Institutional Support and Technological Upgrading: Evidence from Dynamic Clusters in Latin America and Asia

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Abstract

In light of wide differences in economic outcomes in the world, this paper uses an evolutionary set of lenses to examine the clusters of Buenos Aires' automotive, Los Lagos' salmon, Penang's electronics and Qiaotou's buttons with an elucidating view towards evaluating the significance of institutional support in driving technological upgrading in firms. The purpose is to demonstrate if industrial and location specificities and industrial policy instruments matter in upgrading outcomes. The results show that transnational corporations drove automotive and electronics clusters in Buenos Aires and Penang respectively, while domestic firms dominated the origin of salmon and button clusters in Los Lagos and Qiaotou. Domestic organizations have been the prime drivers of upgrading in Los Lagos and Qiaotou. Whereas the meso organizations in Los Lagos adapt knowledge from frontier clusters abroad, they are the basis of knowledge generation in Qiaotou. Whatever the differences, the role of government through institutional change has been critical in stimulating upgrading, but the extent and nature of intervention in the four clusters were industry and location specific.

Key words: institutions, technological upgrading, economic synergies, clusters

1. Introduction

Dynamic clusters have originated in several ways (Best, 2001). Some emerged from the relocation of labour-intensive and low value added segments of value chains (Helleiner, 1973; Rasiah, 1988)). Some were deliberately spawned through government policy (Amsden, 1985; Lall, 1996). Others arose as a result of lengthy processes of skills and craft development and socio-economic interactions (Piore and Sabel, 1984; Pyke and Sengenberger, 1992; Rasiah, 1994, Becattini et al., 2009, Guerrieri et al., 2001). Some arose from natural resource endowments (Narula and Dunning, 2000). Export processing zones have also acted as the spearhead for the development of dynamic industrial locations (Rasiah, 2007). The development of clusters is often underpinned by the geographical agglomeration of firms of a given sector or different sectors and industrial networks.

Clustering in developing countries typically starts as fragmented activities: either as an agglomeration of domestic firms or of transnational corporations (TNCs) relocating labour- or resource-intensive activities from abroad. However, whatever the circumstances of origin, institutional direction have acted as critical drivers of technological upgrading and integration in export markets (Markusen, 1996).

This paper extracts some aspect of the evolutionary argument that technological upgrading experiences are industry and location specific (Nelson, 2008) to answer the question of why technological upgrading experiences are uniquely different by evaluating the experiences of four locations from the

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developing world where clustering has reached reasonable maturity. Two clusters each were selected from Latin America and Asia to identify the drivers of technological upgrading and economic synergies.[3]

The first cluster, automotive in Buenos Aires, evolved initially from the 1950s when giant transnational corporations (TNCs) relocated subsidiaries to assemble automobiles for the domestic market. The cluster faded in the 1970s and 1980s before re-emerging strongly following reconstruction policies from 1991. The second cluster, salmon in Los Lagos, emerged in the 1970s following government efforts to promote the industry in Southern Chile to alleviate poverty (Chile, 2003). It is from the 1980s that the cluster began to grow strongly following strong coordination between meso organizations, the industry association and government instruments as successful incubators from Fundacion Chile (FC) were actively sold to private firms. The third cluster, electronics in Penang, emerged from export processing zones from the early 1970s when TNCs relocated assembly operations to take advantage of cheap labour and tax holidays (Rasiah, 1988). From assembly operations production was transformed to knowledge-intensive activities from the 1980s. The final cluster, buttons in Qiaotou, evolved when Italian firms outsourced manufacturing to Chinese firms since 1982 to check spiralling production costs. Knowledge flows from meso organizations helped the upgrading of button production from 2006.

Hence, the aim of this paper is to show how industrial and location specificities and the nature of institutional support drove technological upgrading in the four clusters. The rest of the paper is organized as follows. Section two discusses the main theoretical arguments. Section three presents the methodology and data. Section four analyses technological upgrading, and growth in exports, employment, wages, and skills intensities in the four clusters. Section five evaluates the drivers of economic synergies. Section six presents the conclusions.

2. Theoretical considerations

Since the focus of the paper is on institutional support clusters are used as examples of dynamic locations characterized by a unique configuration of economic activities. It is important to note that elements of industrial policy exists so long as governments strategize by targeting any or more of the following economic instruments - e.g. tariffs, tax holidays, grants, subsidies, preferential capitalization, specialized support for particular educational fields on skills and foreign exchange exemptions to stimulate industrialization. Hence, in this paper we consider efforts of governments to spawn particular industries through any of these elements even if no preference is offered to national capital over foreign capital or if protective tariffs are no longer used as elements of industrial policy. Also, we prefer to assess the original contributions to understand the critical concepts and relationships than reviewing the latest publications.[4]

There is recognition that mature clusters of economic activities integrated in global markets demonstrate strong elements of technological upgrading and economic synergies (Best, 2001, Becattini et al., 2009). Clusters here are defined as regionally or locally networked sets of economic agents that connect firms, organizations and institutions, and are considered to produce the most synergies when the requisite macro institutions, meso organizations and micro-agents are in sync to drive learning, innovation and competitiveness through circular and cumulative causal processes. What Young (1928), Abramowitz (1956), Kaldor (1967) and Cripps and Tarling (1973) argued at an abstract and aggregate level can be presented dynamically through the concept of clusters.

The systemic nature of knowledge flows was demonstrated by Marshall (1890), and Nelson and Winter (1982: 63). Scitovsky (1954) and Rosenstein-Rodan (1943: 207-208) distinguished non-pecuniary from pecuniary external economies. Nelson (2008) went further to discuss the imperfect, non-linear, and coordinated and uncoordinated nature of knowledge flows. The specificity of industries, initial structural conditions and the timing of upgrading strategies have also attracted different institutional roles (Hobday, 1995; Malerba et al, 2008). Mature firms in open integrated clusters gain new ideas to support continuous

[3] Although there are considerable publications on the automotive and salmon clusters in Argentina and Chile, and the electronics cluster in Malaysia, we use in the paper fresh data collected in 2008-09. The story of the button cluster in Qiaotou is fairly new.

[4] Unfortunately several journals are more interested in promoting the most recent literature even if they added no new knowledge to the old ones.

organizational change as old employees are replaced to make way for fresh ones, while new firms benefit from the released entrepreneurial and technical human capital to start new firms (Best, 2001; Rasiah, 1995). Saxenian (2006) documented the development and movement of human capital, which has supported new firm creation and several fast growing regions in the world.

However, unlike its modeling application by neoclassical economists who often reduce it to an exogenous black box (Rosenberg, 1982), knowledge appropriation requires considerable effort as pointed out by Lall (1992). The historical sequence of the development of technological capabilities through industrial policy started in Britain when Henry the VII imposed taxes on exports of wool in 1485 (Reinert, 1994: 175). A series of follow up industrial policies helped the United States, Germany, Sweden, Japan, Korea and Taiwan achieve technological superiority in increasing returns industries. In examining institutional support, we assume North's (1990) definition of institutions as the 'rules of the game', and meso organizations and firms the players. However, following Nelson (2008) we use a wide role for institutions with markets being only one of them.

Freeman (1988) had demonstrated using the experience of Japan that international flows of stocks of knowledge from developed to developing economies take a sequential movement from imports to adaptation, assimilation and innovation. Katz and Stumpo (2001: 137) observed movement of motor vehicle firms from Argentina and Brazil that were integrated through TNCs as trade transformed from process adaptation to designing activities from the 1990s.

While the Marshallian systemic doctrine of knowledge flows remains critical in the generation and diffusion of technological spillovers institutions other than markets, such as laws and government directives, trust relationships supported by particular socio-cultural and intermediary organizations have been no less important in driving technological upgrading (Piore and Sabel, 1984; Becattini et al., 2009). Also, as Hirschman (1970) had argued, host-governments have the potential for translating potential to real spillovers. Hence, whereas the government can support steep catch ups by supporting firms to appropriate latecomer advantages (Veblen, 1915; Gershenkron, 1952; Abramovitz, 1956), markets alone only offer gentle structural change experiences (see Chakravarthy, 1993).[5]

The strong and responsible government of South Korea ensured that performance standards drove technological catch up by Samsung in electronics, Hyundai in shipbuilding and automobiles and Posco in steel in the 1970s (Amsden, 1989; Kim, 1997). The government in South Korea also insulated successful chaebols from the destabilization caused the oil crisis of 1973-75. The Industrial Technical Research Institutes created by the Taiwan government in 1974 drove technological catch up *inter alia* in machinery (Amsden, 1985; Fransman, 1986). The government financed the acquisition of Radio Company of American (RCA) in 1977-79 and the founding of the joint-venture company of Taiwan Semiconductor Manufacturing Corporation (TSMC) with Philips in 1987, which by the end of 2000 had become the world’s leading contract manufacturer of fabricated wafers.

Governments can create or strengthen institutions to promote agglomeration effects, and also screen particular clusters to identify bottlenecks, gaps and weaknesses. Such problems can take the form of weaknesses in basic infrastructure, high tech infrastructure, network cohesion or integration in global markets (Rasiah, 2009). Given the problems of information asymmetries between government and firms, and the public good characteristics of knowledge, intermediary organizations such as chambers of commerce, training institutions and R&D labs often help solve collective action problems. Interdependent relationships that are driven by the discipline of the market, direction of government when public goods are involved and complementation through trust-loyalty to extract social commitment from the participating humans has been vital in the development of competitive clusters (Brusco, 1982). Stakeholder coordination (e.g. through industry, government, consumer and labour coordination councils) often help root and expand social capital.

A lack of firm-level drive, human capital, high tech institutions and external competition to stimulate innovation and competitiveness have often undermined the capacity of clusters to enjoy sustainable differentiation and division of labour, which also explains the stagnation that has characterized industrial estates in many developing economies.

[5] Chakravarty (1993) advanced the notion that markets are good servants but bad masters.

Frontier clusters are characterized by innovation. The focal point of innovation in a dynamic cluster is essentially the interdependent and interactive flow of knowledge and information among people, enterprises and meso organizations, which must include coordination between the critical socioeconomic and technological agents across value chains who are needed in order to turn ideas into processes, products or services in the marketplace. In dynamic clusters, such as, the Silicon Valley, Route 128 and the Hsinchu Science Industrial Park, innovations evolve from a complex set of inter-relationships among actors located in a range of enterprises, universities and research institutes. The role of user-producer interactions in driving learning and innovation was articulated lucidly by Lundvall (1992). The effective execution and appropriation of innovations often requires the involvement of other actors in dynamic clusters, such as intermediary organizations (including R&D labs), suppliers, venture capitalists, property rights lawyers and marketing specialists. While it is possible for large firms to internalize the function of creating public goods in R&D labs, the embedding meso organizations must evolve to higher levels to support firms' participation in R&D activities. The United States' government funds strategic research in the military, universities and other laboratories in recognition of knowledge as a public good (Mazuzan, 1994). Also, clusters do not evolve in a linear way. They have often started at different levels of integration and follow different trajectories (Guerrieri et al., 2001). In addition, although some clusters have fragile origins in developing countries, firms may still appropriate certain advantages from agglomeration economies and meso organizations (see Rasiah, 2009, 2010).

Value chains of particular commodities in dynamic clusters are globally integrated in factor and final markets. Global markets provide the economies of scale and scope and the competitive pressure to innovate. Global value chains assist economic agents in clusters to orientate their strategies to the critical dynamics that determine upgrading and value addition (Gereffi, 2002; Gereffi, Humphrey and Sturgeon, 2005, Pietrobelli and Rabellotti, 2007). Examples of such changes include the introduction of cutting edge just-in-time and flexible specialization techniques in electronics, the proliferation of software technology in the use of cad-cam machines and the interface between firms' assembly activities and major markets. However, the depth of integration and potential for technological upgrading in particular host-sites in value chains depends very much on the embedding institutions and meso organizations.

Demand-supply influences from buyers and users in domestic and export markets and the embedding institutions and organizations play a critical role in driving technological upgrading in firms (Lundvall, 1992; Nelson, 2008). While it is important to examine the supporting strength of the embedding environment it is also important to evaluate its impact on the level of technological activity of firms located in particular locations.

In doing so we attempt to widen the scope and flexibility to strengthen the old arguments in support of industrial policy, such as 'getting relative prices wrong' (Amsden, 1989), 'governing the market' (Wade, 1990) or targeting 'institutional quality' (Rodrik, 1997) so as to increase the explanatory power of heterodox approaches. We hypothesize that the nature of industrial policy pursued in the four clusters will be somewhat different because of industry and locational differences. Not only will initial conditions matter, the institutions and meso organizations created and the responses of the micro agents will also be critical for technological upgrading to occur.

3. Methodology and data

The empirical investigation was started with the identification of 10 clusters enjoying at least 20 years of experience in which export growth of lead products from the locations exceeded the national growth rates over the period 2000-2006 (see UNIDO, 2009).[6] The four most dynamic upgrading experiences among the 10 clusters researched are used for the purpose of this paper. The locations selected, the principal initiators and breakdown of firms chosen by ownership are shown in Table 1.

[6] Wages were estimated after deflating for inflation using consumer price indices supplied by national consultants.

Table 1: Dynamic industrial clusters, Latin America and Asia, 2006

Country	Industrial cluster	Product	Average annual growth rate of exports 2000-06(%)		Number of surveyed firms	Foreign owner-ship in sample* (%)	Origin
			National	Location			
Argentina	Buenos Aires	Automotive	11.7	15.3	50	70.0	Started as a special economic zone
Chile	Los Lagos	Salmon	11.1	18.6	50	37.5	Started as a specially designated salmon farming region in the early 1980s
China	Qiaotou	Buttons	12.0	12.4	100	0.0	Originated through entrepreneurs investing in button manufacturing in the 1980s
Malaysia	Penang	Electronics	4.6	6.7	103	83.7	Started with Free Trade Zones from 1972

***** Ownership was classified as foreign if foreign equity constituted at least 50% of total equity of firms and the rest as national.

Source: UNIDO, *Survey of Dynamic Industrial Locations*, 2007-08

Only when firms enjoy technological upgrading will they be able to sustain long run growth in exports, value added, skills and wages. The brainstorming sessions with the industry association in Buenos Aires, Los Lagos, Santiago, Penang, Qiaotou and Hubei helped the delineation of the typology by taxonomies and trajectories. We differentiated technological upgrading to include all vertical and horizontal integration that entail participation in higher technological capabilities with a commensurate increase in value added. We preferred this alternative to the separate classifications by Schmitz (2004) because functional integration does not always translate into the utilization of higher knowledge content. For example, TSMC integrated lower value added wafer bumping to higher value added wafer fabrication (Yap and Rasiah, 2013).

The first round interviews with officials of the industry associations show that firm-level technological upgrading often rely extensively on knowledge accumulation stimulated by institutional change. The evidence we obtained shows that change not only requires the introduction and enforcement of the appropriate institutions but also the creation and strengthening of intermediary organizations to solve collective action problems. Drawing from Rasiah's (2007, 2009) work, four systemic pillars were identified and differentiated by taxonomies and trajectories to stimulate firms' movement from simple activities to the technology frontier (see Table 2). Despite the specificity of particular industries and locations, the evidence shows that a typology of taxonomy and trajectory can be drawn up to map these developments with sufficient amount of openness to allow for the capture of new information, which is consistent with Keynes' (1890) argument that inductive approaches cannot be assumed to evolve completely in a vacuum and are generally intertwined with deductive postulations. Table 3 shows a typology of taxonomies and trajectories of different levels of knowledge accumulation in firms, which is developed from the generic explication of taxonomies presented by Dosi (1982) and Pavitt (1984). In the formative years, incentives are often useful only in moving firms from level 1 to levels 2 and 3. Training and human capital organizations become important from level 2 onwards, which increases in importance as clusters mature technologically. Grants become more important to attract firms' participation in levels 4 and 5 activities. R&D scientists and engineers, and R&D labs, and incubators become important at levels 4 and 5 activities.

The paper first locates the depth of technological capabilities achieved by firms by taxonomies and trajectories, as well as, their contribution to growth in exports, employment and wages, and skills intensity level achieved in 2006. The paper then assesses the individual experiences to identify the drivers of technological upgrading and economic synergies. Because each experience is assumed to be different the study used an inductive approach with a ledger of critical generic questions directed at industry associations in the locations. Consistent with Keynes (1890) notion of inductive theorizing, evidence was compiled along a generic typology by taxonomy and trajectory.

The data on the technological depth of operations, and exports, employment, wages and skills was collected by national consultants under our supervision. The firms were selected using a stratified sampling procedure on the basis of ownership and size of firms in the clusters.[7] Location was not used as one of the criterion because the firms are from a particular location. The sample size of firms in Buenos Aires and Los Lagos was 50 each, and 100 in Qiaotou and 103 in Penang. The response rate was close to 100% in all the locations, which is largely because of the use of national consultants who were chosen because of their tacit links with the firms. The numbers in Latin America were smaller compared to those in Asia because of the smaller population of related firms in the former over the latter.

Whereas the evaluation of institutional support facing firms is based on the typology presented in Table 2, the technological capabilities of firms were rated using the typology shown in Table 3. The scoring in Table 2 was based on consensus reached from brainstorming sessions held with industry association officials in 2007-08, while individual firms' responses were tallied for Table 3. The sessions for the scoring reported in Table 2 were conducted by national consultants in Buenos Aires (automotive cluster), Santiago (salmon cluster), Penang (electronics cluster), and Qiaotou (button cluster) in 2007-08.

[7] The sampling was undertaken by national consultants: Penang (Rajah Rasiah), Buenos Aires (Gonzalo Bernat), Los Lagos (Lydia Vidal) and Qiaotou (Xin Xin Kong).

Table 2: Systemic pillars and technological upgrading

	Basic infra-structure	**High tech institutions**	**Network cohesion**	**Integration in international markets**
Initial Conditions (1)	Political stability and efficient basic infrastructure	Presence of some economic agents seeking knowledge inputs	Social bonds driven by the spirit to compete and achieve	Connecting to the international economy
Learning Phase (2)	Strengthening of basic infrastructure with better customs and bureaucratic coordination	Import, learning by doing and duplicative imitation. Human capital development	Expansion of tacitly occurring social institutions to formal intermediary organizations to stimulate connections and coordination between economic agents	Access to foreign knowledge through machinery and equipment import and FDI Integration in global value chains
Catch Up Phase (3)	Basic infrastructure capable of providing strong essential services.	Import, creative duplication and innovation. Beginnings of Mark I system of learning	Smooth links with meso organizations connecting and coordinating to solve collective action problems	Access to foreign knowledge through licensing, acquisition and imitation, through imports and exports. Upgrading in global value chains, IPR regulation starts here.
Advanced Phase (4)	Advanced basic infrastructure instruments	Developmental research to support creative destruction (Schumpeterian Mark 1).	Participation of intermediary and government organizations in coordinating technology inflows, initiation of commercially viable R&D	Access to R&D human capital and collaboration with R&D institutions, high tech resources and markets abroad
Frontier Phase (5)	Novel Basic infrastructure to support new developments in basic infrastructure	Basic research to generate new knowledge paths (Schumpeterian Mark II system).	Participation of intermediary organizations in two-way flow of knowledge between producers and users	Global pursuit to connect with frontier nodes of knowledge

Source: Authors

Table 3: Firm-level technology by taxonomies and trajectories

Knowledge depth	HR	Process	Product
Simple activities (1)	On the job and in-house training	Dated machinery with simple inventory control techniques	Processing of raw materials, and assembly of components, CKDs and CBUs using foreign technology
Minor improvements (2)	In-house training and performance rewards	Advanced machinery, layouts and problem solving	Use of precision engineering and minor adaptations to products
Major improvements (3)	Extensive focus on training and retraining; staff with training responsibility	Cutting edge inventory control techniques, SPC, TQM, TPM	Cutting edge quality control systems (QCC and TQC) with original equipment manufacturing (OEM) capability
Engineering (4)	Hiring engineers for adaptation activities; Separate training department	Process adaptation: layouts, equipment and techniques	Large scale product adaptation (including improvement of fish species)
Early R&D (5)	Hiring engineers for product development activities; Separate specialized training activities	Process development: layouts, machinery and equipment, materials and processes	Product development capability. Some firms take on original design manufacturing (ODM) capability. Strong emphasis on ergonomics, sanitary conditions of fish and consumer safety features of products
Mature R&D (6)	Hiring specialized R&D scientists and engineers wholly engaged in new product research	Process R&D to devise new layouts, machinery and equipment prototypes, materials and processes	Novel product development capability, with some taking on original brand manufacturing (OBM) capability. Among lead firms putting up new automotive, electronics and button models, and improvements in fish standards

Source: Authors

4. Institutional upgrading

This section uses information gathered from the brainstorming sessions with industry associations and secondary documents to locate the level of institutional development of the four clusters. The assessment of the systemic pillars is based on the results shown in Table 4.

The basic infrastructure in all four clusters were equally good with good roads, flight connections, power supply, water supply, primary and secondary schools and internet support qualifying them all at stage 4 level. We did not find the globe's most novel planning (level 5) initiatives targeted at technological upgrading in firms or improvements to the environment in the four clusters. Nevertheless, government planning showed considerable efforts to support technological upgrading and the strengthening of supporting infrastructure.

Industry association officials reported that the high tech infrastructure facing automotive firms in Buenos Aires, salmon producers in Los Lagos and electronics firms in Penang have reached level 3 upgrading phase.[8] Whilst these locations have training, standards and testing organizations, they do not have fully equipped R&D labs and designing centres to support firms apart from a handful of universities engaged in specific developmental activities. FC and CORFO only support adaptive development activities with their R&D labs not equipped to support new knowledge creation activities. Hence, when the Infectious Salmon Anemia (ISA) virus struck in 2007, FC and CORFO could not respond (Iizuka and Katz, 2011).

[8] The Malaysian government approved grants and import of human capital to foreign firms in 2005 to attract wafer fabrication and designing activities.

Button firms in Qiaotou enjoy the most sophisticated support from the designing, training and testing centres and R&D labs and universities that assist with the development of new materials and button designs. However, most button firms in Qiaotou have only advanced to level 4 technology-intensive activities as the designing, testing and developmental aspects of button technology is undertaken in the meso organizations and universities.

The intensity of interactions between the firms, and between firms and meso organizations, and those governing the regulatory instruments in Buenos Aires, Los Lagos and Penang have reached level three. Yongjia County officials in Zhejiang Province, China, have worked hard to strengthen connections and coordination between the button firms, the meso organizations, and the incentive providers to reach level 4 technological activities.

All four clusters are highly integrated in global markets, especially when it comes to exports, and access to foreign knowledge. Button firms in Qiaotou originally learnt from their Italian masters to eventually move to the technology frontier by seeking support from designing centres, R&D labs and universities in China. The TNCs have introduced best practices – including designing activities – in Buenos Aires and Penang. CORFO and FC provide adaptation support utilizing foreign knowledge from Norway, Scotland, United States and Canada for salmon production in Los Lagos.

Because high technology meso-organizations have reached only level 3, the human capital and knowledge generated domestically in Penang is not adequate to support firms' extensive participation in designing and R&D activities. The inability of government programmes to attract on a large scale human capital inflows from abroad has restricted the capacity of Penang to support further upgrading, though firms such as Intel, Motorola, Advanced Micro Devices, Fairchild and Alterra have captured the limited supply of engineers to engage in designing activities.

Qiaotou has reached the technology frontier of button manufacturing as the masters in Italy from whom they learnt button production over the period 1976-1990 now attend exhibitions in Zhejiang Province to monitor the introduction of new designs and materials. The level 4 sophistication of R&D labs and universities has facilitated this development. However, we classified the cluster as enjoying level 4 institutional support rather than level 5 because the technologies realized in materials used in button manufacturing are a result of the coevolution of existing technology in metal, chemicals, plastics, and testing and manufacturing processes undertaken in Gansu and Guangdong states.[9]

All four clusters enjoy strong integration (level 4) in global markets. However, whereas the automotive and electronics clusters of Buenos Aires and Penang are extensions of TNC production chains, the salmon and button clusters of Los Lagos and Qiaotou enjoy strong national ownership.

Table 4: Embedding institutional pillars, selected locations, 2006

	Basic infrastructure	**High tech organizations**	**Network cohesion**	**Integration in international markets**
Catch Up Phase (3)		Buenos Aires Los Lagos Penang	Buenos Aires Los Lagos Penang	Buenos Aires Penang
Advanced Phase (4)	Buenos Aires Los Lagos Penang Qiaotou	Qiaotou	Qiaotou	Los Lagos Qiaotou

Source: UNIDO, *Survey of Dynamic Industrial Locations*, 2007-08

[9] This decision was validated by industry officials in Qiaotou when we interviewed them on 24 December 2007. We are grateful to Kong Xin Xin for assisting us with the interview.

5. Technological upgrading and economic synergies

This section analyses the level of technological upgrading, and growth in exports, employment, wages, and skills intensity in the four clusters. Over 50 per cent of firms in the clusters were at least engaged in level 3 knowledge-intensive activities. The upgrading achieved by these clusters has helped to sustain exports, employment creation, wage increase and high intensity of skills.

Technological upgrading

All four clusters are technologically advanced. With the exception of one TNC in level 6 activities and significant numbers of TNCs in level 5 activities in Penang, the percentage shares of firms in the four clusters are mainly concentrated in level 4 technological capabilities (see Table 5).

Interviews show that the automotive cluster in Buenos Aires faced a dualistic evolution of supplier capabilities as TNC assemblers and their suppliers continued to enjoy strong capabilities, while independent suppliers targeting the second hand market and exports were characterised by inferior capabilities. Whereas suppliers to TNCs were engaged in tier 1 activities to provide completely knocked down modules, tier 2 firms supplied components to these firms, and the TNCs. Whereas TNC assemblers were reported to operate at level 5 capability and their suppliers were reported to function at level 4 capability, independent national suppliers were reported to operate at level 3 capability. Modularization and changes in the regulatory environment created by the Automotive Industry Decree and the *Mercado Común del Sur* (MERCOSUR) agreement that pressed for the introduction of new models drove the relocation of designing of small vehicles by TNCs, thereby stimulating the development of human resource and process technology capabilities in Buenos Aires (Bernat, 2008). Foreign TNCs are the only car assemblers in the automotive cluster in Buenos Aires. Despite Brazil providing a much larger market, TNCs have retained Buenos Aires and Sao Paolo as major regional production locations.

As in Norway, salmon farming has become horizontally integrated since the 1990s as price competition intensified (see Aslesen, 2007). However, whereas vertical coordination through a blend of competition and cooperation has intensified in Norway, vertical and horizontal integration has increased in Chile, especially among a firms seeking to internalize development work to raise quality and yield. Millions of Atlantic salmon eggs are imported every year from Norway, Ireland and Scotland, though the figure fell as national producers of salmon eggs worked with universities, such as, the University of Chile to reduce dependence on foreign suppliers (Katz, 2006: 203). The hatcheries handle hatching and infant growth of the salmon smolts in vats placed in fresh water lakes. Highly skilled employees ensure that the water and temperatures remain ideal through the infantile period of growth of the salmon. Once the salmon grows to adult size it is then transported to the sea by trucks, boats or helicopters where it is farmed using rectangular net cages until it is harvested. Apart from diseases, sea lions often poach a number of the salmons before they are harvested. Skilful divers are often required to stitch up nets damaged by sea lions. Salmon are fed in the dark. Once harvested, the salmon is then sent to factories for processing, which is undertaken through automated conveyor belts where skilled workers handle the different aspects of cleaning, slicing, finishing and packing. While most of the processed fish are frozen some are smoked for export in the same factories. Throughout these activities firms have absorbed best practices from the United States, Canada, Scotland and Norway. Some of the larger firms have also installed automated machinery and equipment to carry out research to improve water and salinity control techniques, feeding behaviour of salmon and processing techniques to reduce throughput time.

Although Qiaotou was utilizing the newest materials, machinery and equipment, chemicals and metal mixes, we did not classify them in level 6 because its inputs were supplied by R&D labs located outside the clusters studied. Whereas the firms studied were directly involved in the manufacture of buttons significant knowledge inputs attracting new designs and materials comes from labs located in the University of Lanzhou and Huanan University of Technology. Hence, the firms studied were not highly knowledge-intensive as their activities were confined to manufacturing only. Nevertheless, improvements in layouts, automation and the implementation of best practices were becoming important in these firms.

Motorola was the only firm reporting that their plant in Penang was the most sophisticated in their microcosm and were engaged in new product development. Whereas Intel, Alterra, AMD, Fairchild and Agilent also reported involvement in extensive designing work they reported having their most sophisticated operations abroad. Over 50 per cent of firms in all four clusters had evolved to at least level 4 technological capabilities - across human resource, process technology and product technology. The electronics cluster in Penang enjoys a high agglomeration of firms engaged in component manufacture and the assembly of telecommunications and industrial electronics products. The assembly of consumer electronics and disk drives became important in the 1980s and 1990s but were relocated to China, Philippines, Indonesia and Vietnam as labour shortages became a problem.

Of the four clusters, the incidence of firms having level 4 knowledge intensity capabilities was highest among electronics firms in Penang. Overall, 83.7 per cent of the sampled electronics firms in Penang were either fully or majority foreign owned in 2008. Foreign firms dominated participation in levels 4 and 5 activities in Penang. Most national firms were engaged in level 3 knowledge-intensive activities. Vitrox is among the few national firms engaged in level 4 activities. A number of foreign TNCs (e.g. Intel, Motorola, Agilent, Advanced Micro Devices, Fairchild and Alterra) were engaged in level 5 designing activities that generated patents in the United States.

Whereas the salmon and button clusters of Los Lagos and Qiaotou were fairly integrated with firms engaged both in the value chain and in complementary activities, the automotive and electronics clusters of Buenos Aires and Penang, have often faced wide swings in production focus. In addition, firms in Buenos Aires, Los Lagos and Penang have had to also contend with macro-volatilities generated by wide swings in prices and exchange rates. The majority of firms in the salmon and button clusters enjoyed designing and adaptive engineering support from national meso-organizations located within proximate distance. Button firms in Qiatou in addition also enjoyed R&D support in the development of new designs and material mixes from universities and R&D labs located in other provinces in China. The level 5 designing activities of automotive firms in Buenos Aires and electronics firms in Penang take place in-house in foreign TNCs. Although some collaboration was reported in 2008 between salmon firms in Los Lagos (Vidal, 2008), automotive firms in Buenos Aires (Bernat, 2008) and electronics firms in Penang (Rasiah, 2011) with universities they were strong and related to their prime activity only between a handful of firms and particular universities, but in most cases were *ad hoc* and did not relate to the core aspects of their operations.

Table 5: Technological intensity of firms in clusters, 2006

a) Latin America

Buenos Aires: Automotive cluster

	HR	PT	RD
1	50(100)	50(100)	50(100)
2	50(100)	50(100)	50(100)
3	50(100)	50(100)	50(100)
4	7(14)	7(14)	7(14)
5	2(4)	2(4)	1(1)
6	0(0)	0(0)	0(0)

Los Lagos: Salmon cluster

	HR	PT	RD
1	50(100)	50(100)	50(100)
2	50(100)	50(100)	50(100)
3	50(100)	50(100)	50(100)
4	12(24)	12(24)	5(10)
5	2(4)	3(6)	0(0)
6	0(0)	0(0)	0(0)

b) Asia

Penang: Electronics cluster

	HR	PT	RD
1	103(100)	103(100)	103(100)
2	103(100)	103(100)	73(71)
3	85(83)	85(83)	66(64)
4	69(67)	69(67)	57(55)
5	35(34)	35(34)	11(11)
6	1(1)	1(1)	1(1)

Qiaotou: Button cluster

	HR	PT	RD
1	100(100)	100(100)	100(100)
2	100(100)	100(100)	100(100)
3	75(75)	75(75)	72(72)
4	39(29)	37(37)	33(33)
5	3(3)	3(3)	2(2)
6	0(0)	0(0)	0(0)

Note: Figures in parentheses refer to percentage of total firms.

Source: UNIDO, *Survey of Dynamic Industrial Locations*, 2007-08

Economic synergies

Technological upgrading helped stimulate growth in exports, employment and wages (see Figure 1), and improvement in skills (see Figure 2) in the four clusters. Only firms in the button cluster showed low skills intensity, which is a consequence of the knowledge-based activities confined to external universities and labs.

Exports drove growth in clusters, while the differentiation and division of labour arising from technological upgrading drove export growth, with the latter providing circular push to support the former. Export growth continued to be strong in all four clusters over the period 2000-2006 (see Figure 1).

The salmon cluster of Los Lagos (18.6%) and automotive cluster of Buenos Aires (15.3%) have recorded the strongest export growth over the period 2000-2006. Whereas, institutional arrangements that required exports to compensate for imports within the MERCOSUR agreement were important in the growth of regional automotive exports from Buenos Aires, the expansion in supermarket coordinated demand has been instrumental in salmon exports from Los Lagos to global markets.

The Qiaotou (12.4%) and Penang (6.7%) clusters also enjoyed strong export growth demonstrating that foreign demand has been the spearhead of cluster development in these locations. Although a saturation in human capital supply has slowed down new firm relocation, it has not stopped existing firms from continuing to expand exports from Penang (see Chandran, 2008; Rasiah, 2011). Similarly, despite selling the bulk of buttons to export-oriented clothing firms in China, exports have continued to grow strongly in Qiaotou (Kong, 2008).

The agglomeration of export-oriented activities has driven strong differentiation and division of labour so that employment has recorded strong growth in all four clusters (see Figure 1). Employment in Los Lagos grew at an annual average rate of 11.9 per cent over the period 2000-2006. Employment in the automotive cluster of Buenos Aires and button cluster of Qiaotou grew at 6.5 and 5.6 per cent per annum respectively, and the electronics cluster of Penang grew at 4.0 per cent per annum in the period 2000-2006.

All the locations examined enjoyed positive real wage growth over the period 2000-2006. Los Lagos and Qiaotou in the samples enjoyed the highest annual average wage increments of 27.1 and 13.1 per cent, respectively over the period 2000-2006 (see Figure 1). Rapid technological upgrading helped these regions capture significant shares of exports in global markets for salmon and buttons produced.

Average annual real wages grew slower in Penang (1.1%) and Buenos Aires (0.5%) clusters over the period 2000-2006. Whereas high inflation slowed down real wage growth in Buenos Aires, the lack of technological capability building and an influx of foreign unskilled labour restricted the capacity of Penang to support rapid real wage growth. The liberalization of import restrictions reduced the automotive component manufacturing of national firms to low value added activities thereby keeping real wage growth low in Buenos Aires (Bernat, 2008).

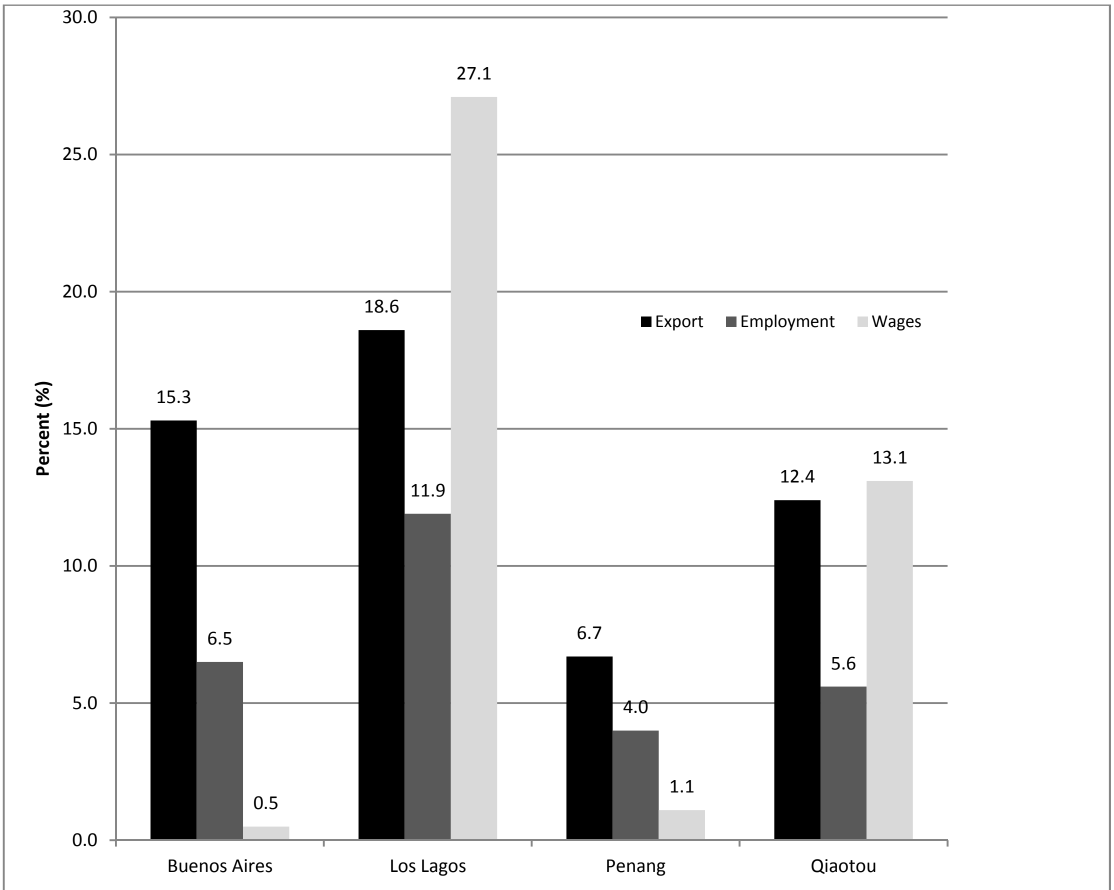

Figure 1: Export, Employment and Wages, Average Annual growth, 2000-2006

Source: UNIDO, *Survey of Dynamic Industrial Locations*, 2007-08

While a low skills base has often been the point of integration of particular locations in global value chains, sustained technological upgrading and economic synergies have often driven improvements in skill-intensities.[10] The data collected allowed the inclusion of skilled direct workers into the skills category, though skills intensities vary with industry.[11]

Skills intensity percentages of the automotive cluster in Buenos Aires and the salmon cluster in Los Lagos were 64.3 and 63.0 per cent respectively in 2006 (see Figure 2). Whereas in-house and external training were important in the development of skills of workers among salmon producers in Los Lagos, the industry association officials considered TNCs as the prime source of skills training among automotive firms in Buenos Aires.

Skill-intensity was highest in Penang's electronics cluster at 87.7 per cent. The long period of production experience and rising pressure for upgrading since the introduction of flexible production techniques from the 1980s has been pivotal in raising skills levels in Penang. Especially integrated circuits (IC) assembly and test activities, which forms the nucleus of the electronics cluster in Penang, became knowledge intensive since the 1980s (see Rasiah, 1988).

Skill intensity levels were lowest in Qiaotou (31.1 per cent) whose button firms are limited to just manufacturing. Button firms in Qiaotou specialize in manufacturing in a division of labour where the highest value added activities of testing, designing and R&D take place in meso organizations either in Zhejiang or other provinces in China.

[10] Skill intensity was calculated as a percentage of professional, managerial, supervisory and clerical personnel, and skilled workers among direct workers as a share of the workforce.

[11] Skill-intensity is typically estimated by dividing the sum of managers, professionals, and technical, clerical and supervisory personnel by the total workforce. We included skilled direct workers in the numerator.

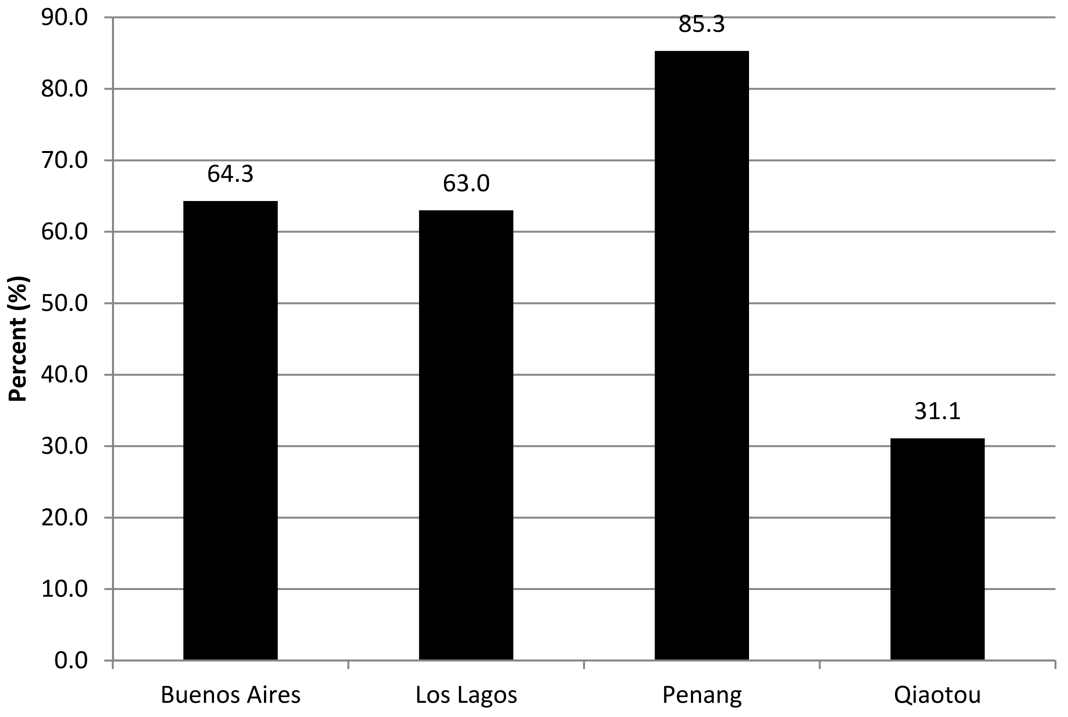

Figure 2: Skills Intensity, 2006

Source: Computed from UNIDO, *Survey of Dynamic Industrial Locations*, 2007-08

6. Drivers of upgrading

All four clusters have generated knowledge to support substantial technological upgrading and economic synergies. Whereas foreign sources of knowledge still drive innovation in the salmon cluster of Los Lagos, and TNCs in the automotive cluster of Buenos Aires and the electronics cluster in Penang, national meso organizations have assumed that role in the button cluster of Qiaotou. We discuss in this section the drivers of technological upgrading and economic synergies in the four clusters.

Automotive cluster of Buenos Aires

While the automotive industry in Buenos Aires was started earlier, it began to expand strongly from the 1950s under an import-substitution (IS) regime that was characterized by several agreements between the Argentinian government and TNCs, which became the basis of the relocation of subsidiaries to supply the domestic market. The production of motor vehicles in Argentina grew rapidly from 100,000 units in 1961 to 200,000 units in 1968 and 294,000 units in 1973 (Bernat, 2008: 3). Employment in the industry grew from 10,000 in the late 1950s to 57,000 in the mid-1970s.

After a long period of contraction from the mid-1970s till the end of the 1980s arising from falling demand domestically as the macroeconomic environment took a hit from economic mismanagement, three important developments drove the rejuvenation of the industry. First, the Reconstruction of the Automotive Industry Decree of 1991 underlined benefits and obligations of automobiles manufacturers operating in Argentina, which allowed producers to import parts and finished vehicles tax free when compensated through exports, and if they met investment criteria associated with new technology and the launching of new models. The Decree also restricted imports of automotive parts, which boosted domestic producers.

Second, it was established within the MERCOSUR agreement between Argentina, Brazil, Paraguay and Uruguay in 1995 for a commercial compensation exchange involving automotive goods between members of the union so that imports of such items from one member country will be compensated by reciprocal exports of related items to that country, which drove the leading global producers to retain operations in both Argentina and Brazil (Bernat, 2008: 4). Third, the Convertibility Regime that was introduced in the early 1990s encouraged increases in domestic incomes, which helped raise demand for cars in the country, though the 2001 crisis also hit hard the firms owing to the collapse of the convertibility mechanism.

Whereas the contracting plants such as Mercedes began to expand operations again from 1991, new TNCs such as Volkswagen, General Motors, Peugeot, Fiat, Ford, Renault and Toyota relocated operations from the mid-1990s as a consequence of the new policy developments. Automobile production in Argentina subsequently grew from 262,000 units in 1992 to 446,000 units in 1997 (Bernat, 2008: 4). Production of automobiles in the Buenos Aires cluster rose from 188,000 units in 1992 to 232,000 units in 1997. Employment in the cluster increased from 18,000 in 1991 to 26,000 in 1997. While the MERCOSUR proved superior to the IS regime of the past, exchange rate fluctuations often created considerable problems, which weakened the industry over the period 2001-2003. Production of automobiles in the Buenos Aires cluster fell to 90,000 units in 2003 leading to the Argentinian government suspending the MERCOSUR agreement, which led Katz to call for effective macro-micro coordination to insulate Argentinian firms from external shocks.[12] The situation reversed from 2004 as an appreciating Brazilian Real and a depreciation in the Argentinian peso in 2003 made exports attractive. The changed environment also attracted the relocation of Honda into the Buenos Aires cluster.

The TNCs have been the main source of knowledge flows to the Buenos Aires automotive cluster. While the TNC assemblers imposed stringent standards they also played a critical role by transferring technology to the national suppliers through quality assurance certifications, and quality and inventory control systems. The suppliers that enjoyed strong relationship with the TNCs had in possession ISO 14001 and quality standard (QS) certifications. Through networking that shows a blend of competition and cooperation, the TNCs assisted in the acquisition of state of the art precision machinery and equipment by the suppliers. The TNCs often encouraged their domestic suppliers to share knowledge in developing their engineering capabilities so as to participate effectively in generating the innovations essential to perform original equipment manufacturing and original design manufacturing operations. The strong training regimes essential to stay competitive in the automotive industry practiced by the TNCs was extended to the first-tier suppliers who also undertook profound training and retraining of staff. Several TNCs also regularly trained personnel from suppliers whenever a new model was to be launched (Bernat, 2008).

TNCs have been the major drivers of knowledge flows into both the introduction of new models, assembly of vehicles and component production (see Bernat, 2008). Indeed, a distinct division of labour has emerged between automotive suppliers tied to TNCs and the independent automotive component manufacturers. While the Reconstruction of the Automotive Industry Decree and the MERCOSUR agreement have played important roles in TNCs deploying high technology operations in Argentina, the global restructuring of the industry also helped, which has driven TNCs to introduce best practices in all major locations. However, while new model designs have emerged in the main assembly locations, none of their operations are sophisticated enough to undertake level 6 technological depth operations. Also, contrary to the believe that a freer world will lead to the concentration of production among the most efficient (on the basis of good infrastructure, market size and best incentives) locations, automotive production appears to be dispersed over locations with reasonably large markets because of one, capabilities that have been evolved from past policies, and domestic demand.

Salmon cluster of Los Lagos

Although Union Carbide's subsidiary, Domsea Farms Chile, began farming salmon in 1974 (Katz, 2006: 195), the mass development of the industry in Southern Chile started as part of the government's initiatives from the post-Allende era to alleviate poverty. The Public Works Corporation (CORFO) was very much

[12] Communication with Jorge Katz whose argument is consistent with Keynes' (1936) and Stiglitz's (2002) accounts of the disruptive consequences of leaving financial instruments to market forces.

instrumental in the growth of the next salmon farming firm in 1974, Lago Llanquihue, which exported the fish to France since 1978. Following severe problems that derailed Domsea's operations, FC bought its facilities in 1981 to create Salmones Antartica, which became the first firm to produce over 1 thousand tons of the fish in 1998 (Maggi, 2006: 113). The geo-political support the industry received from the United States, Canada, Scotland and Norway to transfer salmon farming technology to Chile is also important (Chile, 2003).

The transformation of Salmon from ornamental fish to a commercial food-based export good started with the import of salmon eggs, vats, breeding technology and other inputs from United States, Canada, Scotland and Norway. Salmon was identified among a number of resource-based sectors by FC that included timber and wine for development through sector specific policies at a time when Chile under the Pinochet regime had abandoned tariff-based import-substitution policies. The Chilean government through the Institute of Fishing Industries and the Fishing and Hunting Division of the Department of Agriculture, and CORFO and FC, intervened extensively to promote the industry in the poorer regions of Southern Chile. Interviews with officials of FC show that Chile's participation in salmon farming to become the second largest exporter in the world after Norway owes much to public-private initiatives that brought together government agencies, financial institutions, and development and experimentation laboratories.[13] CORFO and FC carried out several experiments to adapt technology imported from the United States, Canada, Scotland and Norway. Foreign agencies and firms that relocated support through Nichiro Chile, the Japan International Cooperation Agency, and the University of Washington were among the early pioneers in the transfer of knowhow to Chile (Katz, 2006: 194). Nichiro Chile is a Japanese firm that started to cultivate salmon farming in Chile to supply the Japanese market. The FC also incubated firms that were sold to private owners once they matured.[14]

Financial regulation and deregulation was not only aimed at financing enterprises by government authorities of Chile but also at insulating enterprises in the country from external shocks (Bank of Chile, 2004). The impact of the debt crisis of the early 1980s led to the enactment of a new banking law in 1986 to check moral hazard and systemic risks, and regulations' governing financial institutions that were amended to strengthen the financial sector (Bank of Chile, 2004: 11-12). The government introduced capital controls to insulate the economy from volatile financial fluctuations, which included a 3-year stay on foreign direct investment.[15] Salmon firms were some of the firms that benefited from the capital control measures that shielded them from disrupting technological upgrading.

The United States' Food and Drug Administration, and the Food and Agriculture Organization (FAO) assisted in the improvement of quality standards in the 1980s. A blend of competition and cooperation helped the firms amortise investments by pooling and undertaking bulk purchases of inputs from abroad. CORFO and FC played important roles in building the bonds of trust between the firms and meso organizations. The major breakthrough into global expansion started when supermarket chains took control of salmon value chains. Chilean Salmon enjoyed this connectivity from the 1990s when large retailers got into the monitoring of production and into the marketing of the fish. This development provided the impetus for large scale production as markets became large and more secure. Also, the large supermarkets helped connect the salmon producers with the major standards organizations regulating sanitation standards in Europe.

While some large private farms absorbed and adapted from abroad some of the best practices, the FC and CORFO played a wide role on a national scale to attract best practices from Canada, Scotland, United States and Norway, which were adapted and introduced in especially the smaller salmon farms in Chile. In fact, interviews with farm officials, and officials from FC and CORFO showed that much of the adaptation of fish cultivation, virus treatment and feed meal experimentation were started in the public-private organization of FC before it was absorbed by the salmon farmers and processors. The prime focus of FC has been on experimentation and adaptation without deep involvement in R&D. Having strong links with

[13] We had the benefit of talking to officials from firms, FC and Corfo to make the point.

[14] FC played the role of supporting the private sector, selling its successful incubators whenever there were buyers (Chile, 2003).

[15] The three-year stay was reduced to one year in 1995 (Bank of Chile, 2004: 12).

the frontier salmon farming systems in Canada, United States, Scotland and Norway helped as best practices were fairly easily imported, adapted and introduced in Chile.[16] The best practices included the size of breeding vats, feeding materials, frequency of feeding, sterilizations before use of the vats and the organization of process flow in both the vats, and when it matures in the sea, and processing factories.

As competition increased in the second half of the 1990s with sharply falling prices, the firms began to merge and expand vertically to expand participation into hatchery, cultivation, and processing, and in some cases also in the production of feed meal, fish eggs, and several other inputs. Demand for high quality, quick delivery, and transparency in the production process against a fall in profit margins meant that fewer but highly integrated large firms began to dominate the export market. Some family firms became suppliers to these large firms.

Salmon production has since the 1990s also become highly concentrated worldwide (Iizuka and Katz, 2006). The average firm became more capital- and technology-intensive with skill intensities growing strongly as workers were exposed to higher daily targets, automation and technical tasks. The expansion in size is also a consequence of a lack of growth in independent knowledge suppliers to support rapid productivity growth. In fact, salmon firms in Chile, as well as, FC and CORFO, still rely considerably on R&D undertaken in Scotland, Canada, United States and Norway.

Overall, the origin of a commercially viable salmon farming and processing industry in Los Lagos started very much with the role of government to absorb its farming from the typical salmon farming countries of the United States, Canada, Scotland and Norway. The government, through FC and CORFO played major roles to experiment, adapt and introduce farming methods until they became successful in the 1980s by when they had begun to sell these ventures to private owners, which differs considerably from Perez's (2005) who argues that the industry association was instrumental in the development of salmon farming in Chile. Our view was also shared by the senior researchers interviewed from the government hatchery labs in Puerto Mont who explained that the government's role was central here, though, their objectives was always to support private firms. The early acquisitions were by Chilean firms, including family firms with national firms dominating salmon farming in the 1980s.The government also helped with improvements to the infrastructure in the farming provinces. Hence, the prime drivers were the Chilean government and the foreign providers of the knowledge with the mobilizational role of the United States – who also enticed Canada, Scotland and Norway to support the exercise.

As competition from abroad and domestically intensified, farming lakes and shores became congested, the industry began to face vertical integration as the small and medium firms were not able to compete as prices crashed, and to meet the quality standards demanded by export markets. It is since the late 1990s that foreign firms began to acquire brownfield firms to participate in increasing numbers in salmon production in Chile. Nevertheless, the drivers of technological change from the late 1990s still included FC and CORFO who continued to adapt and adopt best practices developed in the R&D labs in Norway, Scotland, United States and Canada, and the supermarket chains that became the main wholesale link for producers in Los Lagos. While such strategies facilitated the upgrading of salmon farming activities to levels 3 and 4 technological capabilities, the lack of strong participation in R&D activities domestically left Chilean salmon farming vulnerable to the vicissitudes of new virus outbreaks. Hence when ISA struck in 2008 the Chilean innovation system lacked the capability to generate the new knowledge essential to cure the disease at the expense of a huge contraction in production as output fell by almost 60 per cent from its peak of 700 thousand tons in 2006 with close to 20,000 job losses (Iizuka and Katz, 2011: 269).

Electronics cluster of Penang

The electronics cluster began in Penang following the relocation of Clarion and National Semiconductor in 1971. The government earmarked the Bayan Lepas Free Trade Zone to attract labour-intensive export-oriented manufacturing activities through the provision of tax holidays and guaranteed the repatriation of profits, tariff-free imports and exports, leasing of subsidized land and security (see Rasiah, 1988). Interventions to offer the additional relative benefits of decomposing and relocating labour-intensive

[16] See Pietrobelli (1998) for an early account of this experience.

segments from more secure developed sites to less secure and developed sites, such as Penang, were important.[17] Since the domestic market was small, the relocation of electronics assembly to Penang in the 1970s was meant completely for export.

Over the period 1972-80, the government provided tax holidays and good basic infrastructure in the export processing zones. A change in government policy over the period 1981-85 that saw an ending of tax holidays began to discourage new investments. However, the economic crisis of 1985-86 drove the government to renew the tax holidays and devalue the Ringgit to attract new TNCs into the country (see Malaysia, 1986). The government used the macro-micro coordination initiative again when capital controls were introduced in 1998 to shield the country from currency attacks (Rasiah, 2000). The government also allowed exporting firms to handle transactions in US dollars. A strong US economy helped boost electronics exports during the 1997-98 Asian financial crisis. The government subsequently introduced fiscal stimulus in 2009 following a massive contraction in exports during the global financial crisis of 2008-09 and assisted with the repatriation of foreign workers back to their home countries as a recession gripped the electronics cluster (Malaysia, 2010).

Government incentives and grants have played an important role to stimulate upgrading. Incentives were given since 1988 to stimulate upgrading, which was augmented by further efforts to promote technological upgrading following the implementation of the Action Plan for Industrial Technology Development (APITD) in 1991. The APITD gave rise to important meso organizations to drive training, testing, R&D (including the provision of grants), government-funded venture capital and high tech infrastructure (see Malaysia, 1996). The late 1980s and 1990s saw the promotion of clustering in Penang when consumer and industrial electronics firms were attracted to use components produced in the Island. However, the relocation of consumer and industrial electronics firms did not raise the technological intensity of the cluster as the forward integration involved less knowledge-intensive activities than integrated circuits production. The government's Second Industrial Master Plan of 1996 included Penang's clustering as one of its main promotional targets (Malaysia, 1996). However, the lack of human capital, and a mechanism to vet and appraise investment and production restricted its capacity to drive upgrading.

The government also strengthened basic infrastructure and security in the export processing zones, including the construction of an excellent airport to fly in wafers and other components and fly out assembled products from Penang, which was strengthened further since the 1980s with the expansion of highways, broadband internet service and bridges to facilitate the employment of employees across the Penang Straits. As the industry became increasingly knowledge-intensive, the Penang Skill's Development Centre (PSDC) was started in 1989 with the government imposing only a nominal rent on its building, while the TNCs donated computers and other machinery and equipment. The PSDC subsequently upgraded its services to include designing through federal grants. The Penang Development Corporation played a critical role in coordinating the demands of the TNCs with the regulatory institutions of the federal government. The entrepreneurial Chinese community took advantage of growing demand for proximate sourcing of precision machine tools and plastics products to evolve a sizable group of suppliers over the 1980s and 1990s. A number of engineers who had gained experiential knowledge working in the TNCs left in this period to start machine tool, plastic injection moulding and electronics firms (see Rasiah, 1995).

The skill-intensity of electronics firms in Penang rose strongly with increasing demand. However, the lack of human capital to participate extensively in designing and R&D restricted the capacity of Penang to upgrade extensively into level 5 technological capabilities *a la* Korea and Taiwan. Electronics firms also lacked access to R&D from meso organizations in Penang. Hence, the handful of TNCs that managed to obtain R&D grants from the government internalized their designing activities without much links to domestic R&D labs and national universities. Only Motorola reported having its most sophisticated plant in Penang. Also, all firms engaged in levels 5 and the one firm engaged in level 6 knowledge-intensive activities are foreign TNCs. National firms are only engaged in levels 3 and 4 activities in Penang.

[17] Indeed, as Hymer (1960) had argued, the relative benefits of host-sites against home-sites were important in the relocation of electronics TNCs in Penang.

Button cluster of Qiaotou

Two brothers began distributing buttons in Qiaotou in 1978 that were purchased from Huangyan in Hubei, which then snowballed into the opening of over 300 stalls by 1982 (Kong, 2008: 3). Markets dominated the initial growth of the industry. Faced with rising costs, exhaustion of raw materials and competition from the emerging economies, Italian button producers responded to requests by Qiaotou's entrepreneurs to outsource the manufacturing stage of button production over the period 1982-84. Chinese clothing firms supplying export markets using foreign brand names were an important catalyst in stimulating the relocation of button manufacturing in Qiaotou.

Button sales began expanding rapidly from 1984 as production in Qiaotou soared to account for over 4,000 stalls, 28,000 varieties of buttons, 14,000 employees, and over RMB2.6 billion in sales by the mid-1990s (see Kong, 2008: 4). Operations in this period were still largely driven by markets. However, the limits of market-based coordination became obvious from the late 1990s when national firms in Qiaotou were not able to upgrade technologically. Government support and social networks helped provide the spur for technological upgrading from 2000. However, the button manufacturers remained mainly confined to levels 3 and 4 activities as the designing and R&D support evolved in design centres, R&D labs and universities that supplied these inputs through strong social networks established by the Yonjia County local government. The world class quality of button designs and materials saw leading buyers of garment value chains visiting Qiaotou exhibitions to seek new designs to import. Over 160 international brands began to source their buttons from Qiaotou by 2005. In fact, the entire cluster of activities from button materials and design to complementary activities related to machinery and components, resins and dyes and other inputs had evolved in Qiaotou by 2006 (see Rasiah, 2012).

While a long history of entrepreneurial experience was important, effective coordination between government, the entrepreneurs and markets was instrumental in the development of the cluster, as well as, provide the firms with testing, training, materials and designing, and R&D support. The local government of Yongjia took measures to stimulate upgrading the infrastructure in the county by focusing on the construction of an information channel that included industrial conferences to connect the button firms to the whole country, develop a special industrial zone, establish incubation facilities for new firms, and mapping and filling the missing components of the button cluster so as to generate a complete button ecosystem, and to support new brand development and knowledge diffusion.

A button and slide fastener Industrial Park was built in Qiaotou to locate the firms with basic infrastructure connected with excellent roads, water and electricity supply, telecommunication, pollution disposal centres, and internet cables. The local government also offered subsidized land and regulation fees for industrial operations with standard factory buildings. To assist firms to resolve collective action problems in fields, such as, training, testing and technological upgrading, the government either attracted or collaborated with meso organizations, such as, universities to support training, standards testing, designing and R&D. Also, the local government encouraged firms and universities to collaborate through science and technology projects. In 2006, the local government encouraged Wenzhou Mailida and Dongda Integrated Chemicals to work with Huanan Technical University to develop new technologies to raise button quality and recycling button material waste productively. New button technologies that were developed from such collaboration – both product and process – helped raise value added of the industry by 2008 (Kong, 2008: 15).

The county government also established the pump and valve industrial science and technology innovation centre with collaboration from Lanzhou Technical University located in Gansu Province in Northwest China, which provides technology information and human resource support for button manufacturing firms in Qiaotou.

The stable exchange rate regime of China ensured that the small button firms in Qiaotou were not drowned by sudden destabilization from plummeting or soaring exchange rates. While markets drove the initiation of the industry in Qiaotou, the Yongjia local government in collaboration with the firms and meso organizations played a critical role in supporting technological upgrading in the industry.

7. Conclusions

The evidence presented in this paper is convincing enough to support the heterodox argument that industrial policy and in particular institutional change is essential to drive technological upgrading. However, consistent with evolutionary arguments the evidence also shows that technological upgrading in particular clusters is conditioned by industry and location specificities. The Buenos Aires and Penang clusters were characterized by the origin and expansion of TNCs that transformed the technological intensity of their operations as competition drove upgrading at host-sites. Important institutional changes were made to the regulatory environment to provide both the incentive and the pressure to upgrade operations to high value added activities. Qiaotou has enjoyed upgrading until R&D and designing, though, such activities are confined to meso organizations located outside the button firms. The government agencies of FC and CORFO have continued to access foreign sources of knowledge to drive firms' participation in level 4 knowledge activities with some firms' participating in level 5 activities. The most sophisticated technological operations in Buenos Aires and Penang involve designing by TNCs.

All four clusters have continued to enjoy strong growth in exports, employment and wages. Skill intensity levels of firms in Penang, Buenos Aires and Los Lagos was high. It was low in Qiaotou because of the organization of economic activity where the button firms researched only specialized in manufacturing with intermediary organizations supplying knowledge generated from designing, testing and R&D. Government-business coordination initiatives in the four locations have produced institutions and intermediary organizations that are uniquely industry and location specific to stimulate upgrading. The networking with meso organizations of universities, training, testing and designing centers and R&D labs organized by Yongjia County has helped support the production of the world's latest buttons in Qiaotou. However, state intervention in Los Lagos, Buenos Aires and Penang was limited to pressuring firms to participate in cutting edge process technologies and designing. Whereas the lack of supply of experienced engineers was reported as a barrier for further upgrading in Buenos Aires and Penang, the reluctance of government to stimulate adaptive engineering capabilities to new knowledge creation has restricted firms' movement to the frontier in Los Lagos. Whereas government policy not to support R&D through grants appears intentional in Buenos Aires and Los Lagos owing to the risks and uncertainty associated with R&D, the inability to mobilize a critical mass of quality engineers is the prime barrier to further technological deepening in Penang.[18]

Federal governments in the four clusters have also played important roles to prevent volatile macro disruptions from undermining technological upgrading by either pegging currencies or imposing capital controls during turbulent times in the external environment. Whereas buttons firms in China enjoyed stable exchange rates as the government avoided foreign calls to float the RMB, the governments of Chile and Malaysia imposed capital controls to stem volatile external disruptions in the 1980s and 1990s respectively. Argentinian firms perhaps were the hardest hit as the appreciating peso destroyed firms in the period 2001-03 but the government still responded by suspending the free commercial interchange under the Mercosur Agreement.

Therefore, we conclude that the analysis in the paper compliments industrial policy arguments on the need for interventions in markets to target technological upgrading by focusing on the importance of industry and location specific characteristics. Firms' movement up the technology ladder in particular clusters depends very much on how institutional change supports upgrading. Industrial policy and institutional change have played critical roles with their significance varying over time and industry and location specificities. The only constant in the development of the clusters has been the focus on technological upgrading through effective coordination between firms, intermediary organizations and macro institutions.

[18] Interviews showed that national firms enjoyed R&D grants to undertake knowledge-intensive activities from 1990, but foreign firms were only approved similar grants after 2005.

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