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The State and Innovation Policy in Late Development: Evidence from South Africa and Malaysia

Banji Oyelaran-Oyeyinka

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Abstract

This paper analyses the main institutional mechanisms that foster the emergence and performance of firms in knowledge-intensive sectors in developing countries. We use the empirical data collected in 2005 and 2006 in the South African computer hardware and software sectors and the Malaysian computer hardware sector to illustrate the linkages between interactive learning and technological capabilities and how state support plays a critical role in enabling this in the case of knowledge intensive industries. However, as the analysis in this paper shows, state support is not just implementing a set of policies that succeed elsewhere; it is the ability of the state to set up institutions that reflect a harmony between knowledge and physical infrastructure and the formal and informal institutional compensations that are important to, and structure the idiosyncratic exchange processes of developing economies.

Key Words: Interactive learning, technological capabilities, knowledge, institutions, development, innovation, South African hardware and software, Malaysian hardware.

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1. Introduction

This paper analyzes the determinants of innovation and firm performance resulting from collaborative learning in the South African and Malaysian computer sector, which consists of software and hardware specialized firms. The analysis focuses on two main propositions. The first is to examine the well-established notion that the microeconomic processes of interactive learning leads to innovation even in the context of a latecomer economy. The second proposition is that firms in a latecomer economy require state support to produce and innovate because markets do not function well. In such contexts policy choices made are instrumental in explaining the success/ failure of sectors. However, as the analysis in this paper shows, state support is not just implementing a set of policies that succeed elsewhere; it is the ability of the state to set up institutions that reflect a harmony between knowledge and physical infrastructure and the formal and informal institutional compensations are important to, and structure the idiosyncratic exchange processes of developing economies.

Essentially, technical change or innovation is largely incremental but nonetheless useful in advancing productivity growth and has been classified into three different categories (Bell, 1984). First we have technical change that involves the introduction of new techniques (products and processes) into the economy through new investments in plants and machinery. This type of technical change broadens the industrial base of the economy. The second form of technological change involves evolutionary (incremental) improvement to existing techniques by effecting technical change to existing products and third, the generation of new knowledge through research within the firms or within separate R&D institutions.

So how and what explains the process by which countries and firms move from one level or knowledge domain to the other? The observed structure of knowledge or sets of capabilities that one finds in an economy is a result of cumulative technological mastery and investment efforts made over a long time. In other words, technological change is a cumulative and path-dependent process, in order words, national or firm level actions taken in previous times condition the current state of capabilities. In short technological capabilities acquisition processes are not just strongly cumulative in nature they have elements of strong path dependence (Dosi, Nelson et al. 1988). The conceptual and empirical literature on technological capabilities (TC) blossomed in the late 1980s received considerable attention from the mid-1980s through and early 1990s (Westphal, Kim and Dahlman (1985; Dahlman, Ross-Larson et al,1987); Lall,1990, 1992; Bell and Pavitt, 1993, 1995). Several authors refined the typologies and elaborated upon them but essentially the key ideas revolve around the same concepts[1]. The essential elements of the framework are as follows:

1. TC focuses on efforts to "make effective use of technological knowledge in production, investment and innovation Westphal, Kim and Dahlman (1985) [p. 171]'.

2. The process has strong heuristic elements of feedback from previous experiences to current states and as such skills and knowledge gained in previous domain becomes part of the organizational memory of firms and nations that create a new capability domain resulting in more efficient techniques and systems[2].

3. The build up of capabilities therefore entails individual and organizational "learning" (Lall, 1987, 1990, 1992; Dahlman and Westphal 1982; Katz 1984, 1987 and Dahlman, Ross-Larson et al., 1987). The process is re-conceptualized as essentially efforts by organizations to master technological functions though learning driven by explicit investment.

4. Firms and nations require explicit investment capabilities in order to identify, prepare, design, set up and commission a new industrial project (or an expansion of it). In other words if the processes of capability build up must continue, this set of skills and experience will be built in a co-evolutionary process with technical capacity.

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[1] Authors Nelson and Winter (1982) developed the notions of "routines". Bell (1984), Scott-Kemmis and Bell (1988), Katz (1987), used "technological capacity" to described the learning processes involved in building up a minimum base of essential knowledge to engage in innovative activity.

[2] Dahlman, Ross-Larson et al., (1987) conceived TC as the ways to use existing technology to produce more efficiently and to use the experience gained in production and investment to adapt and improve the technology in use.

5. As technical change and innovation do not take place in isolation and is only possible within a network of other actors, firms and countries require a systemic framework. This has been conceptualized as "linkage capabilities" which knowledge and experience required to foster interactive learning (see point 3 above).[3]

However, capability acquisition is largely driven by interactive learning, which is conducted with a multiplicity of firms and non-enterprise actors in any system. A firm needs external knowledge on a continual basis to regenerate itself failing which it might well stagnate or regress. The stage-wise gradation of firm/country from one level of knowledge and technological capability to a next higher one over time reflects the heuristic feedback loops involved between policies and institutions that promote interactive learning and thus help to build capacity. The mode of learning is also related to the level of capability that a firm or country has accumulated. The amount of learning and skills required to move from the lowest domain of artisanal and indigenous manufacturing to the second lowest knowledge domain of modern manufacturing are embedded in primary and secondary schooling capacities, apprenticeship training, training to read engineering designs and blueprints and organisation of production. Several of these aspects are missing in developing countries – foundary making, metal cutting, and so on – are essential skills to move to the next higher level but a hiatus in several most developing countries since they constitute "nodes of learning" (Rosenberg, 1976). To move from here to the next higher knowledge domain to design and re-engineer products and innovate, one needs not only primary and secondary schooling but tertiary education that equips individuals with technical and analytical skills and public sector investments into building basic R&D capabilities for standards, metrology and other infrastructure. To operate in this domain, a country also requires significant entrepreneurial capabilities which act on the 'demand side' of the market, and act to stimulate demand for certain kinds of products (Rodrik, 2007). The learning associated with transitioning to this knowledge domain is more systematic and systemic, rigorous

[3] Linkage capabilities are defined as "…the capacity of forging co-operation between managers and workers within the firm, for securing co-operation between firms in the supply chain, and for crafting co-operative interfaces between firms and the wider institutional milieu, be it local, regional, or international" (Cooke and Morgan 2000).

and has to be sustained over a long period of time and capable of being replicated across several sectors. It also requires an unlearning of several of the conventional ways of conducting the innovation business in these countries. This means new perspectives on collaboration, public-private partnerships, education system design and administering of courses as well as new entrepreneurship models. For a country to move from here to the final knowledge domain where learning becomes concentrated in R&D activities and can be measured using conventional indicators, such as patents, skilled employees, and so on. At this level, the absorptive capacity of firms/entities relies on concentrated efforts in key facilities by highly specialised individuals who conduct research and design activities (Cohen and Levinthal, 1990). This is the level where orthodox measure of R&D as a source of national knowledge begins to apply.

Catching–up is both a mountain climbing metaphor as it is a marathon challenge where firms and countries practically run the gauntlet and whereby failure is costly. The notion of latecomer therefore signifies the fact that the entity (country or firm) is late to meeting up certain key capabilities compared with both the forerunners as well as competitors. Economic history shows that whereas countries move easily from the lowest knowledge domain to the next higher one, moving further up into knowledge domains that focus on incremental design and innovation and then to frontier innovation is ridden with lack of success. Several countries on a supposedly sound catch-up path often do not move as predicted or regress along this path mainly due to the inability of these countries to manage the coordination efforts required in setting up a sound basis to move to the next knowledge domain. This is not surprising since the efforts required are significant and need to be designed to combat both market failure and government failure simultaneously. Merely focusing on industrial policy that does not take into account the scale effects, thresholds of scientists of engineers and minimal standards of domestic knowledge infrastructure as well as conducive policy environment for domestic innovation are common flaws in latecomer countries.

In this paper, we use the empirical data collected in South Africa and Malaysia to illustrate these interlinkages between state policy, technological capabilities and interactive learning. Sections 2 and 3 present the results of our innovation surveys in the South African and Malaysian computer sectors respectively. Our empirical analysis focuses specifically on factors that impact upon new product development in the sector, and a discussion on the actors and triggers for innovation. We then discuss the comparative insights on learning and collaborative behaviour as well as state support in section 4. The South African data used in this Paper was collected during a 2006 survey, which consists of 82 South African firms from the computer sector of which 19 firms are computer hardware firms. The Malaysian data was collected between 2004 and 2006 from two computer clusters, namely Penang and Johor.[4] The survey covered 360 firms from both clusters.

In the empirical analysis, we use t- and z-tests to stress the differences between the software and hardware sectors. In the South African data, we consider a probit model of innovation, which is estimated by maximum likelihood and a linear and a censored regression model of economic performance. The linear regression model is estimated using ordinary least squares (OLS), instrumental variables, limited information maximum likelihood and generalized method of moments, and the censored regression is estimated using maximum likelihood. Finally, we carry out a descriptive analysis using t- and z-tests to study the characteristics that distinguish collaborators from non-collaborators.

2. The South African Computer Sector

In South Africa, emerging high-tech activities in the computer sector have a strong geographic locus; such firms are concentrated in Gauteng and to a less extent in the Western Cape. We consider four types of actor interactions in our analysis to understand the innovation dynamics of the sector, namely: subcontractors, industry associations, main suppliers and buyers. Appendix Table 1 presents the definition of the dependent and independent variables used in the innovation and performance analysis, and Table 6 reports descriptive statistics for the whole sample, when contrasted with those of the

[4] The data collection was carried out by Prof. Rajah Rasiah for one of the authors' projects. A more elaborate discussion of the issue is found in Oyelaran-Oyeyinka and Rasiah (2008), "Uneven Paths of Development: Learning and Innovation in Asia and Africa"

hardware computer firms.

2.1 Sector characteristics

The descriptive statistics presented in appendix Table 1 show that 66% of all firms are involved in new product development while only 37% carry out innovation in the hardware computer sector. Hence, the percentage of firms that are involved in new product development in the software sector is much higher than in the hardware sector. However, productivity, i.e. sales per employee (in millions of $), is higher in the computer hardware sector than in the computer software sector. In other words, sales per employee are on average about one million dollars in the whole computer sector and twice as much in the computer hardware. The figures for export intensity, i.e. the share of export sales in total sales, and increased net profit are on average similar for the computer hardware and software sectors. More specifically, export intensity is (on average) about 17% in the whole sector and 13% in the hardware sector, and net profit increased for 88% of all firms and for 84% of the computer hardware firms. In short the propensity to innovate is far higher in software firms but much overall similarities exist in the two sub-systems.

The descriptive table also shows that 23% of the firms are computer hardware firms and also have the lower percentage of staff with university or technical degree (human capital) compared with the software firms. Not surprising, 73% of workers in the whole sector have a university or technical degree while the percentage is only 55% in the hardware sector. The figures for firm size, upgrade activities, technology source, government support, customer demand, technical capability and training in the whole sector are contrasted with those of the same variables in the hardware sector. On average hardware firms are much larger in size than software firms. More specifically, the former are on average three times as large, in terms of employees, and four times as large, in terms of sales, as firms in the software sector. Second, the percentage of firms that upgrade with reverse engineering and original design is on average larger in the software than in the hardware sub-sector, while firms that upgrade with original brand is larger in the latter sub-sector compared with the former. Firms that upgrade with quality control are on average similar across the two sectors. And finally, when the figures on technology source of the whole sector is compared we find that software firms depend more for their technology on local expertise and in some cases on a combination of local and foreign expertise such as licensing from clients and buyers relative to hardware firms. Other sources of technology include hiring of skilled employees, collaboration with universities and public institutes, and reverse engineering. For hardware firms technology source is largely from foreign expertise and component suppliers. The two sub-sectors draw equally from joint venture partners, transfer from parent firm and suppliers of equipment.

2.2. Triggers and Actors: Empirical and Econometric Analysis of Innovation

Innovation was measured by the number of new product and process development applied by the firms in the past five years. The survey shows that a relatively large percentage of the firms in the sector can be classified as “innovators”, as 66 per cent of the firms have been involved in a new product development within the last 5 years of operation, and 76 per cent have developed a new service. Our survey shows that software firms are more innovative than hardware firms (75% versus 37%), small firms than larger ones (70% versus 36%) and those firms receiving state support tend to be more innovative than those than do not (76% versus 58%). Also hardware firms seem to be more focused on service innovation rather than product innovation. This is not surprising as most hardware activities are based on assembling and distribution of foreign hardware.

Table 1 shows the distribution of innovation activities related to new products and services and between different classes and size of firms, those that receive support (Sup) and those that do not receive state support (NSup).

Table 1: Types of Innovation

	All	***Software***	***Hardware***	***Small***	***Large***	***Sup***	***Nsup***
New products	***66%***	75%	37%	70%	36%	76%	58%
New services	***76%***	78%	68%	76%	73%	88%	67%

Source: Empirical survey by authors, 2006.

The survey also sought to understand the triggers for such innovation; and the extent to which licensing and foreign support through technical training contributed to new product development in the sector. Most of these new products and services were obtained through own in-house development, particularly in the case of software firms, whereas hardware companies rely more often on licensing and foreign technical support (see table 2). This pattern of behaviour is not surprising given that computer manufacturing remains in a nascent phase in the country as with much of the region.

Table 2: Origin of Innovation

	All	***Software***	***Hardware***	***Small***	***Larger***	***Sup***	***Nsup***
Licensing	22%	24%	16%	23%	18%	21%	21%
Own development	88%	95%	63%	92%	64%	91%	85%
Foreign Technical Support	17%	17%	16%	17%	18%	18%	15%
Others	6%	3%	16%	6%	9%	9%	4%

Source: Survey by authors, 2006.

Approximately one third of the firms tend to innovate at the global level particularly the software firms. This result seems at odds with the lower exporting rate observed for the software sub-sector. However, the reason lies in the fact that much of their innovations were directed at solving local problems needs and their ability to respond creatively to those needs and constraints in the South African and African environments. With innovations driven largely by strong 'localisation' efforts, the incidence of low exports is not so surprising.

On the various factors that help build innovative capabilities, the survey finds that quality control and reverse engineering are the major upgrading paths for the firms surveyed. Remarkably, 80% of the firms are mostly concerned with the quality control systems, although in the majority of the cases, it is an internal quality control system, based on crossed-staff checks of products before they go into the market. In very few cases (less than 25%) there is an external system of quality control, and even in those cases it is limited to those firms with a parent company or a single customer. The 'other' upgrading factors involve different dimension such as growing interaction with their customers' needs and learning by doing (original brand) (see table 3).

Table 3: Nature of Innovation

	All	Software	Hardware	Smaller	Larger	Sup	Nsup
Quality Control	*38%*	40%	32%	39%	27%	33%	40%
Reverse Engineering	*38%*	44%	16%	41%	18%	45%	33%
Original Design	*32%*	38%	11%	37%	0%	45%	23%
Original Brand	*6%*	3%	16%	4%	18%	3%	8%
Adaptive Engineering	*1%*	2%	0%	1%	0%	0%	2%
Others	*68%*	65%	79%	68%	73%	67%	71%

Source: Empirical survey by authors, 2006.

2.3. Factors Affecting New Product Development

Table 4 reports maximum likelihood (ML) estimation results of the probit model that studies the likelihood of being involved in new product development.[5] The estimated coefficients as well as their standard errors are reported in the first pair of columns, while the slope parameters (marginal effects) and their standard errors are reported in the second pair of columns.

The first pair of columns suggests that, other things being equal, upgrade using original design, the effect of government assistance, collaboration, overseas technical training, and competitive challenge from Asia all have a strong and significant effect on the likelihood of a firm being involved in new product development. In addition response to demanding customers in order to conform to higher quality standards has a positive effect, which is not strongly significant. Finally, improved capability through more managerial training and belonging to the hardware sector decreases the likelihood of being involved in new product development.

The second pair of columns shows the magnitude of the effects of the explanatory variables on the likelihood of being involved in new product development.[6] *Ceteris paribus*, involvement in upgrade activity particularly with regard to original design, access to government assistance, investing in overseas technical training, facing more demanding customer demand with regard to conformity to standards, and facing severe

[5] We always report estimation results that include only the jointly significant explanatory variables.
[6] Since all the explanatory variables reported in Table 3 are binary, their marginal effects are calculated as discrete changes of those variables from 0 to 1, (see Greene, 2003, page 676 for more details).

and very severe challenge from Asian competition significantly increase the probability of being involved in new product development by respectively 0.385, 0.259, 0.252, 0.215 and 0.233 (see Table 4). In other words competitive pressure is a major inducement to innovate.

Table 4: Probit Estimation results and marginal effects: New product development

Variable	Coefficient	(Std. Err.)	Slope	(Std. Err.)
Original design	2.125**	(0.732)	0.385**	(0.083)
Gvt. Assistance	2.255*	(0.900)	0.259**	(0.083)
Capability, more manag. Training	-1.611**	(0.494)	-0.399**	(0.115)
Training, overseas technical	1.166*	(0.542)	0.252*	(0.104)
Cust. dem., conf. to standards	0.816†	(0.428)	0.215†	(0.113)
Asian competition	1.454*	(0.648)	0.233**	(0.081)
Hardware firms	-1.756**	(0.609)	-0.566**	(0.190)
Intercept	0.070	(0.368)	-	-
Number of firms		82		
Log-likelihood		-27.758		

Significance levels: † : 10% * : 5% ** : 1%

Source: Empirical survey by authors, 2006.

2.4. Inter-firm Collaboration in South Africa

This section presents only a descriptive analysis of collaboration, as the sample does not allow the estimation of an econometric model of collaboration.[7] We identify six types of collaboration in the sample, namely collaboration with other firms, subcontractors, industry associations, main suppliers, domestic buyers and foreign buyers. Descriptive statistics show that almost 100% of the firms collaborate with other firms and with domestic buyers, 63% collaborate with subcontractors, 57% collaborate with industry associations, 89% collaborate with main suppliers and 54% collaborate with foreign buyers.

[7] The sample is not sufficiently informative to achieve this.

Table 5: Correlation between the types of collaboration

	Other firms	Subcont.	Indus. Assoc.	Main Suppliers	Dom. Buyers	For. Buyers
Other firms	1.000					
Subcontractors	0.044	1.000				
Industry Association	0.023	-0.041	1.000			
Main suppliers	0.197†	0.138	-0.066	1.000		
Domestic buyers	-0.025	-0.120	-0.136	-0.056	1.000	
Foreign buyers	0.170	0.259**	0.187†	0.065	0.012	1.000

Significance levels: † : 10% * : 5% ** : 1%

Source: Empirical survey by authors, 2006.

Table 5 presents the correlation matrix of the six types of collaboration. It suggests that the six types of collaboration are hardly significantly correlated. Three exceptions are collaboration with foreign buyers, which is positively, statistically, and significantly correlated with collaboration with subcontractors and members of Industry Association, and collaboration with main suppliers which is positively, statistically and significantly correlated with collaboration with other firms. Table 6 presents the characteristics of the collaborators contrasted with those of the non-collaborators through t- and z-tests of equality of means and percentages across the two populations of firms.

Collaboration with Sub-contractors

The first pair of columns of Table 5 shows the characteristics of collaborators and non-collaborators with subcontractors. Firms that collaborate with subcontractors have on average a larger share of export in total sales and are older than those that do not collaborate with subcontractors. The percentage of firms collaborating with sub-contractors have greater net profits, higher product quality and product innovation capabilities than those that do not. In other words, *the more established firms tend to focus collaboration with an aim to enhance exports and quality and predictably tend to earn higher net profit.*

Collaboration with Industry Associations

The characteristics of collaborators and non-collaborators with Industry Associations are reported in the second pair of columns of the table. Firms that collaborate within Industry Associations have on average smaller productivity, and are smaller with respect to the three measures of size than those that do not collaborate within an Industry Association. Furthermore, a larger percentage of collaborators receive government assistance and have product innovation improved capability, while a larger percentage of non-collaborators have in-house management and local training. This is not surprising because it is often the small and medium firms with less internal capabilities that participate more actively in collective support programmes provided by governments and industry associations.

Table 6: The characteristics of collaborators and non-collaborators

Variable	Mean							
	Subcontractors		Industry Association		Main Suppliers		Foreign Buyers	
	No	Yes	No	Yes	No	Yes	No	Yes
Product innovation	0.567	0.712	0.571	0.723	0.667	0.658	0.605	0.705
Productivity in 2005	0.609	1.217	1.435†	0.667†	1.662	0.912	0.702	1.247
Export intensity	0.098*	0.212*	0.128	0.203	0.141	0.171	0.003*	0.315*
Increased net profit	0.700*	0.981*	0.857	0.894	0.778	0.890	0.789*	0.955*
Size	79.500	59.577	119.743†	27.489†	36.111	70.658	89.079	47.682
Large firms	0.200	0.096	0.229†	0.064†	0.111	0.137	0.132	0.136
Turnover in 2005	139.782	154.306	317.426†	23.563†	390.322	119.239	155.886	143.039
Hardware firms	0.267	0.212	0.257	0.213	0.111	0.247	0.237	0.227
Age	4.233*	7.558*	7.543	5.447	4.333	6.589	5.000	7.500
Human capital	0.763	0.702	0.647	0.783	0.736	0.723	0.746	0.707
Asian competition	0.167	0.192	0.143	0.213	0.222	0.178	0.132	0.227
Gvt. Assistance	0.100	0.154	0.057*	0.191*	0.111	0.137	0.105	0.159
Capability, more manag. Training	0.467	0.538	0.543	0.489	0.222*	0.548*	0.474	0.545
Capability, more techn. training	0.833	0.712	0.771	0.745	0.556	0.781	0.816	0.705
Capability, improve quality	0.533*	0.699*	0.714	0.660	0.556	0.697	0.605	0.750
Capability, product innovation	0.467*	0.763*	0.486*	0.681*	0.556	0.603	0.474*	0.705*
Training, in-house technical	0.867	0.962	0.914	0.936	0.778*	0.945*	0.895	0.955
Training, in-house management	0.567	0.731	0.771†	0.596†	0.667	0.671	0.632	0.705
Training, overseas technical	0.267	0.404	0.429	0.298	0.111*	0.384*	0.211*	0.477*
Training, overseas management	0.067	0.077	0.114	0.043	0.000	0.082	0.026	0.114
Training, local training	0.733	0.615	0.800†	0.553†	0.556	0.671	0.737	0.591
Number of firms	30	52	35	47	9	73	38	44

The figures are on average statistically and significantly larger for *collaborators, †non-collaborators.

Source: Empirical survey by authors, 2006

Collaboration with Main Suppliers

The characteristics of collaborators and non-collaborators with main suppliers are reported in the third pair of columns of the table. Collaborators in this category tend to devote more explicit investment to building management capability, in-house and overseas technical training compared with the non-collaborators.

Collaboration with Foreign Buyers

Finally the last pair of columns of the table shows the characteristics of collaborators and non-collaborators with foreign buyers. Firms that collaborate with foreign buyers have on average higher export intensity than those that do not collaborate with foreign buyers. Furthermore, a larger percentage of collaborators have increased net profit, product innovation, improved capability and overseas technical training.

In sum, the descriptive analysis of collaboration shows that many characteristics of firms that are collaborators and those that are non-collaborators are similar but the partners they choose to interact with results in *significant differences in terms of performance behavior*. For instance, firm export intensity is higher for firms that collaborate with subcontractors and foreign buyers than those who do not collaborate with those same partners. Also, small-sized firms tend to be the most intense collaborators with industry associations presumably to lobby for greater support as well as benefit from governmental subsidies. Firms that collaborate with subcontractors are also on average older than the non-collaborators, and indulge much more in own product development and capacity development (such as training). This points out to the need for more support for younger, nascent firms in the sector.

2.5. State Support and Collaborative Behaviour

From our interviews we find that government support is directed equally towards software and hardware firms. There are a few exceptions in the kinds of support structures. The survey found that targeted innovation incentives, science park/cluster advantage, and special support for small and medium enterprises (SMEs) that are directed specifically towards the software sector,[8] while public sector R&D institutions for technical solutions and bank loans are mainly directed towards the hardware sector. In other words, government has had a differentiated approach to the two sub-sectors in addition to the more general macro level support. The main sector-specific governmental initiatives are summarized in Box 1 below.

Box 1: Government Initiatives for ICTs in South Africa

The first attempt to develop a sector-specific initiative can be traced back to the South African Information Technology Industry Strategy (SAITIS), in 1995. There were stakeholder meetings conducted on the SAITIS project and the selection of a group of 37 stakeholders as an Advisory Group to the SAITIS Project. They represented key organizations and agencies with interests in the sector. The outcome was a Project Design Document (PDD) to guide the direction of the project and the establishment of a Project Steering Committee (PSC).

The Government of South Africa was also supported by the Canadian International Development Agency (CIDA), under its Country Development program for South Africa to develop the *South African ICT Sector Development framework* in November 2000. Among the numerous goals in this framework, the ones relevant for the ICT sector were those related to: accelerate growth of the base of ICT SMEs, focus on regional growth through clusters, particularly in Gauteng and the Western Cape (mainly Cape Town), and upgrade local expertise to compete in the regional and global markets. Special emphasis was placed on creating and supporting new entrants particularly SMEs. Following the release of the *ICT Sector Development framework*, the ICT Development Council was established in 2000 by the Department of Trade and Industry. The *Strategic Industrial Projects* (SIP) that started in 2001 and is managed by the Department of Trade and Industry (DTI) provides between 50% and 100% tax allowance to encourage investments from local and foreign investors. To support firms further, import duties on IT hardware and software were abolished on 2003. Presently, the firms importing into South Africa only pay a Value Added Tax (VAT) to the South African Customs. As hardware firms source technology mostly from abroad, release from import duties highly benefits South African small firms.

Source: Empirical survey by authors, 2006.

In addition to these, there are a number of provincial initiatives particularly in Gauteng and Western Cape. In the Gauteng province the government launched the ***Blue IQ*** programme in 2002[9]. The first phase of the Blue IQ involved the delivery of 11 strategic projects; the second phase of commercialisation is expected to be dependent on private sector participation. One of these projects was the creation of the Innovation Hub, an ICT incubator and Science Park. The innovation Hub and other similar ICT incubating

[8] The fact that special support for SMEs is mainly directed towards the software sector makes sense as firms in that sector are on average smaller than the those in the hardware sector.

[9] Through Blue IQ, the Gauteng local government is investing R3.7 billion in 11 projects for "strategic" industries and value-added manufacturing to restructure the composition of the provincial economy.

activities are at the centre of the technology support services strategy directed to small entrepreneurs in Gauteng. Also, the Western Cape Province has recently started challenging the dominant position of Gauteng. The Western Cape provincial government, along with the Municipality of Cape Town are devoting efforts to promote the Western Cape into a growing hub for ICT activities and various policies are directly focused on strengthening the sector.

Overall, state policy has been one of non-intervention along with certain innovation incentives; the computer hardware industry has enjoyed some of the lowest tariff levels. The flip side is the lack of manufacturing depth of the domestic industry, which needs policy initiatives to be in tandem with the needs of the firms and sectoral characteristics. Especially, given the dominance of a large number of small and medium scale enterprises in the sector, much more than tax holidays are required to sustain the growth and enhance long term competitiveness.

3. Systemic Collaboration and Performance in Malaysia

In Malaysia, the government established the Kulim and Bukit Jalil high-tech parks in the 1990s although clusters such as Penang have been in existence already twenty years prior to these developments. The Malaysian survey focused the computer and components clusters in Penang and Johor. Few firms are engaged in assembling computers but most of the firms are engaged in computer components (e.g. capacitors, resistors, PCBs, diodes and semiconductor chips) and completely knocked down (CKD) parts (e.g. monitors, keyboards and LCD screens) assembly.

3.1. State Support and Patterns of Collaboration

In order to attract high-tech firms engaged in R&D activities to the clusters and the high-tech parks, the government offered pioneer-status tax incentives. Electronics firms became the prime beneficiary of this initiative, although the rate of take-up has been relatively low compared to that of the free trade zones (FTZs) and LMWs. Additionally, systemic coordination has been facilitated by strong cooperation between the state cooperations and firms for various requirements in the innovation process, and the comparison between Penang and Johor shows the impact of varying levels of state support. For example, the Penang state's Penang Development Corporation (PDC) facilitates systemic coordination amongst firms through the provision of basic infrastructure, among others. A notable example of this sort of policy coordination is the joint approach by the Free Trade Zone Penang Companies Association (FREPENCA) with PDC. This form of strategic intervention in developing infrastructure and other basic services in Penang over time had been instrumental in fostering technological capacity. It has had the effect of facilitating transportation while the other cluster namely Johor has been unable to acquire comparative capacity to provide such service. As a result of good physical infrastructure, the region has succeeded in attracting flagship firms including more than ten semiconductor firms to Penang. In contrast, with the exception of ST Electronics (located in Muar) there are no semiconductor firms in Johor.

The knowledge infrastructure in Penang is also better than that in Johor although the country in general does not have a significant number of R&D labs and in comparative terms, lack strong R&D human capital for the kind of growth that the sector has exhibited. Similar to the firms in South Africa, firms in both clusters in Malaysia also learn mainly through quality control activities and reverse engineering. Technological capabilities developed within firms in Penang are significantly higher and varied compared with electronics firms in Johor and this can also be contributed to the interactions between local and foreign firms in the cluster. But overall, the supply of R&D and human capital yielded very low means irrespective of location or ownership, which validates the poor human capital in Malaysia.[10] It is unclear if government announcement in 2006 to provide Multimedia Super Corridor (MSC) status to Penang and Johor has effected any changes on firms' conduct on R&D activities.

Despite this shortcoming it is evident that greater systemic coordination promoted by the physical and other infrastructure supplied by the government with strong support from

[10] For instance in various interviews, Intel, AMD, Hewlett Packard and Dell officials in Penang reported in 2004 their inability to undertake more R&D activities because of limits imposed on the import of foreign human capital.

the chambers of commerce, FREPENCA and coordinated by the PDC, was instrumental to forging relationships between firms and institutions in Penang, whereas the same deficiencies curb the performance of Johor.

Empirical evidence comparing the two clusters (in table 6) show superior rating for firms in Penang compared to firms located in Johor in all the statistically significant two-tailed results. Knowledge infrastructure represented by R&D support was statistically insignificant, which is reflected by a lack of any sort of R&D relationships between firms (both foreign and local) and R&D institutions (e.g. university R&D, Malaysian Institute of Microelectronics System and the incubators put up in technology parks by the government). Collaboration between local firms and standards organizations is only statistically significant (at 5% level). Interviews showed that local firms mainly sought the international standards organization 9000 series certification from the Standards and Industrial Research Institute of Malaysia (SIRIM).

Table 7: Systemic Collaboration: Computer and Related Component Firms', Penang and Johor, 2004

	Foreign		*T*	**Local**		*t*
	Johor	**Penang**		**Johor**	**Penang**	
Ministries	2.75	3.05	-1.01	2.17	2.77	-0.97
Industry Association	2.17	3.67	-3.15*	2.05	3.25	-2.95*
Training institutions	2.01	3.98	-3.25*	2.15	3.33	-3.02*
Universities	1.03	2.01	-3.11*			
State Development Corporation	2.35	3.57	-2.75*	2.11	2.63	-2.25**
R&D support Units	0.1	0.3	-0.01	0.2	0.5	-0.10
Incubators	0	0	-0.00	0	0	0.00
Standards Organization	2.01	2.15	-0.70	1.88	2.54	-2.45**
Horizontal inter-firm links	1.87	2.45	-2.68*	1.90	2.33	-1.88
Vertical inter-firm links	2.11	2.95	-2.45**	2.00	2.47	-2.01**
Complementary Supplier links	2.21	3.13	-2.97*	2.02	2.94	-2.54**
N	**332**	**28**		**39**	**37**	

Source: Empirical Survey, 2004.

Note: Likert scale score of firms (0-5 with from none to highest possible rating); * and ** - statistically significant at 1% and 5% respectively.

Clearly one of the reasons for the relative superiority of Penang is that it was started much earlier and for much of this time there has been a consistent history of investment in the cluster since the seventies. For instance Penang Electronics was the first electronics firm to be started in 1970, followed by Orion and National Semiconductor in 1971. Investment in Johor however started only from the 1980s. However what marks out the two are the series of explicit investments resulting in the more advanced technical and institutional coordination and knowledge infrastructure that favoured Penang.

4. Comparative Insights and Conclusions

Technological learning involves not just technical learning but learning to build the right kinds of organizations and to foster the institutional forms within which policies would make the expected impact. In the last three decades we have learnt a great deal about the nature and processes by which latecomer countries acquire capabilities but we also have a long way to go in constructing a framework that systematically takes account of the diverse and increasingly differentiated paths of development being taken by latecomers. Much has been learnt through firm-level studies (Lall, 1992; Bell and Pavitt, 1995; Hobday, 1995) but there is a growing level of dis-aggregation among latecomers that we need to begin to address them on this basis. For instance most of the current work focus on the success cases of East Asia "advanced" latecomers to understand the reasons and different pathways to success while much less has been done on the lagging ("falling behind") firms and countries. With these countries learning has come to be conceptualized on the strength of R&D carried out and patents taken just as in the case of industrialized countries. In the lagging latecomers, learning is difficult to quantify, measure or even observe because much of the activity, including incremental technical change is experiential and tacit in nature. At a conceptual level, R&D is not equal to innovation as it is as an instrument of learning. Non-R&D activities (prototype building, design and quality testing for instance) tend to consume a much higher proportion of firm-level level investment in new products and processes and this is highly disconnected from the limited R&D taking place in the local contexts. In essence, orthodox measures create a misleading impression of the learning processes in latecomer countries.

The empirical results reinforce the role of the state in supporting innovation through purposive action, we find evidence of the limitation of the state in deliberately building knowledge infrastructure. Furthermore, the two country analyses show that the focus should not simply be on enacting a long list of institutions that have worked elsewhere, but rather on the combination of specific institutional local innovation as well as working on generating coherence and harmony of institutions and policies that bring about change. The systematic analysis of firm-level behaviour in both countries also shows clearly that systemic collaboration promotes production and export as well as innovation performance of firms. This again confirms what the literature tells us in theory and what has been established in several other studies of this kind. What is novel is that this analysis was carried out for latecomer countries in two separate policy settings with different historical and policy settings.

4.1. Composition and capabilities accumulation amongst actors

The main actors and capabilities in the computer hardware sector are engineers, and scientists. The core knowledge infrastructure includes scientific laboratories as well as design and research centers. The availability of scientific infrastructure, firms, universities and public research institutes determine the scope for specialization in any or all of the stages of the computer hardware industry, both physical and human capital related, which are specific for each one of its sub-stages[11]. Each of these sub-stages requires different combination of knowledge and skills of actors from various disciplines, some as diverse as physics, informatics and computer science required to facilitate innovation. This scope of diverse actor competences points to the limits of vision and action that a country might attempt. Fast Followers such as Malaysia are well able to take advantage of global knowledge pool in this sector but this might stretch the resources of most late comers (group 3).

[11][11] The sub-stages comprise: (1) product design, (2) component manufacturing, (3) assembly, (4) software development, (5) marketing, and (6) distribution.

In Malaysia, the computers and computer peripherals sector has become one of the fastest growing sectors with the establishment of manufacturing facilities by global players like Dell, NEC, Samsung, BenQ Technologies, Fujitsu and Mitsumi. Besides these MNCs, six Malaysian companies – Nascom, FTEC System, Gerak Mobile, Perbadanan Komputer National Berhad, MIMOS and I-Berhad – are currently producing Malaysian brands for the domestic and export markets. The first phase of Malaysia's electronics industry included almost no local firms—except for a few small ones such as Penang Electronics, established in 1970. Foreign direct investment (FDI) dominated the small manufacturing sector, but FDI levels declined from 1975 until the 1980s, when local firms who learned from the presence of foreign firms began to innovate with the help of state support.

Malaysia has a well-established supplier industries producing components and parts such as motherboards, disk drives, power supply units, connectors, printed circuit board assemblies, casings, plastic moulded parts and precision metal stamped/machined parts. On the contrary, South Africa's sector comprises four types of firms:

1) A small number of growing large indigenous firms, some of which have achieved multi-national status;

2) Several State Owned Enterprises (SOEs) that are major players in the ICT market;

3) A growing base of small and medium enterprises specializing in ICTs; and,

4) A number of foreign-owned multinational companies (MNC's) that have established a presence and business relationships in South Africa.

All these firms interact to different degrees with each other and the preponderance of foreign firms in South Africa has been partly fostered by deliberate policy action to attract foreign direct investment (FDI). Between 1994 and 2001, the IT and telecommunications sub-sectors attracted the highest share of FDI in the country[12]. In

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[12] 16 billion Rands (Moleke & al, 2003)
In Nigeria, Mauritius and Indonesia the main actors are small and medium assemblers with little connection to global CH players.

spite of this high level of foreign investment, the growth of the sector in South Africa is currently driven by domestic consumption rather than by exports as our survey shows. The telephony firms such as Telkom and Vodacom and State Owned Enterprises, for example Eskom, Transcom, and SABC, have entered into broad ICT activities such as telecommunications infrastructure and services, applications and content. These firms have adapted to the evolving domestic sector and have been largely driven by local consumption compared to Malaysia where the strategy has been to exploit global export market opportunities. Small firms largely dominate the sector with little prospects for significant global reach. So far, state policy has been one of non-intervention as the computer hardware industry has enjoyed some of the lowest tariff levels. The flip side is the lack of manufacturing depth of the domestic industry.

4.2. Impact of policy choices on learning

Due in part to historical path-dependent factors and more directly as a consequence of choices made by the state, the nature and attributes of regional clusters differ in very many respects and this also impacts upon their performance. Policy choices made by different governments and in coordination with other non-state actors have been instrumental in shaping the development of the clusters in both countries. For instance, the relatively hands-off approach to industrial coordination by state development corporations outside Penang (Malaysia) limited intensity of inter-firm relationships and also the potential of other clusters to develop and thrive. The Penang cluster has enjoyed the most consistent government and private investment and has therefore had the most success in terms of systemic cohesion compared with other regions in Malaysia.

However, the two country examples highlight the limitation of the state in deliberately building knowledge infrastructure. States have limited resources and different geographic zones have evolved from specific institutional settings that may not all be necessarily amenable to uniform policy intervention. The contrasting cases of Gauteng and Western Cape on one hand and Penang Valley compared with Johor on the other illustrate this very well. In South Africa, there is evidence of purposive government intervention at building knowledge infrastructure especially at regional levels but the outcomes have been far different from what obtains in Malaysia. For instance South Africa has had little success in computer hardware (CH) manufacturing and export, while Malaysia has made major strides as a global export player. In other words, while infrastructure is a necessary condition it is not sufficient. What counts is the combination of factors as well as the coherence and harmony of institutions and policies that bring about change.

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Appendix 1: *Descriptive statistics of the dependent and independent variables*

Variable	Mean	(Std. Dev.)	Min.	Max.	Mean	(Std. Dev.)	Min.	Max.
	All firms				Hardware computer firms			
Product innovator†	0.659	(0.477)	0	1	0.368	(0.496)	0	1
Productivity in 2005*	0.995	(1.715)	0.019	13.462	2.026	(2.931)	0.167	13.462
Export intensity	0.171	(0.292)	0	1	0.133	(0.271)	0	0.98
Increased net profit	0.878	(0.329)	0	1	0.842	(0.375)	0	1
Size*	66.866	(159.639)	2	1162	198.316	(290.389)	2	1162
Large firms*	0.134	(0.343)	0	1	0.421	(0.507)	0	1
Turnover in 2005*	148.992	(533.796)	0.075	3500	576.121	(1013.127)	1.200	3500
Hardware firms	0.232	(0.425)	0	1	-	-	-	-
Human capital†	0.725	(0.257)	0.138	1	0.550	(0.281)	0.138	1
Asian competition	0.183	(0.389)	0	1	0.158	(0.375)	0	1
Quality control	0.378	(0.488)	0	1	0.316	(0.478)	0	1
Upgrade, reverse engineering†	0.378	(0.488)	0	1	0.158	(0.375)	0	1
Original design†	0.317	(0.468)	0	1	0.105	(0.315)	0	1
Original brand*	0.061	(0.241)	0	1	0.158	(0.375)	0	1
Local expertise†	0.146	(0.356)	0	1	0.000	(0.000)	0	0
Foreign expertise*	0.159	(0.367)	0	1	0.474	(0.513)	0	1
Combination†	0.695	(0.463)	0	1	0.526	(0.513)	0	1
Licensing from clients†	0.744	(0.439)	0	1	0.474	(0.513)	0	1
Buyers†	0.183	(0.389)	0	1	0.053	(0.229)	0	1
Joint venture partner	0.622	(0.488)	0	1	0.474	(0.513)	0	1
Component suppliers*	0.280	(0.452)	0	1	0.579	(0.507)	0	1
Transfer from parent firm	0.146	(0.356)	0	1	0.158	(0.375)	0	1
Managers/skilled employees†	0.866	(0.343)	0	1	0.737	(0.452)	0	1
Suppliers of equipment	0.951	(0.217)	0	1	0.947	(0.229)	0	1
Univ. and public inst.†	0.195	(0.399)	0	1	0.053	(0.229)	0	1
Tech. source, reverse engineering†	0.512	(0.503)	0	1	0.211	(0.419)	0	1
Gvt. assistance	0.134	(0.343)	0	1	0.158	(0.375)	0	1
Gvt. supp., innov. incentives†	0.280	(0.452)	0	1	0.158	(0.375)	0	1
Gvt. supp., avail. skilled manpower	0.171	(0.379)	0	1	0.158	(0.375)	0	1
Gvt. supp., local univ. for R&D col.	0.220	(0.416)	0	1	0.263	(0.452)	0	1
Gvt. supp., R&D inst. for tech. sol.*	0.073	(0.262)	0	1	0.158	(0.375)	0	1
Gvt. supp., IPP	0.305	(0.463)	0	1	0.263	(0.452)	0	1
Gvt. supp., quality of IT sup. serv.	0.183	(0.389)	0	1	0.158	(0.375)	0	1
Gvt. supp., avail. venture capital	0.232	(0.425)	0	1	0.263	(0.452)	0	1
Gvt. supp., bank loans*	0.110	(0.315)	0	1	0.211	(0.419)	0	1
Gvt. supp., innov. subsidy	0.329	(0.473)	0	1	0.263	(0.452)	0	1
Gvt. supp., taxation policy	0.085	(0.281)	0	1	0.105	(0.315)	0	1
Gvt. supp., science clust. advant.†	0.537	(0.502)	0	1	0.316	(0.478)	0	1
Gvt. supp., procurement policy	0.232	(0.425)	0	1	0.263	(0.452)	0	1
Gvt. supp., spec. supp. for SMEs†	0.451	(0.501)	0	1	0.316	(0.478)	0	1
Gvt. dem., faster deliv. time	0.561	(0.499)	0	1	0.526	(0.513)	0	1
Gvt. dem., packaging quality†	0.305	(0.463)	0	1	0.158	(0.375)	0	1
Gvt. dem., conf. to standards	0.549	(0.501)	0	1	0.474	(0.513)	0	1
Gvt. dem., price	0.634	(0.485)	0	1	0.737	(0.452)	0	1
Gvt. dem., product quality	0.768	(0.425)	0	1	0.684	(0.478)	0	1
Capability, more manag. training	0.512	(0.503)	0	1	0.474	(0.513)	0	1
Capability, more techn. training	0.756	(0.432)	0	1	0.842	(0.375)	0	1
Capability, improve quality	0.683	(0.468)	0	1	0.579	(0.507)	0	1
Capability, product innovation†	0.598	(0.493)	0	1	0.368	(0.496)	0	1
Training, in-house technical	0.927	(0.262)	0	1	0.947	(0.229)	0	1
Training, in-house management	0.671	(0.473)	0	1	0.684	(0.478)	0	1
Training, overseas technical*	0.354	(0.481)	0	1	0.579	(0.507)	0	1
Training, overseas management*	0.073	(0.262)	0	1	0.158	(0.375)	0	1
Training, local training*	0.659	(0.477)	0	1	0.789	(0.419)	0	1
Number of firms		82				19		

†These figures are larger on average in the software sector. *These figures are larger on average in the hardware sector.

Source: Empirical survey by authors, 2006.

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