QUALITY MANAGEMENT SYSTEMS FOR MANUFACTURING INCUBATORS IN CLUSTERS

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ABSTRACT

In the current competitive economic environment, start-up companies struggle to accomplish production tasks alone. As part of the national supplier and enterprise development programs, corporations are discovering innovative ways to enable start-ups to compete within established value streams. Although manufacturing clusters can support collaboration and cooperation among incubation partners, its evolving quality management systems remains an issue. The quality of the products produced and service delivery of these manufacturing clusters are a concern. Still these clusters have not been able to develop a coordinated approach to quality management. Total quality management systems within these clusters can assist to optimize the quality costs and improve the cluster’s overall competitive position within the market. In this research study several cluster case studies were evaluated and incubation clusters within South Africa were visited to understand the quality issues, challenges and opportunities within clusters. A quality management framework was proposed to assist start-up companies to grow into established value streams from these incubation clusters.

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### 1 BACKGROUND AND MOTIVATION

Manufacturing of products and goods is probably the most important economic activity in the world that exists to create value. As it becomes more difficult to understand and control values of products and services, the concept of sustainable value has emerged to target not only ecological sustainability, but also social and economic values [1]. Having a strong manufacturing base is important to any society or community, because it stimulates all the other sectors of the economy [2] to be productive. Manufacturing deserves strong and continuous endeavor of all actors in a modern society to ensure prosperity, better life and sustainable development [3].

This highlights the need to understand the issues, challenges and opportunities better to help simplify the complexities of incubation clusters. Complexity is a term to describe a characteristic which is not yet possible to quantify precisely. Yet the complexity of production systems is the critical cause of many management problems [4]. Figure 1 illustrates the drivers and enablers for complexity that should be managed in any production system to stay competitive [5].

**Figure 1: Drivers of manufacturing complexity in incubation clusters (Adapted from [5])**

The name incubator originates from a chicken processing company that was one of the first tenants in a successful model of promoting small and medium sized enterprises (SMME) development when a very large industry closed down in New York [6].

The United Nations industrial development organization also adopted this incubator model in order to create a support environment for entrepreneurship to expand SMME’s in developing countries [7]. The universal idea is that a company located within a business cluster, experiences better chances of survival and stronger growth than a company located in isolation. It should be considered as a mutual support network for manufacturing.

Small and medium sized enterprises (SMME) suffer from the shortage in skills (know-how), appropriate technology and the lack of a collective support system. This leads to inefficient value creation, a high degree of energy (resources) wasted in production processes and frightening pollution. The failure rate of these SMME’s in the first two years was reported to be over 60% in Africa and other developing countries [8].
The lifecycle for SMME’s to evolve into mature organisations include the growth phases through creativity, direction, delegation co-ordination, collaboration and alliances [9]. In a favourable ecosystem, innovative enterprises can flourish by interacting with different innovation actors and across sectorial boundaries [3]. In order to meet customer demand, production organisations develop rapidly more products, which lead to an increase in the number of variants of assemblies and parts [5]. Thus, the coordination of activities can increase significantly.

Clustered support systems offer the benefit that production engineers can have physical access to the manufacturing floor to keep track of progress, while entrepreneurs are able to meet like-minded individuals to explore new ideas. Clusters can evolve from the hero (entrepreneurship) phase through a mature economics of scale phase, growing into a further renaissance or decline into a museum state [10].

The type and degree of regional specialisation and thus the potential for regional development depends on path-dependent processes influenced by regional characteristics of factors such as available resources, level of education and existing industrial structures. Collaboration in a cluster needs to be facilitated in order to tap the cluster’s full potential [11, 12].

The establishment of international cluster policy collaboration bodies and benchmarking of cluster organisations and programmes helped to develop these policies significantly [12]. Although scientific methods (e.g. agent theory, neural network, genetic algorithms, fuzzy logic [13, 14]) for managing complexity exist, the management and control of complexity in clustering remains a challenge. Key phases for implementation of a clustered based framework and a better understanding of the complex change management are also still needed.

In this research study several cluster case studies were evaluated and incubation clusters within South Africa were visited to understand the quality issues, challenges and opportunities within clusters. This work is a continuation of previous research [11] on industrial clusters. A quality management framework was proposed to assist start-up companies to grow into established value streams from these incubation clusters.

2 INCUBATION CLUSTERS

“An industrial cluster is an entity characterized by a social community of people and a population of economic agents localized in close proximity in a specific geographic region. Within an industrial cluster, a significant part of both the social community and the economic agents work together in economically linked activities, sharing and nurturing a common stock of product, technology and organizational knowledge in order to generate superior products and services in the marketplace” [15].

This definition stresses the geographic proximity of cluster partners which, perhaps, is the main distinction between a cluster and a network. In other words, a cluster is a regional network. The collaboration of SMME’s with each other and the research and development institutions can be seen as an opportunity to renew the economy and the society [12].

Clusters are geographic concentrations of interconnected companies and institutions in a particular field that compete and collaborate at the same time [16]. These clusters also reflect the specialisations of regions in activities, within which companies can gain higher productivity through accessing external economies of scale or other comparative advantages. Business clusters refers to an area that is home to many companies or organizations working within the same industry to gain an edge by concentrating their resources in one area [13]. This support model gains competitive strength because of its better access to trained and experienced employees, suppliers, specialized information and public goods, as well as from the motivating forces of local competition and customer demand [21].
The ability to identify opportunities co-creatively and bring innovative products to market effectively in an efficient way will enhance a manufacturing cluster’s competitiveness. Therefore, as shown in figure 2, desired products should be brought to market on the right time at the desired quality level.

Manufacturing cluster management naturally look first inside their own business entities for creative sparks as it is easier to understand what is available. The bigger sparks, they discover, are ignited when fragments of ideas come together - specifically, when entities across the cluster brainstorm or when business entities can tap external partners for ideas [17].

**Figure 2: Measures of product development success in clusters (Adapted from [13])**

Measures of product development success can be categorized into those that relate to the speed and frequency of bringing new products to market, to the productivity of the equal development process, and to the quality of the actual products introduced [18]. The time, quality and productivity define the performance of development. In combination with other activities like sales, manufacturing, advertising, and customer service the transformation process determine the market impact and its profitability [18]. When entities within a cluster decide to collaborate in open innovation, the level of governance and level of participation should be decided [19].

Industrial clusters can support this type of collaboration and cooperation among partners [20]. Clusters provide a sound basis for competitiveness, innovativeness, agility and adaptiveness by enabling the interconnected partners to (1) form long-term business coalitions, (2) share information, knowledge, resources, competencies and risks, (3) develop mutual understanding and trust, (4) jointly react to business opportunities, and (5) gain synergetic effects by collaboration and cooperation. Thus, they combine good characteristics of large companies with the advantages of SMME’s and introduce new possibilities and potentials for innovation. Innovation is usually one of the strongest motivation factors for establishment of a cluster.

In South Africa the petrochemical cluster around Sasol near Witbank supports various industries and downstream linkages were created. Around East London and Uitenhage, the motor vehicle industry cluster that exists produced around 40% of the country’s vehicle output [21]. Other evolving clusters within South Africa exist within the automotive, chemical, clothing, textile, footwear, leather, agro-processing, forestry and agro-processing industries. Qualitatively new areas of intervention include the green energy, mineral beneficiation, upstream oil and gas services and equipment and boatbuilding industries. Long term advanced capabilities include the nuclear, advanced materials, aerospace and defence and electro-technical industries [22].
Incubators, or more specifically business incubators, are programs which support entrepreneurial or start-up companies via various business support resources and services. There are currently approximately 60 privately- and publicly-funded incubators in South Africa. The Department of Trade and Industry (the dti) currently supports publicly-funded incubators via the Small Enterprise Development Agency’s Technology Programme, and also has very ambitious plans to establish an additional 250 incubators directly by 2015 under its recently-launched Incubator Support Programme (ISP) [22].

Incubation clusters have proven to be an effective way of fostering sustainable business growth and stimulating entrepreneurship. However, establishing a business incubator is a challenging task. The United States National Business Incubation Association (NBIA) [23] defines these incubation clusters as a dynamic system of business enterprise development. Its main task is to support development of supported small and medium-sized enterprises (SMME’s), by providing the right resources at the right time.

3 QUALITY MANAGEMENT SYSTEMS IN MANUFACTURING CLUSTERS

Quality refers to those features of a product which meet customer needs, that is, freedom from deficiencies [24]. Quality also does not pertain to a single aspect of a product, but a number of different dimensions [25]. These dimensions of quality include performance, special features, conformance, reliability, durability, and service after sale [26]. The cost of quality analyses are used in most industries and even constitute one of the primary functions of a quality control department.

The basic assumptions that justify an analysis of the costs of quality include failures are caused, prevention is cheaper and performance can be measured. Deming [24] taught that by adopting appropriate principles of management, organisations can increase quality and simultaneously reduce costs. The costs of quality are generally classified into appraisal, prevention, internal (e.g. unnecessary meetings) failure and external (e.g. distribution problems) failure costs [25]. The standardization in SMME’s will thus help to manage risk, achieve process consistency, to compete better in the market place and to optimize the utilization of resources.

The International Organization for Standardization (ISO) was established as a United Nations Agency in 1947 and is made up of representatives from more than 90 countries and includes the British Standards Institution for the United Kingdom and the American National Standards Institution for the United States [27]. The ISO 9000 series identifies the basic disciplines of a quality management system that can be used by manufacturers, suppliers, distributors and end users. The series specifies the national, regional and international accepted procedures and criteria that are required to ensure that products and services meet the customers’ requirements [27].

The series is divided into a number of different parts which provide details of all the essential requirements for quality assurance during the design, manufacture and acceptance stages of a product. ISO 9001, 9002 and 9003 are the standards by which a company can be certified, if they so desire [27]. According to Tricker [27], since the introduction of ISO, there have been a growing number of bodies to give accreditation to companies that have a quality system in place, which includes the South African Bureau of Standards (SABS).

4 RESEARCH METHODOLOGY

The objective of this research was to understand the quality issues, challenges and opportunities within clusters better. This research was divided into different phases as illustrated in Figure 3. The first step constituted of a thorough literature study incubation clusters and quality management systems. Several case studies were studied in order to
understand dynamics of clusters and the issues and opportunities of implementing quality management systems within these clusters.

**Figure 3: Experimental approach followed to understand the quality issues, challenges and opportunities within clusters better**

Thereafter, several incubation clusters within South Africa were visited between August to December 2013, followed with a short questionnaire. The reasons behind the current incubation and clustering practises were studied and evaluated as input to a proposed quality management framework that can assist start-up companies to grow into established value streams from these incubation clusters.

5 **FINDINGS AND PROPOSED FRAMEWORK**

Several case studies were studied in order to understand dynamics of clusters and the issues and opportunities of implementing quality management systems within these clusters. The value creation processes in these success stories were also studied. Although Africa is still seen as a developing continent, it holds pockets of vital economic activity of which many are clusters scattered across the continent’s countries and industries.

5.1 **The Suame manufacturing cluster in Ghana**

The Suame cluster is one of the biggest in Africa and evolved from a sustained attempt to provide public support for small business development [28]. The role of formal and informal associations has been important to the sustainability of the cluster [29]. The incubated SMME’s filled the gap by producing spare parts that had been previously imported and delivering a repair service. The basic technologies and relatively complex machinery (e.g. tool- and die making equipment) has increased the competitiveness of this incubation cluster.

There is a development from recent studies that the trade in engineering materials and spare parts was more profitable than manufacture and repair work [29]. The market of the Suame cluster currently includes the government, private companies and individuals. The market for vehicle repair benefits from the cluster’s location on the main road as it is linking two capital cities, Accra (Ghana) and Abidjan (Cote d’Ivoire) [29].

5.2 **The Kamukunji metalwork cluster in Kenya**

The Kamukunji cluster occupies about 10 hectares to the east of Nairobi’s central district, known as the Eastlands [29]. This cluster enjoys an advantage with its location, but the role of the Kenyan government in this cluster has been minimal. It has a population of 5,000 artisans. Kenya’s colonial government designated the area as a business centre for native
Africans, so it evolved under the colonial urban policy that segregated space on the basis of race. Business activities carried out in the cluster were restricted to SMME’s that catered to African consumption patterns. Trade licenses were issued to businesses engaged in the sale of indigenous foods, repairs and artisan manufacturing. The products produced included cooking pans and hand tools to meet local household demands. The cluster also served the needs of customers and traders from rural areas, as it was the bus station where busses arrived in Nairobi from the countryside [29].

5.3 The Nnewi automotive components cluster in Nigeria

The Nnewi automotive components cluster is made up of four villages - Otolo, Umudim, Uruagu, and Nnewichi. This cluster obtained its Intellectual property from Taiwan [30]. Each hosts a number of automotive spare parts manufacturing firms. Large and medium-size firms are generally located away from residential areas, while small enterprises are located in homes, apartment buildings, backyards, market stalls, and the federal government’s Technology Incubation Centre. Consequently, the automotive industry serves as a stimulus for the development of other industries (e.g. machine tool production, iron and steel, and transportation). The automotive industry in Nigeria has a capacity to produce 102,000 cars, 55,000 commercial vehicles, 500,000 motorcycles, and 650,000 bicycles annually [30].

5.4 Handicraft and furniture clusters in Tanzania

The furniture and handicraft sectors in Tanzania comprise a predominant number of small-scale enterprises and a few large firms utilizing simple technologies; the workforces of both have relatively low skill levels compared with internationally competitive enterprises. Major challenges include low productivity, lack of capital accumulation, and labour-intensive (though capital-saving) production [28]. The Tanzanian government tried different economic development models since the country’s independence (1961), as recognized the potential socio-economic development of SMME’s [28]. This cluster is still part weak, fragmented, and uncoordinated. The sector also lacks clear policy guidance from government authorities. Despite these challenges, the SMME’s survived and evolved over time and produced relatively good-quality products despite intensified competition following import liberalization [29].

5.5 The Lake Victoria fishing cluster in Uganda

Fish processing and the exporting of it are important to the Ugandian economy [31]. In 1997, the European Union (EU) applied to Ugandan fish exports a set quality standards that led to a conditional ban on one of the country’s most important exports. When the country’s fish processors and exporters were unable to meet the quality standards, the industry was plunged into a severe export crisis. Fish processors were locked out of their largest and most lucrative market for three long years. The industry had no choice but to become compliant with the EU standards. This case study proved to be an interesting example of a technologically weak cluster in Africa that overcame a serious challenge through networking, linkages, learning, and upgrading [31].

5.6 The Textile and clothing cluster in Mauritius

The textile and clothing cluster formed a key strategy by the government to shift the economy’s dependence away from a sugar based production economy. In 2001, the textile and clothing sector accounted for around 82% of its total manufactured exports, but this sector was at risk [32]. From a study [33] the export competitiveness of the Mauritian economy was found to be exceptionally vulnerable. This was due to its dependence on the textile and clothing sector. In order to become more competitive the garment quality and its total production quality systems had to be upgraded and standardised [33].
5.7 The Wine Cluster in South Africa

This wine cluster has been effective at innovation in product and production, by introducing new varieties and by improving the quality of its products [34]. An under resourced, but relatively effective network of technical support and research that closely aligned the industry needs has aided with these quality systems.

5.8 The Film Production cluster in Nigeria

Nigeria is the third-largest film producer in the world, after the United States and India and this film cluster is dominated by SMME's [35]. The lack of an organized industry, inadequate skills and quality systems are some of the challenges experienced by this cluster.

5.9 Issues and Opportunities from incubation cluster visits

Several incubation clusters within South Africa were visited between August to December 2013, followed with a short questionnaire. The reasons behind the current incubation and clustering practises were studied and evaluated as input to a proposed quality management framework that can assist start-up companies to grow into established value streams from these incubation clusters.

None of the visited clusters were found to be practicing any formal quality management system which makes the development of cluster-focused public procurement and local purchasing agreements very difficult. Also, none of these incubation clusters were certified with any ISO standards. These clusters also faced well-known challenges which include product traceability, poor factory layout and poor safety management systems. The clusters have no broker agencies to jointly market their products and then start inter-trading with each other to build on synergies.

These incubation clusters are also very isolated from research and development institutions and have very little cluster specific information available to external parties that would like to join the network. Together with any form total quality management system it is also very difficult for these clusters to develop cluster related marketing material. Therefore, it is not easy for institutions to identify and develop demand-led specific skills and education programmes for these incubation clusters.

Most of these incubation clusters were built on the unique strengths of its region and all agreed that the cluster’s competitive strengths require an on-going conversation with the organisations and other economic actors in the incubation cluster. It was also evident that each cluster has a different strategy according to its needs and that government should rather promote and maintain the economic conditions that enable the evolution, than wishing to develop the cluster’s strategy.

5.10 Proposed framework

A dynamic cluster can’t be isolated and in order for an incubation cluster to prosper it needs an inflow of people with different skills, social development grants, innovative materials, technologies and products and; constant progress of quality management systems.

The early period of an incubation cluster is often identified with a few people, termed the heroes of a cluster as illustrated in figure 4. As the cluster grows through creativity, direction and delegation phases the identifiable cluster begins to emerge.

As the cluster matures in the growth through delegation and co-ordination phases, the cluster matures and certain production strategies will be structured. As economics of scale starts to play an increasing role the quality management systems become standardised according to the external environment.
Ultimately, the incubation cluster goes into decline, finally reaching the museum state or alternatively leapfrogs onto a cycle of renaissance based on the development of innovative intellectual property.

Figure 4: Proposed quality management framework for incubation clusters

Once the incubation cluster reaches critical mass and starts to grow, there is often a strong cumulative process that locks the cluster. In order for these clusters to grow and prosper from the hero (entrepreneurship) phase through a mature economics of scale phase the quality management systems also need to evolve from a chaotic state to a standardised quality management system. This needs to be balanced with factors like demand sophistication, factor upgrading and specialisation and emerging strategies from competition. In addition to this the emergence of new entrants, cluster and quality management system development involves continuous collaboration and emerging social capital.

6 CONCLUSION

Several cluster case studies were evaluated and incubation clusters within South Africa were visited to understand the quality issues, challenges and opportunities within clusters. Incubation clusters vary from location to location and needs a multidimensional approach with a combination of quantitative and qualitative methods to assist SMME’s to develop into global value streams. A quality management framework was proposed to assist start-up companies to grow into established value streams from these incubation clusters.

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8 REFERENCES


efficiency and quality, pp 6-8.


