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A SYSTEMS PERSPECTIVE ON INTER-FIRM AND ORGANIZATIONAL COLLABORATION IN AFRICAN INDUSTRY

Banji Oyelaran-Oyeyinka*[1]

Abstract

Based on recent field survey data collected in three African countries, this study examines inter-firm and inter-organizational collaboration in African industry. Three sets of interactions were analyzed namely: firm-firm linkages, including user-supplier and subcontracting relationships; firm-university linkages; and firm-industrial association linkages. Employing univariate and multivariate analysis, we examined the channels and institutions for collaboration and tested three hypotheses. Collaboration with universities was expected to promote greater firm-level technical innovation resulting in greater output and product quality but little incidence of such collaboration was recorded. However, collaboration among suppliers of inputs, subcontractors and firms was found to have contributed to significantly better performance.

Keywords: Network, collaboration, Africa, industry, innovation

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1. INTRODUCTION

This paper employs a systems approach to examine the structure and dynamics of collaborations among firms, and between firms and other organizations, in a number of African countries. Interactions through networking are increasingly important organizational forms although we are far from understanding their nature and influence in the national systems of African countries. By networking we mean the structuring of linkages among economic agents, such as firms, in such a way as to result in a pattern of persistent interaction. This implies that networks are more than mere channels of information exchange because persistence of relations suggests structure and relative stability. We analyzed and attempted to understand the nature of collaborations in the national systems of three African countries - Nigeria, Kenya and Zimbabwe. Secondly, we compared cooperation across these countries to map the pattern, if any, of existing networks. Much of the research carried out in Africa in the past focused largely on organizations that develop policy for science and technology (agencies and ministries), and public institutions responsible for Research and Development (R&D). Far less attention was paid to the systemic links between knowledge generating institutions and the agents of production.

In the next few sections we briefly review the concepts of systems of innovation and networking among firms and organizations. Section four presents the univariate and multivariate statistical analyses of collaborations among economic agents. Section five discusses the conclusions and implications of the studies.

2. INTER-FIRM AND ORGANIZATIONAL INTERACTION IN SYSTEMS OF INNOVATION

Central to evolutionary and systems of innovation thinking is the notion of interactions among different actors, namely the organizations and institutions that undergird the exchange processes[2]. Shaped in large part by the technological capabilities of the nation and the institutional capacity for innovation, different organizations provide different types of technical services. For instance, the firm is regarded as the locus of production and research, while universities and public research institutions (PRIs) carry out research, consultancy as well as scientific and managerial human resource training. However, there are diverse and important sources of technology and innovation in SI including engineering and maintenance organizations, equipment suppliers and raw material producers, Lundvall, (1988). The SI is relevant to analysing collaborations precisely because innovation takes place within a network of actors for the production and use of new knowledge, (Freeman, 1987; Lundvall, 1992). As these scholars define it, a system of innovation comprises firms and other organizations, their routines and habits, which all interact in ways that produce, utilize, diffuse and adapt knowledge within a given socio-political and economic context. A variety of institutions mediate in this process of innovation and learning. Learning takes place when actors interact in different contexts, which are socially embedded within institutions. Interaction fosters knowledge flows, both old knowledge used in new ways, or new knowledge diffused as innovation. Interactions can take place both in market or non-market environments, but we now know that such interactions are common and widespread.

A study by Edquist (2004) identified three types of interactions, namely, competition, transaction, and networking. According to the study, 62-97 percent of product innovations cited in the Community Innovation Survey (CIS) were achieved in collaborative arrangements. The study found that firms and other actors may be engaged in competitive interaction, which can lead to product or process innovations. Competition promotes learning, while the degree of competition tends to determine the intensity of learning. As North (1996: p.346) observed, "competition, reflecting ubiquitous scarcity, induces organizations to engage in learning to survive".

[2] Institutions are defined as the "humanly devised constraints that structure human interaction". They are the "rules of the game" that determine the "transaction and transformation costs that add up to the costs of production" (North, 1996: p.344). Organizations are the players or actors and tend to be shaped by the institutional matrix of society.

Transaction is a process by which knowledge, goods and services are exchanged between actors. It is often an expensive process that grows more complex as actors in the system multiply and channels of information exchange grow. Networking is a process within which collaboration and competition takes place. Types and roles of networks will be discussed in the next section.

Within a system of innovation, diverse external agents contribute knowledge that augments the internal technological capability of a firm. These non-firm agents include universities and public research institutions (PRIs), both of which rank high although their contribution depends on a number of historical and institutional factors[3]. For instance, universities in developing countries contribute only marginally to industrial research and production and while there is a lot of focus on PRIs established by governments, these organizations suffer perennial funding problems. In industrial countries, public funding of PRIs has been central to the evolution of the research system.

In turn, PRIs and universities have produced trained manpower and facilitated the exchange of personnel between academic institutions and industry. This important human capital function, the movement of scientists from universities to industry, and the formation of other formal and informal collaborative arrangements underlie the importance of networking among the SI actors. Academic-industry exchange is necessary because much of the knowledge is tacit in nature and transferable only by personal communication between scientists. Tacit knowledge is a bundle of information that is most often expressed through the carrying out of routine tasks, rather than through written or verbal instructions. Tacit knowledge is built up from considerable practice and accumulated experience in some narrow tasks, for instance by an apprentice learning from the master. For this reason it is idiosyncratic but not necessarily inapplicable to other situations. There are many dimensions to tacit knowledge[4] but much of the tacit knowledge in firms is transformed into organizational routines[5] (Nelson and Winter, 1982).

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[3] For instance in highly R&D-intensive countries such as the Netherlands and Sweden, ministries of education provide block grants to universities to carry out R&D in general or specific mission-related funding in specific sectors. In other countries emphasis is placed on specific direct grants. Institutions providing support to universities also vary widely and for this reason the nature of research and innovation might differ. For instance, while regional governments are responsible for the largely autonomous universities, in the UK, research councils provide grants on a competitive basis (Edquist, 2004).

[4] Lubit (2001) identifies four categories of tacit knowledge, namely, (a) hard to pin down skills- "know-how", (b) mental models, which show us how the world is constructed, (c) ways of approaching problems, and (d) organizational routines. "The word skill implies tacit knowledge, which ranges from the ability to swing golf balls to the dexterity of handling cells in a biology lab, all which are hard to explain in words.

[5] According to Lubit (2001), p.167 "Routines solidify as standard operating procedures and roles are developed and enforced. Routines includes ways of producing things, ways of hiring

However, there are four broad challenges in achieving fruitful collaboration among SI actors. First, the nature of knowledge generation and transfer between UPRIs is complex, highly systemic and context-specific, particularly as a result of the significant but hardly acknowledged tacit content of scientific skills required which will therefore require more than codified format. Second, there is a wide gap between the motivation, scope and purpose between academic research and industrial research and production. This complicates the transfer process, and restricts the scope for policy incentive, (Dasgupta and David, 1994). Third, external collaboration for purposes building capabilities and carrying out innovation could be very costly, require prior knowledge and skills on the part of firms, while the outcome of this essentially learning process is uncertain. Fourth, as a result of differential motivations (put crudely, firms seek profit, academics seek published papers), public research organizations are often ranked low as sources of technical information despite the considerable investments made on them. For instance in a study by Drejer et. al. (2003), only "one third of the firms found the importance of government laboratories to be either moderate or very significant. No firm indicated that the information from universities or government laboratories was crucial for the innovation process". On the contrary, over 90% of innovative firms identified suppliers of components and materials as moderately significant sources of information in Denmark. Previous studies confirm this finding. DeBresson et. al. (1998) found that universities and PRIs are cited by only an insignificant number of firms (15%) for collaboration. In effect, user-supplier interactions constitute an important and significant source of collaboration within the SI. User and supplier firms build different kinds of relationships with one another in the process of production, innovation and distribution and their roles could be highly sector-spefic. For instance, users are very important actors in the instrumentation and agro-food sectors, while suppliers play dominant role in the downstream component sector (Lundvall, 1988; Von Hippel, 1988; Malerba, 2002).

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and firing personnel, ways of handling inventory, decision-making procedures, advertising policy, and R&D procedures".

3. TYPES OF INTERACTION IN SYSTEMS OF INNOVATION

Systems interaction, defined as linkage capability, and composed of the knowledge, skills and experience to engage other firms and institutions in the process of production and innovation, (e.g. Ernst et al., 1998), is an important firm asset that has not been fully explored in the literature of underdeveloped economies. In addition to internal firm capabilities, a firm succeeds on the strength of its ability to gain access to, and process a whole range of, knowledge outside of itself. It does this by internalizing such knowledge, and by continually engaging in networking with sources of knowledge both within and outside the national system. In doing this, it contends with various actors, employs diverse knowledge channels, and develops process paths to transform knowledge into firm capabilities for production and innovation. Knowledge flows into firms come from both within and outside the national system but in this paper we are primarily concerned with the interaction between internal and external sources of knowledge.

Collaboration in networks can also be conceptualized as information flows and knowledge interactions, which may take several forms. The first entails inter-firm flows of knowledge and skills in a user-producer relationship, through the movement of skilled staff from one firm to another, sub-contracting (manufacturing and trade types), joint ventures, franchise, and supplier-customer relations. These diverse forms of interaction constitute important channels of knowledge flows in advanced and developing economies, Pavitt, (1984), Von Hippel (1988), OECD (1999). Secondly, we have firm-institution interactions in which public agencies, such as technology development centres, of different varieties across countries, and public R&D laboratories. The mandate of these networks in broad terms is to assist firms in process and product adaptations, and in gaining comparative advantage through utilizing natural resources. Ideally, through this mode of interaction, support institutions will assist firms in gaining access to what would otherwise be expensive information (about processes, products and competitors), and providing or subsidizing testing and quality control costs. These are services which firms traditionally access as 'public goods' in much the same way as power supply, water and telecommunication, but which are often completely absent, or poorly provided (Biggs et al,1995; Oyelaran-Oyeyinka, 1997; Romijn, 2001).

There are two broad network types – external and domestic. A developing country relies largely on external linkages for the supply of technology, markets, and to an extent, finance. When properly managed, this form of networking leads to the development of capabilities within firms. In the newly industrializing countries (NICs) such arrangements are viewed as

cooperative networking. In Africa, the reverse is the case as technology transfer is in the main a vertical transfer relationship and poorer countries remain in a state of complete dependence.

Until recently studies of domestic networks within LDCs (see e.g. Nadvi and Schmitz, 1994) tended to pay little attention to Africa. However, these networks are central to sustaining production systems and in promoting interactive learning and innovation, as they possess the positive attributes of geographic proximity as well as cultural and economic space that can help to reduce transactional costs.

Ernst et al. (1994), identified four broad types of organizational networks, namely, supplier, customer, educational and technology networks. A supplier network includes subcontractors and original equipment manufacturers while customer networks relate mainly to forward linkages with distributors, marketing channels, value-added resellers and end-users (in both local and foreign markets). Educational networks enable competing producers to pool resources (financial, production capacities, and human) to increase output and boost geographic coverage, while technology networks assist firms to acquire new product designs, production and process technologies, as well as scientific and technological information.

A network of relationships is formed for a number of reasons (Lall, 1992). First, in a bid to introduce new technologies and innovation firms need to develop an array of technological capabilities. These capabilities include production, investment, minor change, major change, linkage and strategic marketing capabilities (Ernst et al., 1994). All these capabilities are never fully present within a firm. It is through the development of linkage capabilities that a firm is able to reach out and acquire them. Second, external pressures arising from the domestic and external macro economic environment also compel firms to seek collaboration with other economic actors. Third, the pressure arising from technological change elsewhere, which changes the nature of competition as well as the technology market often, induces networking among firms.

In sum, the main factors conditioning the growth and character of networks include:

(i) The resource capacity among large firms for networking (for instance through subcontracting) and the ability of small and medium firms to take advantage of various linkages;

(ii) Transactional exchange, which may be equal among small firms but unequal between large and small firms. This provides opportunities for interactions among firms to facilitate production and innovation;

(iii) The socio-cultural context, which may facilitate or hinder network formation and growth, e.g. trust or lack of it between network members;

(iv) Pressure to generate external network formation, which can be viewed as technological efforts to gain greater skills, higher specialization and deeper levels of technology; and

(v) Linkages facilitated by close geographical proximity, which promote transactions that may be indirect, formal, frequent and even unplanned.

The proximity of firms to one another, and to organizations providing technical services is an important determinant of innovation success and firm performance (Freel, 2003; Oerlemans et al., 2001). It therefore follows that there would be considerable lost opportunities for raising firm technical efficiency and competitiveness where channels of collaboration among firms are weak or absent. Networks and interactive collaborations promote learning and contribute in significant measures to building technological capability in firms (Lundvall, 1988 and 1992).

Interactions and flows involve autonomous firm-level efforts, such as technical and managerial training, hiring of local and foreign consultants, deepening relationships with clients, machinery suppliers, and raw materials suppliers[6]. These different channels of knowledge flows, when properly organized, constitute important learning avenues for firms.

Failure to learn in firms may therefore result from poor interaction and lack of knowledge and skills flows between, and among firms and between firms and institutions supporting innovation. Failure to learn may take the form of inadequate learning, ineffective learning, and complete absence of learning due to a lack of dynamic complementarities (Malerba, 1992).

[6] As reported in the case study of the Nnewi cluster in Eastern Nigeria, most of the firms pay to have Taiwanese engineers, the technical partners spend time in their factories to teach local engineers skills. They are instructed to "close mark" the technical partner, a soccer metaphor typifying close understudying through learning-by-doing and observing the technical partners.

4. METHODOLOGY AND DATA

The paper draws from the findings of empirical firm-level studies carried out in the following countries involving about 200 manufacturing firms and distributed as follows: Nigeria (129), Kenya (47), Zimbabwe (30). The sectors covered include metalworking, food processing, automotive components and repairs. Response rates to our questionnaires in the three countries varied from 60 to 80 percent. Our primary aim was to understand the nature of small and medium enterprise (SME) performance producing within a network of other economic actors that support firm-level innovation. The study is based on primary data[7] collected using structured questionnaires and interview guides. The survey was carried out over a four-month period in the summer of 2001 based largely on face-to-face interviews with the managing directors, who provided greater qualitative information on the nature and quality of interactions. The survey included specific case studies and visits to production sites, and corroboration of information with partners on the precise nature of collaboration. The study focused specifically on urban SMEs employing relatively modern technologies, and producing for medium income consumers.

Table 1 shows the size and skills structure of the sample firms.

Table 1: Size and Skills Composition of Firms in Africa

Variable	Nigeria	Kenya	Zimbabwe
Average firm size	39	48	28
Distribution of employees by their qualification (%)			
University degree holder	17.7	10.5	2.60
High School degree	51.4	52.2	54.90
Elementary School	19.6	24.5	36.42
No formal education	10.3	12.8	6.08

[7] Efforts were made to cover as many firms as possible in all the countries, however, the response rate was better in some countries

4.1 An Analytical Model

We are concerned specifically with inter-firm collaboration and its impact on firm performance and innovation. Technical innovation is an important source of productivity change, with innovation broadly defined as change in product and process that is new to the firm but not necessarily new to the country or other parts of the world. The innovations considered in the study are largely incremental, and relate to routine product-based technical changes. Going by previous studies, these are the predominant types of modifications carried out by the majority of African industrial firms (Oyelaran-Oyeyinka, 1997; Oyelaran-Oyeyinka et al.,1996). In analyzing the effect of collaboration on performance, a number of mediating factors that influence firm-level behaviour such as perceptive, quantitative and qualitative variables, were employed. Among these, firm age, firm size, skills level, and infrastructure indices were used as independent variables. We discuss them briefly.

i. Employees and Owners Skills

The association of technical skills and general managerial capability with performance is well documented. The proportion of university graduates and technical skills within firms is a proxy of capability. The intensified competitive environment tends to require not only a higher level, but also a wider range of skills (Lall, 2001). The skills market faces persistent market failure, particularly in developing countries. However, market failure is not limited to skills but includes access to information, finance and technology markets. SMEs in particular are differentially penalized by information asymmetry, poor access to investment and working capital.

ii. Size of Firm

In this study, size is taken as being the number of employees due to the difficulty in obtaining data on sales turnover and assets. The importance of firm size has received considerable attention in the literature. Different schools, including those focusing on dynamic capabilities, as well as the resource-based literature, emphasize the importance of firms' internal assets (Penrose, 1959; Nelson and Winter, 1982; Freeman and Soete, 1997). The weight of empirical evidence suggests that for the small firm, growth is negatively correlated with firm size and age, while this may not necessarily hold in medium and large firms (Audretsch, 2002). There is a threshold of human and non-human resources required for firm and organizational level effectiveness.

iii. Age of Firm

The age of a firm might be indicative of its learning experience and a pointer to greater internal resources. The literature has treated this variable as a proxy measure of accumulated knowledge

and studies have shown it to have a positive impact on innovation and production performance (Freel, 2003; Love and Ropers, 2001).

iv. Infrastructure

Good quality infrastructure is critical for firm performance. Considerable micro-economic evidence in African enterprises suggests that poor infrastructure is associated with low innovation capability and poor export performance, a proxy for competitiveness (Oyelaran-Oyeyinka et al., 1996; Soderborn, 2000). Firms contend with poor provision of water, bad roads, epileptic power supply, and inadequate telecommunication services that are not only unreliable, but costly. Private associations in a number of African countries are, increasingly filling this gap, and we will examine the impact of these initiatives on firm performance.

v. Types of Collaboration and Networks

Networks are considered important for several reasons. Optimal networking among firms reduces transaction costs and results in collective efficiency gains (Schmitz and Nadvi, 1999). SMEs located within a network of firms and other economic actors compensate for, among others, high transport and communication costs and in the process realize higher levels of efficiency. Types of networks include horizontal links between firms and suppliers (of raw material and machinery/equipment), and between firms and contractors. Small producers do not relate as intensely with universities as large firms do, while the limited number of public research and development institutions (RDIs) - characterized by poor internal capabilities -are severely resource-constrained in developing countries. In the absence of collaboration between public research organizations and firms, enterprises tend to benefit more directly from user-producer, user-supplier type interactions.

Following from the above, we suggest that all these factors are significantly related to the performance of firms in the national system of innovation. In sum we would be examining the following types of collaboration:

- Horizontal and vertical such as firm-firm, user-supplier and subcontracting relationships;
- Firm-university and firm-RDI linkages; and,
- Firm-industrial association linkages.

Three hypotheses are proposed to organize our findings and discussions.

H1: SME collaboration with RDIs and universities will promote greater firm-level technical performance and result in better output and product quality.

H2: Firm-firm collaboration with users, suppliers and subcontractors will lead to better firm performance and profit.

H3: Firm collaboration with private associations results in better performance.

4.2 Univariate Analysis

The firm is conceptualized as the locus of production activities but it carries out innovation in cooperation with other organizations, such as universities, standard setting agencies, research institutes, and financing organizations, among others (Edquist, 2001). Small firms in particular stand to benefit from collaboration with other firms and organizations. In what follows, we examine the nature of organizational relationships in three African countries for which we have comparable data (Table 2). Firms collaborate to a considerable degree with local maintenance organizations and machinery suppliers in all countries. Collaboration is particularly weak between firms and research institutes and universities, and in most cases there is no contact.

Table 2: Inter-Organizational Collaboration (%) responding

Source	Nigeria	Kenya	Zimbabwe
Machinery suppliers	20.0	38.9	8.8
In-House	44.0	50.0	52.9
Foreign Technical	8.0	5.6	5.9
Local Maintenance	80.0	72.2	32.3
Research Institutes/universities	3.8		
Others	5.0	1.9	-

Source: survey 2001

Next we sought to examine the nature and intensity of collaboration in greater detail. Based on a Lickert-type rating (1-3) firms were asked to identify and rate the specific forms of activities undertaken in network relationships (Tables 3-6). A rating of less than 1.5 is weak while one greater than 1.5 signifies strong collaboration. We have in addition compared for the countries, the equality of means for different characteristics of the firm namely skills level, size of firm, and export propensity. The data on tendencies for the three countries were averaged over five years (1996-2000) to minimize point errors that could occur for a single year. Where we are unable to make comparisons for all countries due to unreliability of data, only two countries were compared. In Table 3 both horizontal collaboration and subcontracting data averaged over

five years show less than average intensity. However there is very strong significant difference in the two countries for which complete data were available.

Table 3: Comparison Networking Relationships in Countries

	Nigeria	Kenya	Zimbabwe	F-value	Significance
Network in last 5 years					
Horizontal cooperation with other firms	0.884	0.796	0.500	10.342	0.0001
Subcontracting	0.814	0.558	0.320	16.955	0.000

Note: Cooperation was measured on a binary scale; 0→ no cooperation, 1 → strong cooperation; Figures show the average value of cooperation.

It would seem, however, that collaboration intensified by the year 2000 (Table 4)[8]. When we consider the data for only 2000, there is a significant relative rise in intensity of horizontal and subcontracting relationships. Nevertheless, the three types of relationships show considerable variability across countries evidenced by the high significance in the t-values except for the "links with industrial association" variable. This is not surprising given the growing private association involvement with firms in all countries.

Much of what goes on between firms involves bilateral contractual arrangements with suppliers, subcontractors, and consulting organizations that organize training and conduct investment feasibility studies for firms. We have explored in some details how much and how frequently these contacts are made and for what reasons. Joint skills and collective marketing as well as information exchange are important activities. In all but a few cases, there is no significant difference in these activities across countries. In other words, the countries undertake fairly similar sorts of activities. The detailed interviews threw light on the preponderance of these type of relationships, and the weak links between firms, RDIs and universities. Network related production and innovative activities focus on product technical change, which requires minimal inputs from organizations outside the firms, particularly in the case of firms with adequate numbers of graduate employees. Export oriented firms, however, tend to seek out new sources of knowledge outside the immediate network. In what follows, we examine the role of skills, markets, and size effects on collaboration.

Table 4: Forms of Collaboration in African Industry

	Nigeria	Zimbabwe	T-value (Sig.)	Chi-sq (Sig.)
Network in last 5 years				
1. Horizontal cooperation with other firms	1.53	2.32	3.965 (0.000)	36.989 (0.000)
2. Subcontracting	1.83	0.32	9.782 (0.000)	96.818 (0.000)
3. Links with industrial associations	1.59	1.41	0.991 (0.323)	62.109 (0.000)
Cooperation with other firms				
(i) Information exchange	1.52	1.59	0.387 (0.699)	11.344 (0.010)
(ii) Quality improvement	1.33	1.67	2.001 (0.047)	4.503 (0.105)
(iii) Joint labour training	1.95	2.31	1.469 (0.145)	6.612 (0.085)
(iv) Joint marketing	1.98	2.08	0.359 (0.720)	1.357 (0.507)
Cooperation with main suppliers				
(i) Information exchange	1.60	1.58	0.166 (0.868)	1.561 (0.668)
(ii) Quality improvement	1.28	1.52	2.079 (0.039)	12.489 (0.002)
(iii) In speeding up delivery	1.50	1.75	1.514 (0.132)	2.361 (0.307)
Cooperation with subcontractors				
(i) Information and experience	1.92	1.87	0.223 (0.824)	4.870 (0.088)
(ii) Technology upgrading	1.73	1.57	0.729 (0.467)	0.978 (0.613)
(iii) Quality improvement	1.52	1.47	0.288 (0.774)	2.950 (0.229)
(iv) Programme and production	2.21	1.38	3.163 (0.007)	8.662 (0.34)

Note: Figures in column 2 and 3 show the average value of cooperation that was measured on a Lickert scale (1-3)

Collaboration as a Function of Skills Level, Firm Size, and Market Orientation

In Table 5 we compare firms with "high skills", defined as enterprises with more than 10 percent of the workforce having a university degree and 60 percent with high school education, otherwise a firm is classified as having "low skills".

[8] The data for variables shown in Table 4 were missing for Kenya

Table 5: Equality of Mean of Skills

Variable	Mean						
	Low skills	High skills	All	Df	T-value	F-statistic	Significance level
Horizontal cooperation	1.421	1.430	1.426	182	0.063	0.0039	0.949
Subcontracting	1.375	1.240	1.301	195	1.0040	1.007	0.3168
Linkage with Industrial Association	1.508	1.597	1.559	142	0.596	0.355	0.5523
Cooperation with Input Suppliers	0.713	0.843	0.772	196	1.055	1.113	0.2928
Collaboration with Technology Institutions	0.789	0.786	0.787	201	0.055	0.0029	0.9566

Note: Figures in column 2, 3 and 4 show the average value of cooperation that was measured on a Lickert scale (1-3)

None of the variables, namely, horizontal cooperation, subcontracting, linkage with industrial association, cooperation with input suppliers and technology institution differ significantly with respect to skill intensity of firms. The results are not surprising because the skill intensity based on the qualification of workers is not expected to influence the conduct of firms. The conduct of SMEs is determined largely by the entrepreneurial characteristics of the owner. It is not possible to test the difference in the conduct of firms represented by the above variable due to lack of systematic data on the qualification of Managing Directors.

It Table 6 we present results of differences in the conduct of firms, represented by firm-level variables, with regard to size of firms. Sample firms were classified on the basis of the total employment. The firms that employed less than 50 workers were classified as small and others were treated as medium sized firms.

Table 6: Cooperation and Firm Size

Variable	Mean						
	1. Small	2. Medium	All	Df	T-value	F-statistic	Significance level
Horizontal cooperation	1.473	1.212	1.426	182	1.539	2.370	0.1254
Subcontracting	1.285	1.368	1.301	196	0.496	0.246	0.6206
Linkage with Industrial Association	1.641	1.192	1.559	142	2.376	5.646	0.0188
Cooperation with Input Suppliers	0.768	0.795	0.772	196	0.1886	0.0356	0.8506
Collaboration with Technology Institutions	0.781	0.809	0.787	201	0.397	0.157	0.6921

Note: Figures in column 2, 3 and 4 show the average value of cooperation that was measured on a Lickert scale (1-3)

From the table only one variable, linkage with industrial associations, differs significantly between small and medium sized firms. This confirms our hypothesis that larger firms are better served by industry associations compared to smaller ones. In other words, larger firms are expected to maintain greater links with industry associations in order to obtain support from local bodies and government.

Table 7 presents the analysis of variance results of export intensity of firms. Export intensity is a binary variable representing exporting and non-exporting firms.

Table 7: Cooperation and Export Performance

Variable	Mean						
	Exporters	Non Exporters	All	Df	T-value	F-statistic	Significance level
Horizontal cooperation	1.508	1.111	1.343	107	2.112	4.462	0.037
Subcontracting	1.318	0.551	0.991	114	5.012	25.124	0.000
Linkage with Industrial Association	1.500	1.667	1.554	64	0.646	0.417	0.5208
Cooperation with Input Suppliers	0.894	0.660	0.793	115	1.179	1.392	0.2405
Collaboration with Technology Institutions	0.896	0.667	0.800	114	3.126	9.773	0.0023

Note: Figures in column 2, 3 and 4 show the average value of cooperation that was measured on a Lickert scale (1-3)

Several indicators of inter-firm linkage such as horizontal cooperation, subcontracting, and collaboration with technology institutions, differ significantly between export-oriented firms and non-exporters. The results presented confirm what existing literature, as well as our hypothesis, has to say about horizontal collaboration. For instance, some export-oriented firms asserted that they avoid subcontracting collaboration for fear of compromising on product quality, while other firms prefer subcontracting in order to avoid high overhead costs. Similarly, export-oriented firms are more predisposed to collaboration with technology institutions in order to keep abreast of new opportunities in the technology and products markets. While firms can survive in the domestic market with relatively low skills and technology, they face considerably stiffer competition in the international market for which higher technical skills are required.

Table 8 presents the differences in performance and conduct of firms in three countries. Performance variables are represented by export intensity, profitability, and sales turnover, while conduct variables are the ability of firm to innovate and speed of delivery.

Table 8: Comparison of Firm Manufacturing Performance in Africa

Variable	Nigeria	Kenya	Zimbabwe	F-value	Significance
Firms that carry out Innovations	1.403	0.667	0.50	63.00	0.000
% age of output Exported	34.513	7.619	8.963	25.923	0.000
Firm Profitability	35.592	23.316	34.038	6.349	0.002
Speed of delivery	1.681	0.653	1.692	32.964	0.000
Quality Improvement	1.277	0.940	1.444	10.648	0.000

Note: Innovation, speed of delivery, and quality improvement were measured on a Lickert scale (1-3) and averages are presented; Profitability was measured as % of sales turnover

All the variables, except sales turnover, differ significantly in the three countries. The results suggest that country-specific characteristics and firm performance differ significantly in these countries. In the three countries, firms export largely to regional destinations but there are relatively more export-oriented and firms reporting innovation in the Nigerian sample firms. Firms attribute improvements in speed of delivery in the last five years to domestic and international competitive pressures. They respond to internal capability deficiency by conducting more in-house and external staff training as well as making improvements to the capacity of product quality testing facilities. In sum, univariate analysis shows that horizontal as well as subcontracting relationship exhibit significant correlation with firm performance. Firms in network collaboration tend to show a higher level of performance in terms of export, profitability, sales turnover, and speed of delivery. They also record greater innovative performance.

4.3 Multivariate Analysis

In this section, we employ statistical techniques to separate the group of firms classified by specific firm characteristics. Discriminant analysis has been used to identify factors that discriminated sample firms. The firms were grouped according to innovative capability of firms, cooperation with subcontractors regarding exchange of information and modification in design or production processes, and cooperation with respect to quality improvements. We follow the specification of a knowledge production function by which output is dependent on the availability and volume of internal and external resources (Freel, 2003, p.6; Oerlemans et al,2001, p.9).

The model is specified as follows:

$$P = B_0 + B_1 Subcon + B_2 High\_Edu + B_3 Avg\_sto + B_4 Avg\exp + B_5 Hor\_cop + B_6 Cop\_inp + B7 + B8 Firm\_age + B9 Tech\sup + B10 Infra$$

where P represents group variable.

The empirical outputs were computed using SPSS package. From the literature, all the variables selected are known to have significant associations with firm performance and innovation outputs. The first set of tests was a multiple discriminant analysis based in part on the insights from the univariate analysis carried out earlier. Discriminant analysis is used in situations where observations (firms in our case) are classified using a combined index based on the known characteristics of population (explanatory variables in our case). The advantage of discriminant analysis over regression analysis is that it does not presuppose causality between a group variable and the known characteristics. The parameters of the model are computed in such a way that the variance of the composite index is minimum with groups and maximum between groups.

4.3.1 Results

Tables 9-13 present the outputs of the discriminant analysis computed for the different functions. All relevant variables were included since the discriminant analysis model computes each probability independently. We discuss them in turn.

1. Firms That Carry out Significant Modifications (All three countries)

For identifying factors that discriminate firms based on their capability to innovate, we have quantified this variable. We have assigned value 1 for those that carried out significant modifications over the period of survey and 2 for others. Discriminant analysis identifies factors that discriminate between firms that carry significant modifications (innovations) and those that do not. In all, nine variables (AVG_EXP, COP_INPUT, HIGH_EDU, TECH_SUP, AVG_STO, SUBCON, INFRA, FIRM_AGE, and HCOP) were included in the analysis. From Table 9, eight out of nine variables are significant in discriminating two types of firms. The variable, horizontal cooperation of firms (HCOP) did not emerge a significant discriminant of two types of firms.

Table 9: Determinants of Innovativeness

Variable	Wilks' Lambda	Sig.	Remarks
AVG_EXP	0.63939	0.00	Average exports since 1996
COP_INPUT	0.61125	0.00	Cooperation with input suppliers (binary)
HIGH_EDU	0.56959	0.00	Skill intensity
TECH_SUP	0.55223	0.00	Technological support (binary variable)
AVG_STO	0.53665	0.00	Average sales turnover since 1996
SUBCON	0.52178	0.00	Status of subcontracting (-,=,+)
INFRA	0.49898	0.00	Access of physical infrastructure index
FIRM_AGE	0.48788	0.00	Age of firm

Apart from the significance of variables included in the analysis, another test for goodness of fit of discriminant function is its explanatory power. It can be seen from the classification results (appendix 1) that the total classification power of the function is 93.55 %, which is very high. Normally functions whose classification is more than 50 % is considered good and more than 75% is considered very good.

2. Cooperation with Subcontractors Over the Past Five Years: "Exchange of Information and Experiences" Variable (Nigeria And Zimbabwe)*

The group variable in this case has three values namely, "1" for firms that experienced decreased cooperation, "2" where cooperation did not change, and "3" for firms that experienced increased cooperation. The results of the discriminant analysis are presented in Table 10. The classification power of discriminant function is 82.61% (Appendix 1).

Table 10: Determinants of Exchange of Information and Experience

Variable	Wilks' Lambda	Sig.	Remarks
SUBCON	0.77178	0.0750	Status of subcontracting (-,=,+))
AVG_EXP	0.58060	0.0315	Average exports since 1996
AVG_STO	0.46922	0.0261	Average sales turnover since 1996
FIRM_AGE	0.40099	0.0320	Age of firm
INFRA	0.35552	0.0476	Access of physical infrastructure index
TECH_SUP	0.29784	0.0512	Technological support (binary variable)

The results suggest that cooperation with subcontractors with respect to exchange of information is more intense among export-oriented firms that have a comparatively larger size

of operation. We conclude from the results presented in the table that older firms with better access to physical and information infrastructure assign greater importance to exchange of information and experience. The technological support variable emerged a significant discriminant of firms that assign importance to exchange of information with others. The results confirm our hypothesis as larger firms with higher export-intensity need to exchange information with sub-contractors as they are more concerned about their business commitments (product of flexible designs, product quality, and delivery schedule etc.) than smaller firms operating in the domestic market.

3. Cooperation with Subcontractors Over the Past Five Years with Respect to Modifications (Nigeria and Zimbabwe)*

In this case also the group variable has three values, i.e. "3" for firms that have experienced decreased cooperation, "2" where cooperation has not changed, and "1" among firms that have had increased cooperation. According to our analysis only average sales turnover emerged significant in discriminating the three types of firms (Table 11).

Although sales turnover is the only variable that has emerged significant, the discrimination power of the function (Appendix 1) is very high.

Table 11: Determinants of Technological Modifications

Variable	Wilks' Lambda	Sig.	Remarks
HCOP	0.81122	0.1112	Horizontal cooperation
AVG_EXP	0.69595	0.1150	Average exports since 1996
SUBCON	0.60652	0.1254	Status of subcontracting (-,=,+)
AVG_STO	0.44401	0.0459	Average sales turnover since 1996

4. Co-operation with sub-contractors over the last five years with respect to quality improvement (Nigeria and Zimbabwe)*

Like other cooperation variables this group variable also takes three values, i.e. "3" representing firms for whom cooperation has decreased, "2" where cooperation has not changed, and "1" for firms that have experienced increased cooperation.

Table 12: Determinants of Quality Improvement

Variable	Wilks' Lambda	Sig.	Remarks
AVG_EXP	0.78797	0.0819	Average exports since 1996
HCOP	0.68426	0.1003	Horizontal cooperation

Some export oriented firms engage in subcontracting mainly for quality improvement and this is not unexpected. However, the discriminating power of the function (appendix 1) is not very high (40.38). This suggests that in addition to subcontracting, there are other variables that contribute to quality.

5. Cooperation with Subcontractors Over the Past Five Years Using Composite Index (All 3 countries)

A composite binary index was generated in order to enable comparisons for all the firms because the Kenya sample index is on a binary scale. Firms were assigned value "1" where any type of cooperation has increased over the last five years and value "0" otherwise. This was the definition used for the Kenya index. The results are presented in Table 13.

Although the classification power of the function in only 67.95 % (Appendix 1), all the variables that were included in the analysis emerged significant discriminants of firms that believe in cooperation with sub-contractors. The results are similar to what have been reported when each factor was considered separately**.**

Table 13: Determinants of Cooperation with sub-Contractors

Variable	Wilks' Lambda	Sig.	Remarks
AVG_EXP	0.95020	0.0614	Average exports since 1996
AVG_STO	0.92643	0.0744	Average sales turnover since 1996
HIGH_EDU	0.90270	0.0749	Skill intensity

4.3.2 Discussion

This multi-country study examined a variety of collaboration factors that influence the performance of the firm within the national system. All three hypotheses were confirmed by our analysis, albeit differentially in each country - that is, not all variables emerged as equally

significant in every country. In sum, we found that the following variables promoting firm collaboration with other firms and agents are significant if we take the three countries together:

(i) Horizontal cooperation between firms;

(ii) Firm size: larger firms tend to collaborate more;

(iii) Human capital represented by a higher proportion of educated workforce promotes collaboration;

(iv) Cooperation to share information

Inter-firm collaboration with clients, contractors, suppliers and input suppliers seems to be the most widespread and the most prominent among small enterprises. Small producers are far more concerned with meeting daily production schedules rather than with medium to long term innovation planning. This consideration, more than anything else, tends to determine the dynamics of collaboration. Again due to credit and other resource constraints normally associated with small firms, there is a tendency to depend on credit suppliers that in most cases are larger firms. This kind of forced reliance is not inevitable, but a necessity in the absence of alternative state support.

The weakest form of collaboration among the countries surveyed is with the universities. We identified four main reasons for this. First, small firms have relatively small proportions of an educated workforce, although the proportion of owners-entrepreneurs tends to be higher. This lacuna in the skill structure of firms affects collaboration in two ways. In the first place, a well educated management is needed in order to understand, and search for information. Firms thus suffer the incidence of inter-organizational knowledge dissonance. In the second instance, the cognitive disability of a firm with a large proportion of uneducated workers sets a limit on its innovation search efforts. The second reason relates to the overall low technological capability base of small firms in underdeveloped areas, which may mean that the types of innovation they carry out will be routine, incremental, and with little scientific inputs. Third, small firms are hardly able to spare the requisite manpower and finance required for innovation search and adaptation, and they are less disposed to take the high risks of innovation failures. Fourth, universities themselves often have little in common with small firms as much of their research work is defined and carried out by individual researchers with an aim to publish rather than disseminate to the local small producers. In developing countries, the most evident contribution of universities to firms is their science and technology training programmes. Such training has a more direct impact on firms than research outputs, which at best would require further tests and resources to be usable at the commercial level.

Small firm collaboration with distant suppliers commonly involves the supply of machinery, equipment and spare parts. In some cases this is enhanced by technical training provided by

suppliers. The case of auto parts producers at Nnewi in South East Nigeria most vividly illustrates this phenomenon. A study of the cluster (Oyelaran-Oyeyinka,1997) found that more than 90 percent of firms in the cluster imported machinery from Taiwan and had developed strong trade relations with the Taiwanese firms. The present study similarly found that there is a strong local network of suppliers and contractors in Nigeria through which firms place orders for inputs, and this is true although to a lesser extent in the other two countries.

In addition to the foregoing reasons, the perceived lack of dynamism in African industry is also tied to poor infrastructure delivery and the poor state of formal institutions of human capital. The low technical and managerial capacity of universities and RDIs, and the subsequent impact on their outputs can be illustrated with the examples of Kenya and Nigeria. In both countries the teaching and research functions have declined considerably in recent years as a result of poor funding, coupled with high growth in enrolment, and mass exodus of university lecturers. Paradoxically, the universities face the dilemma of new expectations from the state and society to forge greater links with, and provide support for, industry.

Table 14 shows the absolute increase in R&D expenditure in Kenyan universities over a seven-year period (1988 to 1995) and an almost doubling of R&D as percent of GDP. However, as a percent of gross academic expenditure (GAE), the 1993 university research expenditure accounted for only 40% of the level in 1986, a real significant decrease. More importantly, close to 80% of the expenditure for most universities is allocated to staff salaries. At the same time the value of this item fell significantly from 0.15% of total government expenditure in 1988/89 to 0.05% in 1995/96. The trends in university funding (Figure 2) shows an uneven but sure decline over time.

Figure 2: Trends in University Funding in Kenya (1986-1994)

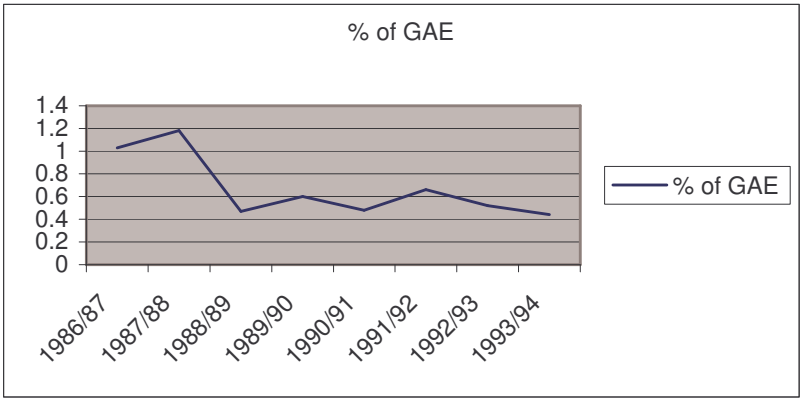

Table 14: Selected Science and Technology Expenditure in Kenya

Year	Total University research **(Ksh)**	NCST Research Grant	Other GoK research grant	Total GoK research expenditure	Total private*	Total R&D expenditure	R&D expenditure % GDP
1988/89	7.32	0.15	0.116	48.33	4.83	53.16	0.82
1989/90	7.920	0.09	0.150	56.71	5.67	62.38	0.84
1990/91	9.3	0.066	0.016	7.14	7.81	85.95	1.03
1991/92	11.64	0.050	0.10	87.98	18.78	96.78	1.01
1994/95	13.48	0.050	0.014	185.22	18.52	203.7	1.51
1995/96	14.49	0.050	0.287	159.80	15.98	175.8	1.09

* 10% of total Government of Kenya (GoK)

These data show that the percentage of university research expenditure fluctuated in the periods 1986-87 and 1993-94. However, if we consider the entire period, there is sharp decline in the percentage of university research expenditure, from 1.03 in 1986-87 to 0.44 in 1993-94 (Appendix 2).

There are 43 tertiary educational institutions in Nigeria made up of federal, state, and recently private universities. The three private universities are less than 5 years old while most of the state universities range in age from 10-20 years. In 1996/97 a total of 52,823 students graduated from the universities, twenty thousand more than the 1986/87 period. The growth rate of output from first generation federal universities is lower - Ibadan (9.6%), Ife (2.45%) while in some of the new generation universities, the growth rate exceeds 20%. In the past decade, enrolment doubled to 325,000 students, while the knowledge and physical infrastructure remained largely unchanged until the new democratic government initiated a process of reform. This includes building of new hostels, establishing an IT network to link the universities, significantly raising the salary of lecturers, and licensing of private universities to lessen the enrolment pressure on public universities.

The teacher-student ratio (TSR), a proxy measure of quality of education, relates the number of students that a teacher ought to have to the actual situation in a class. A high TSR suggests greater interaction between teachers and students and a tendency to quality instruction. The TSR in Nigerian universities declined from 1:15 in 1995 to 1:22 in 1999, while the UNESCO recommended a ratio of 1:10. This declining ratio may well be due as much to higher enrollments as to the mass migration of teachers from the university system to Europe, North America and the Middle East.

5. CONCLUSIONS AND IMPLICATIONS FOR POLICY

This study examined inter-firm and inter-organizational networks in African industry. Four sets of interactions were analyzed namely: horizontal (firm-firm), vertical (subcontracting) relationships; firm-university linkages; and, firm-industrial association linkages. We presented an analytical framework to test three hypotheses that organized our findings and analyzed the data within univariate and multivariate frameworks. We expected that SME collaboration with research and development institutions (RDIs) and universities would promote greater firm-level technical performance and result in better output and product quality, but found little incidence of collaboration between firms and technological institutions. However, there is statistically significant incidence of collaboration among suppliers of inputs, subcontractors and firms and a positive correlation between networking and firm-level performance. There are a variety of channels of interactions, namely exchange of information, joint marketing, through for instance trade fairs, and subcontracting.

While the study found multiple institutions and channels of exchange that could potentially provide a platform for innovation, it emerged that firms tend to employ only a limited number of these avenues. For instance the data clearly show that despite fairly widespread horizontal cooperation, as well as vertical (subcontracting) relationships, cooperation between SMEs and knowledge institutions is rather weak and for the most part, non-existent. Another issue has to do with the quality and intensity of the exchanges. Firms and organizations with which they interact introduce modifications largely to products and often in response to certain bottlenecks but we found no evidence of systematic innovation initiatives. Even though participating firms showed increasing levels of market performance in terms of turnover, and profitability in relation to networking, they have not taken a proactive stance on exploiting innovations as a strategic competitiveness tool. This is reflected in the responses of firm to questions on the nature of collaboration with universities. For a firm to progress to greater competitive levels, innovation processes would need to involve not only cooperative relationships between firms, suppliers and subcontractors but also with technological institutions.

Three sets of issues with implications for policy emerged from our detailed interviews. First, the study makes tentative conclusions that inter-firm relations, particularly between firms and other economic agents, involve more than the mere exchange of information about prices and volumes, although we are far from fully understanding all the factors that induce networking. However, fostering cooperative interaction between economic agents in industry has not come about naturally and networking institutions remain weak in all three countries. Second, there is a

measure of interaction among economic agents but this relates largely to maintaining firm daily routines, and to an extent effecting minor technical modifications that keep plants working. Innovation policy should therefore seek to *move up* the quality of firm level activity as well as promote greater interaction among firms and technological institutions. Policy should also establish, or strengthen where they already exist, organizations and institutions to regulate and coordinate innovation functions, which following the prevailing Neo-Liberal prescriptions, would be left to the markets. Finally, there is evidence that collaborative exchanges raise economic performance, which provides an economic rationale for intervention to promote inter-firm collaboration. We suggest therefore that developing African countries need to approach the task of developing their NSIs but with no preconceived ideas of "ideal" types as the notion of optimality has no place in systems thinking.

APPENDIX

Appendix 1: Classification Power of Discriminant Functions

Function: Innovativeness			
	Predicted Group Membership		No. of Firms
Actual Group	Innovating	Non-Innovating	
Innovating	52 (96.3%)	2 (3.7%)	54
Non-Innovating	2 (25.0%)	6 (75.0%)	8
Total discriminating power 93.55 %			
Function: Exchange of Information and Experience			
	Predicted Group Membership		No. of Firms
Actual Group	Decreased cooperation	No change	Increased cooperation
Decreased cooperation	6 (66.7%)	2 (22.2%)	1 (11.1%) 9
No change		8 (100%)	8
Increased cooperation		1 (16.7%)	5 (83.3%) 6
Total discriminating power 82.61 %			
Function : Technological Modifications			
	Predicted Group Membership		No. of Firms
Actual Group			
Decreased cooperation	13 (92.9%)		1 (7.1%) 14
No change	1 (12.5%)	5 (62.5%)	2 (25.0%) 8
Increased cooperation			2 (100%) 2
Total discriminating power 83.33 %			
Function: Quality Improvement			
	Predicted Group Membership		No. of Firms
Actual Group			
Decreased cooperation	10 (33.3%)	9 (30.0)	11 (36.7%) 30
No change	4 (22.2%)	8 (44.4%)	6 (33.4%) 18
Increased cooperation	1 (25.0%)		3 (75.0%) 4

Total discriminating power 40.38 %			
Function: Cooperation with sub-Contractors			
	Predicted Group Membership		No. of Firms
Actual Group			
Decreased cooperation	38 (79.2%)	10 (20.8%)	48
No change			
Increased cooperation	15 (50.0%)	15 (50.0%)	30
Total discriminating power 67.95 %			

Note : % is row percentage

Appendix 2: Indicators of S&T Expenditures in Kenya

Year	Personnel* costs as % of recurrent expenditure	University research expenditure as % of GAE**	% of Science Students admitted	Overall enrolment in public universities	Enrolment growth rate
1986/87	68.4	1.03	42.4	8.653	14.9
1987/88	66.5	1.18	39.1	15.116	74.7
1988/89	65.8	0.47	31.2	20.180	33.5
1989/90	71.2	0.60	31.2	24.111	19.5
1990/91	76.1	0.48	29.1	28.353	17.6
1991/92	74.1	0.66	42.1	40.562	78.3
1992/93	76.3	0.52	39.6	38.748	-0.004
1993/94	84.3	0.44	40.0	35.810	-0.001

*University of Nairobi

**GAE= Gross Academic Expenditure

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