because lead firms hardly sustain the development of strategic "core" capabilities. The case of the shoe industry in the Sinos Valley in Brazil (Bazan and Navas-Aleman, 2004; Schmitz, 2006) is an exemplification of how inclusion in GVCs can facilitate product and process upgrading but prevent functional upgrading, leaving firms dependent on a small number of powerful customers. In the Sinos Valley, local shoe suppliers were discouraged from engaging in design, marketing and sales because these are the core competences of the US buyers, the leaders of the main GVC. Brazilians have been feeding into the footwear value chain mostly as producers, and their buyers have been more than happy to keep the status quo. Other empirical evidence on the Brazilian sport shoe sector shows that in terms of design and product development the local suppliers have developed the

capability to adapt designs to local conditions (*tropicalizaçao*) but they have not been involved by the lead firms in new design development (Lemos and Palhano, 2003).

In this regard, Schmitz (2006) makes an important point explaining that over time the direct involvement of US buyers in assisting the product and process upgrading of Brazilian shoe producers diminished: initially in the 1980s most of the support came from US specialised technical staff, who was gradually replaced by local staff and moved to China in the 1990s, because the risk of supplier failure was much higher there at that time.

The Sinos Valley offers an additional insight on important learning mechanisms that occur across (inter-) GVCs. In fact, in this case functional upgrading in design, branding and marketing, prevented by US buyers, has been achieved by those firms selling to buyers in the domestic and regional markets in Latin America . A similar process of transferring experiences from one chain to the other has also been detected among the Mexican footwear producers selling in the domestic market and in some cases also in the rest of Latin America (Rabellotti, 1999).

Finally, at the opposite extreme of the typology is *vertical integration*, where the lead firm takes direct ownership of some operations in the chain. This turns out to be like the case of the intra-firm trade between a trans-national company and its subsidiaries, implying various potential mechanisms of learning, widely analysed in the literature on FDIs in LDCs, such as transfer of management, skilled labour turnover, training of local workforce, knowledge spillovers and imitation (Barba Navaretti and Venables, 2004).

8.4. Linking learning patterns in GVC with innovation systems

The GVC analysis suffers from a significant shortcoming because it does not pay much attention to the institutional context within which local firms interacting in GVCs are embedded. This limitation has been rightly stressed in the literature on Global Production Networks (GPN) which deals with how actors in various GPNs are embedded in different places, including therefore the geographical dimension from the national to the local scale (Ernst, 2002, Hess and Yeung, 2006). The work of geographers and planners on local industrial agglomerations has also stressed the spatial embeddedness of tacit knowledge and the importance of tight interdependencies between geographically clustered firms (Storper, 1995).

At the national level, the relevance of rules, values and institutions (e.g., financial system, corporate governance, education and training systems) profoundly affecting the character and evolution of industries and firms has instead been stressed in the literature on the varieties of capitalism (e.g. Berger and Dore, 1996). Among these rules and organizations especially remarkable are those "…. elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge, … and are either located within or rooted inside the borders of a nations state" (Lundvall, 1992). These institutions and these organizations may have profound effects on value chain governance and on the appropriate innovation and learning strategy of firms in developing countries. In this section we try to integrate the two approaches discussed above to address the issue of the role that innovation systems may play within the GVC-driven learning and innovation process in developing countries. To this aim, we follow up on the classification discussed so far.

Our focus is on two aspects of innovation systems: innovation policies and organizations. Innovation policies cover such areas as technology import by licensing and FDIs, networking, incentives for local R&D and for training and in general competence building in different organizations of the system. The organizations are the main actors in the system. In the following discussion we will focus mainly on technology organizations like quality, standards, metrology and technical extension bodies, R&D and training organizations such as universities or research centers. This partly differs from industrial countries – as noted above – where the emphasis lays much more on basic research and creation of new knowledge. These organizations may be government-run, started by the government but run autonomously, or started and managed by industry associations or private actors. In developing countries, government-run organizations often play a leading role, given the weakness and precariousness of the private productive sector.

Many services provided by these organizations are essentialy ‘public goods’, facing market failures of the sort that every government, regardless of its level of development, has to remedy. Among these services, we can mention:

a). public research institutes and universities undertake basic research that does not yield commercial results in the short term, but provides the long-term base of knowledge for enterprise effort;

b) quality, standards and metrology institutions provide the basic framework for firms to communicate on technology and keep the basic measurement standards to which industry can refer

c) extension services help overcome the informational, technical, equipment and other handicaps that SMEs tend to suffer.

How do different innovation systems affect the determinants of GVC governance? The relationship between the form of governance and the nature of the system cannot be univocal (one-to-one), given the variety of possible systems and the endogeneity of most of these events, with frequent two-way directions of causality and continuous feed-backs.[7] Moreover, the nature of the innovation systems often has effects across the whole range of possible modes of governance of value chains. Following Table 8.3. we discuss the relationship between the GVC governance and the nature of the IS by looking at how the latter affects the three key determinants: complexity of transactions, extent of codification, and suppliers' capabilities.

8.4.1. Complexity of transactions and innovation systems

A well-structured and efficient innovation system may help to reduce the complexity of transactions, and therefore make transactions based on markets or on weak hierarchical forms of GVC governance possible – the risk of falling into a captive relationship, or even of being acquired by a leader, diminishes. In other words, the lower the complexity of transactions the less an effective IS is needed - but an effective system also raises the capabilities to cope with complex transactions.

When investors take make-or-buy decisions, they face a trade-off between lower costs of production and increasing transaction costs. In countries with weak institutions, implying weak contract enforcement, pervasive corruption, cumbersome bureaucratic

procedures, multiple barriers to trade and poor infrastructure it is difficult to capitalise on the benefits of inter-firm specialisation (Altenburg, 2006b).

The weaker the institutional framework is, the costlier and riskier will be contract enforcement, inter-firm coordination and transactions will be more difficult and therefore convenience tilts towards non-market forms of governance, and possibly up to vertical integration. An additional downside of the related unnecessary bureaucratic procedures and high administrative costs for the registration of small firms may be their exclusion from doing business, "emerging" out of informality, and from linking up with global and national value chains.

More specifically on science and technology, if the system offers efficient and homogeneous standards, testing, and quality assurance institutions and organizations, the costs of technology and learning-related transactions will be lower and easier and smoother will be the relational forms of governance. Likewise, local firms' learning in captive VCs may extend beyond simpler tasks into, for example, design and planning of activities. The experience of Taiwan in the industrial and technological development of its firms and clusters offers insightful examples of an innovation system supporting the transition from hierarchy and captive chains led by foreign leaders to local innovation, functional upgrading, domestic firms-led value chains. Taiwan's IS grew stronger over time thanks to substantial investments in human capital and scientific and technological research, institutions and rules rewarding innovation, and organizations such as S&T parks that further eased efficient inter-firm and University-Industry collaborations in high-tech activities (Guerrieri *et al*., 2001; Saxenian and Hsu, 2001; Tsai and Wang, 2005; Wen-Hsiung and Wei-Tzen, 2000).

8.4.2. Codification of transactions and innovation systems

In market-based transactions, all relevant information is conveyed by the market price – given that the complexity of transactions is rather low. However, if complexity increases, most enterprises in developing countries are likely not to have the internal skills and capabilities to operate within a context of codified transactions. The innovation system may enhance their efforts, and especially the metrology, standards, testing and quality (MSTQ) infrastructure.

MSTQ institutions form the basic infrastructure of technological activity in any country. Standards are a set of technical specifications used as rules or guidelines to describe the characteristics of a product, a service, a process or a material. The use of recognized standards and their certification by internationally accredited bodies – and sometimes by GVC leaders themselves - is increasingly demanded in world trade.[8] Standards can reduce transactions costs and information asymmetries between the seller and the buyer, and so minimize uncertainties with respect to quality and technical characteristics. Metrology (the science of measurement) provides the measurement accuracy and calibration without which standards cannot be applied. The application of standards and the certification of products necessarily imply (accredited) testing and quality control services.

In recent years, the importance of industrial standards has risen because of the fast pace of technical progress, the growing complexity of new products, the increasing multiple use of technologies and the growing fragmentation of industrial activities. Therefore, standards importantly contribute to the diffusion of technology within and across

industries. Most importantly, in a developing country a standards organization can disseminate best practice in an industry by encouraging and helping firms to understand and apply new standards and, to our present aims, this is also likely to induce an improvement in suppliers' competence. Redundant experimentation with new technologies is reduced, and enterprises are forced to use a common language that is also shared by the international market. In turn, this reduces the complexity of inter-firm technical linkages and collaboration.

The existence of well-structured (complete) MSTQ institutions and organizations has important implications for GVCs, for their governance and for developing countries' innovation and technology systems. Indeed, the better standards and metrology organizations are in a country, the easier it is to handle complex transactions and the easier it will be for a GVC leader to govern its web of local relationships. In principle, modular and relational chains are more likely to prevail, provided that local suppliers are competent, understand and use technical codes and standards. The choice of either form may in turn depend on the different degrees of codificability of knowledge.

Standards increasingly matter also for natural resource-based activities. Thus, for example, in Southern Chile a very successful salmon cluster has developed since the early 1990s, and the study of the standards setting and compliance processes offer remarkable insights (Katz, 2006, Maggi, 2007). More specifically, by complying with the standards, the Chilean salmon industry has achieved the transformation from 'passive' to 'active' learning, with greater involvement of local firms both as value chain leaders and suppliers in foreign-led chains (Iizuka, 2006). In this process, a meso-level institution, the Association of (Chilean) Salmon Industries, appears to have played a crucial role.

An explicit account of the dynamics may also help to better understand the implications that different systems may have on the GVC governance and on the opportunities for learning (Table 2): better systems of MSTQ organizations may enhance the probability of modular or captive forms of governance to occur and transition from a captive to a relational VC is easier with a "better" IS.

The probability of a relational value chain to emerge is related to the existence of complementary knowledge between the leader and local partners. Local clusters and firm agglomerations may help increase the local generation of innovative processes and practices, and this may further attract GVCs and induce them to choose relational forms of governance. Indeed, several authors have shown that such agglomerations are the places where the most relational portions of global value chains might be found (Sturgeon, 2003; Schmitz, 2004).

8.4.3. Suppliers' competence and innovation systems

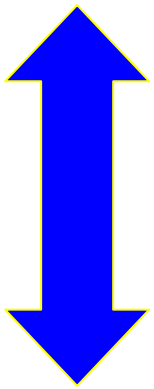
The innovation system also includes all the institutions and organizations that contribute to improve suppliers' competence. They consist of the organizations in charge of education and technical training, as well as the set of incentives that induce individuals to further invest in improving their knowledge and competences. While suppliers learn and improve their competences, the GVC governance is also likely to change accordingly. In very general terms, we would expect that increasing capabilities in the supply-base help to push the architecture of global value chains away from hierarchy and captive networks and toward more relational and modular chains (Gereffi *et al.*,

2005). However, higher suppliers' capabilities are also likely to have effects within the same mode of VC governance, and ceteris paribus, enhance learning mechanisms within all value chains and allowing suppliers to benefit to a larger extent from participating in VCs.

An example of the possible local interactions between technical competences, the IS and value chains is provided by the states of Jalisco (Mexico) and Penang (Malaysia), where strong local systemic coordination has produced human capital synergies in two of the largest electronics clusters in emerging economies (Rasiah, 2007). Local human capital and suppliers' competences, and the specific differentiation and division of labour that has emerged in Penang and Jalisco, have allowed remarkable integration with multinational corporations and global value chains.

However, although this has initially generated remarkable economic and export performance, it appears that the growing deficits in technical and R&D scientists and engineers, together with the relatively underdeveloped high-tech and R&D infrastructure in both Malaysia and Mexico, have undermined the capacity of MNCs and local firms to achieve functional integration. This situation has not attracted or produced higher value-added segments in value chains and the consequent horizontal integration necessary to drive regional synergies to higher levels.

Table 8.3 GVCs and the role of innovation systems

	Governance Type	Determinants	Systems of innovation	
1	**Market**	Low complexity		A well-structured, complete, smooth system makes **1-2-3** more likely to occur.
		High codification	MSTQ organizations matter	
		High supplier competence	Education, training organizations matter	
2	**Modular**	High complexity		
		High codification	MSTQ organizations matter	
		High supplier competence	Education, training organizations matter	
3	**Relational**	High complexity	"Local" systems and complementary knowledge matter	
		Low codification	MSTQ are perhaps less crucial	
		High supplier competence	Education, training organizations matter	
4	**Captive**	High complexity		
		High codification	MSTQ organizations matter	
		Low supplier competence		
5	**Hierarchy**	High complexity	Local R&D organizations may benefit from interaction	**4-5** may prevail also with 'poorer', fragmented systems. The chain leader may compensate system weaknesses, but upgrading is restricted.
		Low codification		
		Low supplier competence	GVC is expected to improve human technical skills	**Possible Dynamics** ▪ Improvement in MSTQ may ease shift towards **2 or 4** ▪ Improvement in "local" systems favour **3** ▪ Transition **from 4 to 3** is facilitated by improved systems

Source: authors' elaboration

Of course, suppliers' competences matter across the board, as human capital improvements matter in GVCs as well as in all other forms of industrial development and innovation. It has been suggested that lead firms should be involved in the design and implementation of policies (Altenburg, 2006a, Pietrobelli and Rabellotti, 2007). This is a reasonable proposal that could find a specific application in the joint definition (and to some extent implementation) of training programmes and university curricula on the basis of the needs expressed by leaders and local suppliers.

8.4.4. Learning across different chains (innovation systems may help)

The literature has shown that noteworthy learning mechanisms also occur across different value chains. Innovation systems may also help in this regard. As a matter of facts, this often happened in Taiwan in the 1990s, where Taiwanese firms, embedded in a developed IS, often participated in more than one GVC (Guerrieri and Pietrobelli, 2006), and *leveraged competences across chains* (Schmitz, 2006). This has also happened in the Sinos Valley, where suppliers could learn and employ different competences by working with two or more VCs.

Within this domain, public policies may sustain diversification of value chains and mechanisms of learning from one chain to the other. For example, an information-bargaining outfit to identify emerging/promising markets and chain leaders could help, through information and motivation events, subcontracting exchange schemes, supplier fairs and exhibitions (Altenburg, 2006b).

In sum, this section has shown that the IS interacts with GVC governance and suppliers' learning and innovation in multiple interesting ways. We have started to sketch some

possible forms of interactions and mutual effects. More analytical and empirical research may draw further light on these issues.

8.5. Conclusions

Questions have been raised over whether the spatial embeddedness of learning and knowledge creation might be challenged by alternative organizational forms.[9] According to this view, organizational or relational proximity would be more important than geographical proximity in supporting the production, identification, appropriation and flow of tacit knowledge. Thus, multinational firms as well as global value chains, with their dispersed but carefully organized knowledge bases and sites of innovation – often also in developing countries -, and their use of "community of practices", may well overcome the absence of geographical proximity.

This hypothesis with a focus on GVCs has been addressed in this chapter to argue that innovation systems interact with global value chains in multiple ways, and that they influence whether and how developing countries' firms may benefit from entering and interacting within GVCs. The relational proximity created within GVCs cannot replace – but rather interacts – with IS.

The Global Value Chain represents one of the most common options for small suppliers in LDCs to get access to international markets, to updated knowledge, innovations and new technologies. The attention on the different patterns of governance regulating the relationships among actors in the chains has pushed some scholars to put forward a theoretical framework to help explain why one form or another may prevail. The five

types of global value chain governance - market, modular, relational, captive and hierarchy – proposed by Gereffi *et al.* (2005) are our starting point to move a step forward and analyse the implications of these different patterns for learning and innovation in LDCs firms and in innovation systems.

The first main message here is that the different characteristics of the value chains have an impact on the mechanisms of learning prevailing in the chain. In general, LDCs firms learn and innovate thanks to their participation in the GVCs because they have to satisfy the requirements in terms of product quality, delivery time, efficiency of processes, environmental, labour and social standards imposed within the chains. Nevertheless, the learning mechanisms can be very different in the various types of chain: it can be the result of the pressure to accomplish international standards or it can be facilitated by a direct involvement of the chain leaders when the competence of suppliers is low and the risk of unsatisfactory compliance is very high. When the competences among actors in the chain are complementary, the learning mechanism can be mutual and based on intense face-to-face interactions. Finally, other channels of learning prevailing in the two forms of governance at the opposite extremes of the typology – market and hierarchy – are those widely analysed in the economic literature as knowledge spillovers and imitation. A number of additional implications have been documented in the literature. For instance, in modular chains learning in developing countries' firms tends to be confined to production capabilities, and the acquisition of capabilities in planning and design are often restrained. Similarly, in captive chains, lead firms actively favour the transfer of capabilities to undertake simple assembly tasks but hamper any attempt to develop other capabilities that are their core competences.

The second main message of this chapter is on the multiple forms of interaction between the IS, the GVC governance and suppliers' learning and innovation. More analytical and empirical research is needed to draw further light on these issues. However, we expect that a well-structured and efficient innovation system may help to reduce the complexity of transactions, and therefore make transactions based on the market or on weak hierarchical forms of GVC governance possible. In other words, the risk of falling into a captive relationship, or even of being acquired by a leader, diminishes. The lower the complexity of transactions the less an effective IS is needed- but an effective system also raises capabilities to cope with complex transactions. The system of organizations in charge of Metrology, Standards, Testing and Quality (MSTQ) also plays a central role, and may affect the convenience of different forms of governance.

The avenues for further research that this chapter opens are multi-fold. More quantitative analyses on value chains, their forms of governance, and the impact they may have on local firms is needed.[10] The same applies to innovations systems in developing countries, with their specificities. Moreover, as GVCs and their modes of governance tend to change over time, studies on their dynamics are also very necessary.

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NOTES

[1] Among the many see Freeman, 1995; Lundvall, 1992; Nelson, 1993; Metcalfe, 1995 and Edquist, 1997.

[2] The concept of 'market failure' is well known in economics, and refers to those situations when the market cannot function properly as to deliver the expected optimal allocation of resources. Failures in information and knowledge markets are especially widespread and diffuse (Stiglitz, 1989 and Lall, 2000).

[3] In this sense, we have argued in previous occasions that the term 'National Technology System' might be appropriate to developing countries than 'National Innovation System', in accordance with Lall and Pietrobelli (2002, 2003 and 2005).

[4] www.globalvaluechains.org presents a synthetic and clear presentation of these concepts.

[5] Humphrey and Schmitz (2002a) call networks the type of value chain named relational by Gereffi et al. (2005).

[6]In order to observe the variety of innovative processes across sectors, Nelson and Winter (1982) introduced the concept of ‘‘*technological regime*,” broadly defined as a technological condition that delimits the boundaries and the direction of the innovative and problem-solving activities of technicians. More recently, technological regimes have been differentiated on the basis of factors such as technological opportunity, appropriability of knowledge, cumulativeness of learning and nature of the knowledge base (Malerba, 2004).

[7] In an effort to develop the discussion, we will be tempted to classify innovation systems along a linear dimension (from “good” to “bad”), although we are fully aware that non-linearities and idiosyncracies are especially relevant and frequent here. Clearly, there is simply no single best way to organize an innovation system, and it is the different forms taken by IS that determine different effectiveness.

[8] The International Standards Organisation (ISO) has introduced the best known quality management (not technical) standards in use today: the ISO 9000 series. ISO 9000 certification has become an absolute must for potential exporters, signalling quality and reliability to foreign buyers, value chain leaders and transnational corporations seeking local partners and subcontractors.

[9] See Asheim and Gertler, 2005 for a discussion.

[10] See Pietrobelli and Saliola (2008) for a recent attempt to develop a method to measure GVC governance.

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