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Global Value Chains Meet Innovation Systems

Are There Learning Opportunities for Developing Countries?

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Abstract*

The literature regarding innovation systems (ISs) tends not to emphasize the crucial impact of international knowledge and innovation exchange and collaboration through, for example, inter-firm and intra-firm networks and global value chains (GVCs). In developing countries, knowledge and innovation exchange, and collaboration are crucial, with integration in GVCs playing a growing and very important role in accessing knowledge and enhancing learning and innovation. However, there is no agreement in the literature about how innovation systems and GVCs interact or how this interaction is likely to affect enterprise learning.

Three main conclusions emerge from the analytical framework and evidence presented in this paper. First, learning mechanisms can vary widely within the various forms of governance of GVCs: they can be the result of the pressure to achieve international standards or they can be facilitated by direct involvement of the value chain leaders when the suppliers' competence is low and the risk of failure to comply is high. When the competencies of the actors in the value chain are complementary, learning is mutual and is based on intense face-to-face interactions. Second, as innovations systems are "opened" to foreign sources of knowledge, the relationship between GVCs and ISs is nonlinear and endogenous, allowing all actors involved to benefit. Based on the model herein, a well-structured and efficient innovation system would help reduce transaction complexity and enable transactions based on relational forms of GVC governance. Third, the internal governance of a GVC is a dynamic phenomenon that is subject to continuous adjustments and changes, and the nature of the innovation system affects this co-evolution.

JEL Classification: F23, O14, O33
Keywords: Global Value Chains, Innovation Systems, Governance, Foreign Direct Investment, Learning, Upgrading, Productivity

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1. Introduction

No one would disagree that learning and innovation are essential to the competitiveness and growth of nations, regions and firms. In addition, some observers emphasize that innovation and learning are affected by firm-specific attitudes and actions, and the meso- and macroeconomic contexts in which firms operate. In advanced countries, the concept of an innovation system was developed to account for the role played by institutions and organizations that systemically interact and have an effect on the rate and direction of technological change in an economic system (Lundvall, 1992; Nelson, 1993).

Increasingly, however, it is being stressed in the literature that the innovation system approach would be enriched by an international dimension (Asheim and Herstad, 2005; Bunnel and Coe, 2001; Carlsson, 2006; Fromhold-Eisebith, 2007). The literature regarding innovation systems often plays down the crucial impact of international information exchange and collaboration on the generation and diffusion of knowledge and innovation, for example, through inter-firm and intra-firm networks.

In relation to less developed countries (LDCs), international information exchange and collaboration is even more important. The extra-national influences on the innovation process are particularly crucial given that frontier innovation is rarely achieved in LDCs and most of the knowledge and technology have to be imported. Various segments of the IS literature analyze the impact of foreign firms on the process of innovation and learning in developing countries (Wagner, 2007; Barba Navaretti and Venables, 2004; UNCTAD, various years), with the most recent focusing on global value chains (Gereffi, 1994, 1999; Giuliani, Pietrobelli and Rabellotti, 2005; Kaplinsky, 2000; Humphrey and Schmitz, 2002a,b; Pietrobelli and Rabellotti, 2007). For firms in developing countries, inclusion in a GVC not only provides new markets for their products, but also plays a growing and crucial role in access to knowledge and enhanced learning and innovation.

In taking account of the linkages of innovation systems to foreign sources of knowledge, it is important to recognize that the relationship between GVCs and ISs is nonlinear and endogenous, allowing all actors involved to benefit. For example, in terms of enterprise learning, GVCs may contribute to improving the local IS, which in turn would affect decisions about local sourcing of inputs and support for local firms' learning and innovation. This paper addresses two research questions: How do learning mechanisms operate in

different types of global value chains (i.e., through pressure to learn or through explicit support and deliberate knowledge transfer)? What is the supporting role of the innovation system in GVC-driven learning and innovation processes? Empirical evidence is used from the authors' research as well as secondary sources. Given the highly differentiated reality behind the sketchy and simplistic term "developing countries," the paper focuses on a particular group of middle-income developing countries: Brazil, Taiwan and Mexico. The next section of this paper discusses the concept of innovation systems in developing countries and review the main issues addressed in the GVC literature to highlight the different mechanisms of learning that may prevail in different types of value chains. The following section explicitly links GVCs and their different governance patterns to the notion of innovation systems and discusses avenues of mutual interaction.

2. Innovation Systems and Global Value Chains in Developing Countries

2.1 Innovation Systems

Application of the innovation system concept (Freeman, 1995; Lundvall, 1992; Nelson, 1993; Metcalfe, 1995; Edquist, 1997) to developing countries is relatively recent but is increasing rapidly even though there are a number of reasons why this is not straightforward (Arocena and Sutz, 1999; Cassiolato, Lastres and Maciel, 2003; Edquist, 2001; Intarakamnerd, Chairatana and Tangchitpiboon, 2002; Lundvall et al., 2009).

First, innovation processes in LDCs differ from those in developed countries. In developing countries, incremental innovation and absorption of knowledge and technologies is more frequent and relevant than the sometimes radical and new to the world innovation that happens in developed countries. While the analysis of innovation systems in industrialized economies increasingly focuses on research and development (R&D) and frontier innovation, in most LDCs, the nature of the technological effort is quite different and is based mainly on firm-level activities that are not included in formal measures of innovation. In developing countries, most innovation is based on non-R&D activities that consist of operationalizing technology that is new to of the particular application (Bell, 2007). Second, the main science and technology organizations analyzed in developed country contexts, such as universities, R&D laboratories and research institutes, may not exist in some developing countries or may be inadequate, and linkages among them and with local firms may be nonexistent or very weak. The organizations that are more important in the systems in developing countries are those providing technology diffusion and extension services such as metrology, standards, testing

and quality (MSTQ), and technical and organizational consultancies (or knowledge-intensive business services, KIBS). Third, inflow of knowledge and technology from external sources is essential for innovation and learning in LDCs. Thus, what matters are the policies and institutions that affect international flows of equipment and services, human capital and foreign investments, as well as the global value chains.

This has led some authors to propose the term "national technology system" since the bulk of technological activity in developing countries concerns absorption and improvement of existing technologies rather than frontier innovation (Lall and Pietrobelli, 2002, 2003, 2005).[1] Most importantly, the concept of a national technology system emphasizes that in developing countries what is essential is the ability to absorb technology and knowledge produced elsewhere and to incrementally generate innovation.[2] In the emerging global pattern of industrial organization, GVCs represent an increasingly important opportunity for firms in LDCs to learn and innovate.

2.2 GVCs and Patterns of Governance

It is quite common for enterprises to outsource a number of activities that previously were handled internally and to keep in house those activities in which they have core competencies. Different parts of production processes are becoming increasingly dislocated across various developed and developing countries.[3] A common feature in this new global division of labor is that lead firms, often from developed countries, coordinate the activities of their business partners upstream and downstream. They may prefer different forms of governance for different strategic reasons. A very useful typology of GVC governance patterns was proposed by Gereffi, Humphrey and Sturgeon (2005), who discuss the conditions under which different patterns can be expected to emerge. According to these authors, three factors determine the lead firm's choice of governance: the complexity of the information involved in the transactions, the possibility of codifying that information and the competence of the suppliers along the value chain.

[1] In LDCs there are huge differences in innovation and technological capacity. A small number of developing countries have begun to make the difficult transition from being economically successful in industrial production to building innovation capabilities (Schmitz and Strambach, 2009). Thus, China and India, or some parts of these countries, have very similar innovation systems to those in developed countries and in some sectors are a world class standard (Altenburg, Schmitz and Stamm, 2008).

[2] This view of a technology system as open and deeply embedded in global flow of knowledge and technology is shared by scholars such as Ernst (2002) who believes that innovation system theory fails to address the disruptive changes imposed by globalization on the geography of an IS.

[3] www.globalvaluechains.org provides a synthetic and clear presentation of these concepts.

The GVC literature stresses the role played by the leaders in the chain in terms of transferring knowledge to their suppliers. For small firms in LDCs, participation in value chains is a crucial means of obtaining information about the type and quality of products and technologies required by global markets and of gaining access to those markets. However, this information needs to be combined with local technological capabilities, which requires substantial technological and learning efforts (Morrison, Pietrobelli and Rabellotti, 2008). What role the leaders of a GVC play in fostering and supporting this process is one of the focuses of the literature (Giuliani et al., 2005).

The analysis for this paper showed that the dynamics of governance patterns is crucial for understanding the opportunities for suppliers to move up the value ladder, moving from the low end to competitiveness, where competition is based mainly on price and squeezing wages, and the barriers to entry are low (Pietrobelli and Rabellotti, 2007, Pietrobelli, 2008). By building and deepening their technological capabilities, small suppliers in LDCs can exploit opportunities for different types of upgrading: **process upgrading** is transforming inputs into outputs more efficiently by reorganizing the production system or introducing superior technology; **product upgrading** is moving into more sophisticated product lines in terms of increased unit values; **functional upgrading** implies acquiring new, superior functions in the chain, such as design or marketing, or abandoning existing lower-value-added functions to focus on higher-value-added activities; **inter-chain upgrading** is applying the competence acquired in a particular function to move into a new chain. The challenge is not always about moving into more advanced functions but is often about deepening the specific capabilities required to explore new opportunities in the value chain stage in which the firm is currently engaged (Morrison et al., 2008). Moving from exploitation of natural resources to manufacturing, packaging, distributing and branding can be described as climbing the ladder. But deepening capabilities to explore new original features and varieties at each stage of the global value chain (e.g., from new flower varieties using biotechnological research, to new packaging with original, highly valued characteristics) is also important and clearly requires learning, creating and acquiring higher level skills and more complex technological capabilities.

2.3 Learning Mechanisms within GVCs

It is increasingly common for firms in LDCs to participate in a GVC to access knowledge and learn how to innovate. To satisfy requirements related to product quality, delivery time, efficiency of processes, environment, labor and social standards imposed by a GVC, firms

specialized in different functions have to learn and innovate. The governance of the GVC influences how learning takes place, and different mechanisms of learning and innovation are likely to dominate in different types of chains. Table 1 presents some empirical evidence about the different learning mechanisms discussed in the rest of this section.

Table 1. Learning Mechanisms within a GVC

Governance type	Complexity of transactions	Codification of transactions	Competence of suppliers	Learning mechanisms within GVC
Market	Low	High	High	▪ Knowledge spillovers ▪ Imitation
Modular	High	High	High	▪ Learning through pressure to accomplish international standards ▪ Transfer of knowledge embodied in standards, codes, technical definitions
Relational	High	Low	High	▪ Mutual learning from face-to-face interactions
Captive	High	High	Low	▪ Learning via deliberate knowledge transfer from lead firms ▪ Confined to a narrow range of tasks (e.g., simple assembly)
Hierarchy	High	Low	Low	▪ Imitation ▪ Turnover of skilled managers and workers ▪ Training by foreign leader/owner ▪ Knowledge spillovers

Source: Adapted from Gereffi et al., 2005

Arm's-length GVCs, which are more usual for relatively simple and easily codifiable transactions involving competent suppliers, only accept into the value chain suppliers with the required capabilities. Inclusion in a GVC provides a window into—and related information about—the global market's requirements in terms of products, processes, technology and standards. The main learning mechanisms are spillovers and imitation, which

allow small LDC firms to capture the knowledge about adaptive change and innovation needed to stay in the value chain.

Schmitz (2004) provides some examples of market-based chains characterized by the small size of buyers. In Brazil, buyers selling in the domestic market purchase ready-designed shoes and sell them either under their own labels or under the supplier's brand. Similarly, in Ludhiana (India), knitwear firms sell to small foreign traders and these firms also develop their own products (Tewari, 1999). Based on this empirical evidence, Schmitz (2004) concludes that advances in functional upgrading seem to be facilitated by dealing with small rather than large customers. Firms' varying capabilities to make investment in design, product development and marketing may explain why some succeed and others do not.

When the complexity of the transactions is high and there are capable potential suppliers, then **modular chains** prevail with highly codified links and transactions. Technical standards that require suppliers to make products to a customer's specifications and to take full responsibility for process technology contribute to codification. In modular chains, suppliers learn how to produce components and modules to fully specified technical standards. The need to adhere to these standards induces learning – lead firms put pressure on their suppliers to innovate and keep abreast of technological advancements but do not become directly involved in the learning process. In other words, lead firms represent a crucial external stimulus for learning and innovation among suppliers and are the spectator and final judge of the process. In addition, upgrading within modular chains may result in positive externalities for the rest of the economy based on spillover to other sectors served by the same suppliers.[4]

Firms participating in modular chains need to undertake specific investments, build specialized production capabilities and constantly update services and equipment to remain in the GVC. Their learning efforts must be accomplished independently since they are not supported by the GVC leaders. In analyzing GM and Volkswagen in Brazil, Quadros (2004) shows that local suppliers within the GVC improved their production quality and achieved ISO 9000 certification, but the leading firms in these chains played little part in assisting suppliers to meet these standards. Technical support came mostly from consultancies and accredited certification institutions. Similar evidence was found for the automotive sectors in Argentina (Albornoz, Milesi and Yoguel, 2002) and Mexico (Dutrénit, Vera-Cruz and Gil, 2002).

[4] The authors thank an anonymous referee for pointing this out.

In **relational chains** transactions are complex and not easily codified. Relationships tend to be idiosyncratic and thus difficult and time-consuming to re-establish with new value chain partners (i.e., switching costs are high). In relational chains, mutual dependence is regulated by reputation, social and spatial proximity, long-term commitment and reputation, and in some cases is based on family and ethnic ties. Trust is a deliberate strategy to enhance economic performance (Sako and Helper, 1998).

Given the complexity of tacit information and knowledge, the linkages in relational chains are very tight and often involve a high proportion of face-to-face interaction and mutual learning. The firms in these types of chains have highly complementary competencies. LDC suppliers must be able to maintain and strengthen their production and linkage capabilities to interact with lead firms in the GVC. Learning efforts imply (sunk) costs and take time, which binds parties to continued interaction. An example of the evolution of a chain from captive to relational is the apparel industry in East Asia, which upgraded from assembly to full-package production. This upgrade required the development of capabilities to interpret designs, produce samples, monitor product quality and meet buyers' price and time conditions (Gereffi, 1999). According to Gereffi et al. (2005: 92), the main opportunity in these chains is that they allow "….local firms to learn how to make internationally competitive consumer goods and generate substantial backward linkages to the domestic economy."

The Taiwanese computer industry is another case of a local supplier that progressed from producing to buyers' specifications to manufacturing their own designs (Kishimoto, 2004). The knowledge was transmitted through the blueprints supplied by multinational corporations to local suppliers and interactions between personnel to transfer the tacit dimensions of technology creation (Guerrieri and Pietrobelli, 2006). The technology and technical expertise acquired through manufacturing within a GVC are transferred via the products manufactured for other multinationals and/or in the production products designed and branded by the manufacturer. Taiwanese computer firms often participate in more than one GVC and "leverage competencies across chains" (Schmitz, 2006: 561).

In the Brazilian State of Espírito Santo, learning occurred in a relational chain in which local small and medium-sized enterprises (SME) benefited from interacting with larger firms that acted as anchors for the local cluster. The process was fostered by the activities of intermediary institutions (matching the interests of small and large firms) and by the active role of the local government, which provided these firms the authority and credibility

necessary to negotiate with large firms and create better linkages and collaborations with SMEs (Villaschi, Cassiolato and Lastres, 2007).

When suppliers lack competencies, there are also alternative patterns: **hierarchical chains** are vertically integrated and occur when transactions and technology are difficult to codify; **captive chains** are buyer-driven,[5] with small suppliers depending on larger, dominant buyers that can exert high levels of monitoring and control, and occur when transactions are easier to codify. In **captive chains**, lead firms intervene actively in the learning processes of suppliers that lack competencies, but their support is usually confined to a narrow range of tasks such as simple assembly. In this case, there is a risk that the suppliers will get locked into a position in the value chain because lead firms do not promote development of strategic, core capabilities within the smaller firms, and in fact sometimes prevent it. The shoe industry in the Sinos Valley in Brazil is an example of how inclusion in a GVC can facilitate product and process upgrading but prevent functional upgrading, leaving firms dependent on a small number of powerful customers (Bazan and Navas-Aleman, 2004; Schmitz, 2006). Local shoe suppliers in the Sinos Valley were discouraged from design, marketing and sales because these were the core competencies of the U.S. buyers, the leaders in the GVC. Brazilians have been members of footwear value chains mostly as producers, with their buyers keen to maintain the status quo. Other empirical evidence about the Brazilian sport shoe sector shows that local suppliers have developed the capability to adapt designs to local conditions (*tropicalizâçao*) but have not been involved by lead firms in new design development (Lemos and Palhano, 2003).

Over time, the direct involvement of U.S. buyers in assisting in upgrading products and processes of Brazilian shoe producers has diminished. In the 1980s, most support came from specialized U.S. technical staff that was gradually replaced by local staff. The activity was moved to China in the 1990s because the risk of supplier failure in Brazil was much higher (Schmitz, 2006). The Sinos Valley shoe industry provides insights into the learning mechanisms that occur within (inter) a GVC. The functional upgrading in design, branding and marketing, which was discouraged by the U.S. buyers, was achieved anyway and allowed the suppliers to sell to buyers in the domestic and regional markets in Latin America (Bazan and Navas-Aleman, 2004). A similar process of experience being transferred across

[5] Gereffi (1999) introduced the useful distinction between buyer-driven chains, dominated by large retailers, branded marketers and branded manufacturers, and producer-driven chains in which large, usually transnational, manufacturers play the central roles in coordinating production networks.

chains occurred in the Mexican footwear sector, where producers also began selling into the domestic market and some other parts of Latin America (Rabellotti, 1999).

At the opposite end of the typology is **vertical integration**, where the lead firm takes direct ownership of some of the operations in the chain and transactions are not easy to codify. This is similar to the case of intra-firm trade between a transnational company and its subsidiaries, and implies various potential learning mechanisms analyzed in the literature on foreign direct investment (FDI) in LDCs, such as transfer of management, skilled labor turnover, training of the local workforce, knowledge spillovers and imitation (Barba Navaretti and Venables, 2004).

3. Innovation Systems and Interactions with GVCs

GVC analysis is limited because of the lack of attention to the institutional context within which local firms interacting in a GVC are embedded. This limitation is highlighted in the literature on global production networks (GPN), which deals with how actors in the various networks are embedded in different places, including 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 stresses 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 system) that affect the character and evolution of industries and firms is highlighted in the literature on types of capitalism (e.g., Berger and Dore, 1996). Especially remarkable among these rules and institutions 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 nation state" (Lundvall, 1992). These institutions and organizations can have profound effects on value chain governance and the innovation and learning strategies of firms in developing countries. This section explores the role of innovation systems in the GVC-driven learning and innovation process in developing countries, and focuses on two aspects of innovation systems:[6] technology policies and technology organizations. In developing countries, technology policies cover aspects such as technology imports via licensing and FDI, and incentives for local R&D and training. Technology organizations are

[6]Although this paper argues that "technology system" is the more accurate term to describe systems in developing countries, for simplicity the term innovation system is used.

those bodies that provide services such as MSTQ, R&D, training and knowledge-intensive business services. In industrial countries, the emphasis is much more on basic research and the creation of new knowledge. Organizations can be government run, started by government but run autonomously, or started and managed by industry associations or private actors. In developing countries, government-run organizations often play leading roles to counter the weaknesses in and precariousness of the private sector.

Many services provided by these organizations are the essential public goods of technological effort. Public research institutes and universities undertake basic research that does not yield commercial results in the short term but provides a long-term base of knowledge for enterprise effort. Quality, standards and metrology institutions provide the basic framework for firms to communicate about technology and maintain basic standards for the industry. Extension services alleviate informational, technical, equipment and other SME handicaps. KIBS are consultancy services related to technical and organizational issues and, so far, their investigation is confined to the developed country context;[7] however, as Schmitz and Strambach (2009) show, they are becoming increasingly relevant in some developing countries. The provision of these services remedies market failures that all governments face, regardless of the national level of development. How do different innovation systems affect the determinants of GVC governance and through this the opportunity for enterprise learning and upgrading? The relationship between the form of governance and the nature of the system is intrinsically dynamic and cannot be univocal (one-to-one) given the variety of possible systems and the endogeneity of most of the events outlined above as well as the frequent two-way causality and continuous feedback.[8]

The nature of the innovation system affects the range of possible modes of governance of value chains. Table 2 shows the relationship between GVC governance and the nature of the innovation system, and shows how the latter affects the three key determinants of governance: complexity of transactions, extent of codification and suppliers' capabilities. The last column of Table 2 presents some possible dynamic trajectories from the different patterns of GVC governance that may emerge from a well-functioning innovation system.

[7] The literature on KIBS is vast. Among others, there are Miles (2005), Strambach (2008) and Wood (2002).
[8] To simplify the discussion, there is the temptation to classify innovation systems along a linear dimension, from "good" to "bad" systems. Nevertheless, non-linearity and idiosyncrasies are especially relevant and frequent in this analysis. Clearly, there is simply not a single best way to organize an innovation system, and a system that can be good at a certain point in time may not be so in a different moment given the intrinsic dynamism in the innovation process.

Table 2. GVCs and their Interaction with Innovation Systems

<table>
<tr><th></th><th>Governance type</th><th>Determinants</th><th colspan="2">Innovation Systems</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Market</td><td>Low complexity</td><td></td><td rowspan="15">A well-structured, complete, smooth system makes 1-2-3 more likely to occur.
4-5 may prevail with weaker, more fragmented systems. The chain leader may compensate for system weaknesses but upgrading is restricted.
Possible Dynamics
↑
▪ From 5 and 4 to 2: Thanks to improvement in MSTQ
▪ From 5 and 4 to 3: Thanks to improvement in “local” systems
▪ From 5 and 4 to 2 and 3: Thanks to IS supporting the co-evolution of suppliers and GVC competencies</td></tr>
<tr><td>High codification</td><td>MSTQ organizations matter</td></tr>
<tr><td>High supplier competence</td><td>Education, training organizations matter</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Modular</td><td>High complexity</td><td></td></tr>
<tr><td>High codification</td><td>MSTQ organizations matter</td></tr>
<tr><td>High supplier competence</td><td>Education, training organizations matter</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">Relational</td><td>High complexity</td><td>“Local” systems and complementary knowledge matter</td></tr>
<tr><td>Low codification</td><td>MSTQ organizations are perhaps less crucial</td></tr>
<tr><td>High supplier competence</td><td>Education, training organizations matter</td></tr>
<tr><td rowspan="3">4</td><td rowspan="3">Captive</td><td>High complexity</td><td></td></tr>
<tr><td>High codification</td><td>MSTQ organizations matter</td></tr>
<tr><td>Low supplier competence</td><td></td></tr>
<tr><td rowspan="3">5</td><td rowspan="3">Hierarchy</td><td>High complexity</td><td>Local R&D organizations may benefit from interaction</td></tr>
<tr><td>Low codification</td><td></td></tr>
<tr><td>Low supplier competence</td><td>GVC is expected to improve human technical skills</td></tr>
</table>

Source: Authors’ elaboration and Pietrobelli and Rabellotti, 2009.

3.1 Complexity of Transactions and Innovation Systems

A well-structured and efficient innovation system can help reduce the complexity of transactions and enable transactions based on arms’ length or weak hierarchical forms of

GVC governance. The risk of falling into a captive relationship or being acquired by a leader is thus diminished. In other words, the lower the complexity of the transactions the less need there is for an effective innovation system, but an effective system increases the capabilities to cope with complex transactions.

When investors engage in make-or-buy decisions, they face a trade-off between lower production costs and higher transaction costs. In countries with weak institutions, weak contract enforcement, pervasive corruption, cumbersome bureaucratic procedures, multiple barriers to trade and poor infrastructure, it is difficult to capitalize on the benefits of inter-firm specialization (Altenburg, 2006).

The weaker the institutional framework, the costlier and riskier will be contract enforcement and inter-firm coordination, and transactions will be more difficult, which favors nonmarket forms of governance, possibly vertical integration. The related bureaucratic procedures and high administrative costs of registration may exclude small firms from doing business, emerging from informality, and linking up with global and national value chains.

In terms of 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 relational forms of governance will be smoother. Local firms' learning in captive value chains may extend beyond simple tasks to, for example, design and planning of activities. The experience of the industrial and technological development of Taiwanese firms and clusters is an insightful example of an IS supporting the transition from hierarchy and captive chains led by foreign leaders to local innovation, functional upgrading and domestic firm-led value chains. Taiwan's innovation system strengthened over time thanks to substantial investments in human capital and scientific and technological research, institutions and rules rewarding innovation, and organizations such as science and technology parks that further facilitated efficient inter-firm and university-industry collaborations in high-tech activities (Guerrieri, Iammarino and Pietrobelli, 2001; Saxenian and Hsu, 2001; Tsai and Wang, 2005; Wen-Hsiung and Wei-Tzen, 2000).

The establishment of relational value chains is also facilitated by a well-functioning innovation system with active technical bodies, where the chain leaders and their local partners can meet to exchange complementary knowledge and to reduce the complexity of transactions. The development of specialized technical institutions is more common in local clusters, where they support local generation of innovative processes and practices (Bell and Albu, 1999). Several authors show that agglomerations are associated with the relational

portions of GVCs (Sturgeon, 2003; Schmitz, 2004). The existence of these supporting bodies may be attractive to a GVC, promoting relational forms of governance and enabling the transition from hierarchical or captive chains to relational chains (in the last column of Table 2, this is the shift from 5 and 4 to 3).

3.2 Codification of Transactions and Innovation Systems

In market-based transactions within efficient markets, all the relevant information is conveyed by the market price because the complexity of transactions is low. However, when complexity increases, enterprises in developing countries are unlikely to have the internal skills and capabilities to operate within a context of codified transactions. The IS can simplify their efforts and enhance their effectiveness, especially through the MSTQ infrastructure. MSTQ institutions form the basic infrastructure for national technological activities. The use of recognized standards and their certification by internationally accredited bodies or GVC leaders is increasingly demanded in world trade.[9] Standards can reduce transaction costs and information asymmetries between seller and buyer, and minimize uncertainties with respect to quality and technical characteristics.

The importance of industrial standards has increased and standards make a major contribution to the diffusion of technology within and across industries. In developing countries, standards organizations disseminate best practices in an industry by encouraging and helping firms to understand and apply new standards, which is likely in turn to improve suppliers' competencies. Redundant experimentation with new technologies is reduced, and enterprises are introduced to a common language that is shared across the international market. This reduces the complexity of inter-firm technical linkages and collaboration.

The existence of well-structured MSTQ institutions and organizations has important implications for GVCs, for their governance and for developing countries' innovation and technology systems, making the handling of complex transactions and the organization of the GVC web of local relationships easier. In principle, modular and relational chains are more likely to prevail provided local suppliers are competent and understand and use technical codes and standards. The choice of either form may depend on the different degrees of

[9] Standards are the set of technical specifications that become the rules and guidelines and describe the characteristics of products, services, processes and materials. Metrology (the science of measurement) provides the measurement accuracy and calibration required for standards to be applied. The application of standards and the certification of products necessarily imply (accredited) testing and quality control services. 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 a requirement for potential exporters, and signals quality and reliability to foreign buyers, value chain leaders and transnational corporations seeking local partners and subcontractors.

knowledge codifiability. Standards matter increasingly for natural resource-based activities. In Southern Chile, a very successful salmon cluster has been developed since the early 1990s and the process of standards setting and compliance offers remarkable insights (Katz, 2006; Maggi, 2007). Compliance with international standards has allowed the Chilean salmon industry to progress from passive to active learning, with more involvement of local firms as value chain leaders and suppliers in foreign-led chains (Iizuka, 2009). The Association of (Chilean) Salmon Industries, a meso-level institution, played a crucial role in this process. An explicit account of the dynamics involved allows a better understanding of the implications of different systems on GVC governance and the opportunities for learning: better MSTQ organizations enhance the probability of a transition from hierarchical and captive value chains to modular forms of governance (in the last column of Table 2, this is the shift from 5 and 4 to 2).

3.3 Supplier Competence and Innovation Systems

The innovation system includes all of the institutions and organizations that contribute to improving suppliers' competencies. It consists of the organizations responsible for education and technical training, and the set of incentives that induce individuals to invest in improving their knowledge and competence. As suppliers learn and acquire greater competence, GVC governance is likely to change. In very general terms, it would be expected that increased capabilities in the supply base to help push the architecture of a GVC away from hierarchical and captive networks toward more relational and modular chains (Gereffi et al., 2005). However, better capabilities among suppliers are also likely to affect the prevailing mode of value chain governance and, ceteris paribus, enhance learning mechanisms within all value chains, allowing suppliers to benefit more from participation in a value chain.

A co-evolution of suppliers and GVC leaders can be envisaged since, if suppliers acquire new competencies, then the chain leaders, often buyers, need to change and adapt their core competencies to the new governance patterns (Sturgeon and Lee, 2001). To support and fit in with the acquisition of new competencies by suppliers, chain leaders would need to receive some benefits from these developments (Humphrey, 2006).

The case of the wine industry in South Africa (Ponte and Ewert, 2009) is an example. The main foreign market for South African wine is the United Kingdom and the way that the GVC is organized has undergone profound changes. Under pressure for shorter lead times, U.K. agents and marketers have had to increase their control over logistics (some importers are selling to retailers on the basis of delivery from the U.K. warehouse rather than free-on-

board export from Cape Town). At the same time, U.K. agents and marketers have increased their role in product innovation, new packaging, new presentations and styles, while retailers are increasingly becoming shelf-space providers. South African producers' cellars have improved in terms of guaranteed wine quality and improved capability to innovate production in response to consumer demand.

In the electronics sector, value chain leaders are happy to outsource increasing amounts of production, including process-related design, to suppliers. In the two electronics clusters of Jalisco (Mexico) and Penang (Malaysia) analyzed by Rasiah (2007), chain leaders encouraged and supported the development of local technical competencies. Local human capital and suppliers' competencies, and the specific differentiation and divisions of labor that emerged in Penang and Jalisco, allowed remarkable integration with multinational corporations and GVCs. Although initially this generated improved economic and export performance, the lack of technical and R&D scientists and engineers, combined with relatively underdeveloped high-tech and R&D infrastructures in Malaysia and Mexico, have undermined the capacity of multinational corporations and local firms to achieve functional integration. Thus, this has not resulted in the horizontal integration necessary to enter higher value-added segments in value chains.

The case of the electronics clusters in Malaysia and Mexico points to the difficulties involved in upgrading to high value-added functions; however, there are some examples of success in emerging countries (Schmitz and Strambach, 2008). The most obvious is software in Bangalore, but there are interesting cases in very different sectors, such as the wine industry in Chile. Cusmano, Morrison and Rabellotti (2010) note that one of the main competitive factors in Chilean wine production, which has a well-integrated international GVC, is the strong links with university research. These links have allowed quality upgrade and up scaling in the global wine market. Another example is Tesco in Thailand, which has developed a novel, low build-cost store format that is essentially a small hypermarket core surrounded by a local fresh food vendor market (leased space) and a farming supplies area. This store format is an attempt to circumvent the threat of tightened development control in low-income provincial up-country towns where conventional large-format hypermarket development is not considered feasible politically and not viable commercially (Coe and Wrigley, 2007).

3.4 Learning across Different Chains (IS Can Help)

There are some significant learning mechanisms in different value chains. In the 1990s, Taiwanese firms embedded in a developed innovation system were frequently participating in more than one GVC (Guerrieri and Pietrobelli, 2006) and leveraged competencies across chains (Schmitz, 2006). The same thing happened in the Sinos Valley in Brazil, where suppliers learned and employed various competencies by working within two or more value chains (Bazan and Navas-Aleman, 2004). Public policy can support diversification of value chains and learning across chains. For example, an information-bargaining organization to identify emerging/promising markets and value chain leaders could help by holding information and motivation events, subcontracting exchange schemes, and supplier fairs and exhibitions (Altenburg, 2006).

This section has described the multiple ways that innovations systems interact with GVC governance and suppliers' learning and innovation, and has discussed some possible forms of interaction and mutual effects, which analytical and empirical research would further clarify. Most importantly, future research could systematically explore the dynamics of GVCs and the co-evolution of suppliers and buyers and of related innovation systems.

4. Conclusions

Questions have been raised about whether the spatial embeddedness of learning and knowledge creation could be challenged by alternative organizational forms (Asheim and Gertler, 2005). According to this view, organizational or relational proximity is more important than geographical proximity to support the production, identification, appropriation and flow of tacit knowledge. Thus, multinational firms and GVCs with dispersed but carefully organized knowledge bases, sites of innovation even in developing countries and communities of practice could compensate for lack of geographical proximity. This paper shows that innovation systems interact with GVCs in multiple ways and influence whether and how developing country firms learn and innovate through entering and interacting in these value chains. The relational proximity created within a GVC does not replace but rather interacts with an innovation system.

The first main conclusion is that the different characteristics of value chains have an impact on the mechanisms of learning prevailing in the chain. In general, LDC firms learn and innovate based on their participation in the GVC because they have to satisfy the product quality, delivery time, process efficiency, environmental, labor and social standards requirements of these chains. The learning mechanisms within GVCs vary according to the

form of governance that is adopted: they can be the result of pressure to match international standards or may be facilitated by direct involvement of the value chain leaders if the competence of suppliers is low and the risk of noncompliance is high. When the actors in the value chain have complementary competencies, learning is mutual and based on intense face-to-face interactions.

The second conclusion of this paper is related to the multiple forms of interaction between innovation systems, GVC governance and suppliers' learning and innovation. On the basis of our analytical framework, a well-structured and efficient innovation system could help reduce the complexity of transactions, enabling arms-length transactions and weaker hierarchical forms of GVC governance. In other words, the risk of falling into a captive relationship, or being acquired by a leader, diminishes with a stronger IS. The less complex the transactions the less the need for an effective IS, but an effective system also increases the capabilities to cope with complex transactions. The system of organizations in charge of MSTQ plays a central role in innovation systems and may influence the form of governance adopted by developing country firms.

The third conclusion is that internal governance of the GVC is dynamic and subject to continuous adjustments and changes. This paper has explored some of these changes. Future research should consider the dynamism of innovation and systematically explore the co-evolution of suppliers and buyers, and the related innovation systems. There is a large body of research showing that buyers have evolving strategies toward their supply chains (Sturgeon and Lee, 2001), and that their strategies can differ, for example, in terms of knowledge transfer—some welcome opportunities to transfer parts of their activities to the supply chain, others obstruct it. The type of innovation system that prevails locally will affect this co-evolution.

Numerous avenues for further research are opened by this study. More quantitative analysis of value chains, their forms of governance and their impact on local firms is needed.[10] More analysis of innovation systems in developing countries is also needed, with specific emphasis on the features highlighted in this paper. Studies of the dynamics of GVCs and the policy strategies of developing country governments and suppliers are also required.

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

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