Application of Complex Adaptive Systems Theory to Ica Wine and Grape Cluster

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Abstract--The enterprises agglomerations are becoming an interesting study topic, so several authors are sure that the interactions and geographic proximity have a strong impact in the competition and innovation of the enterprises of the clusters [1,8,12]. So it is also possible to talk about "learning clusters", knowledge accumulated, and knowledge constructed in a collective form.

For the study of these shapes of post-fordists production organizations and for the many variables that they present new frameworks are necessary, one of them is the complex adaptive systems theory.

The model of the complex adaptive systems permits to evaluate multiple interactions between different agents and the impact of the agent's action in the system. This focus permits to find news and unexpected models from the interactions between the parts of the open systems.

The present paper has the aim of studying: the dynamic interaction, the knowledge transfer, the learning, and the evolution of the Ica wine cluster in Peru with that model.

In this context, the research questions are: what is the dynamic of the interactions between enterprises of the cluster?, how is the knowledge transferred?, how does the cluster learn?, and how is the technological evolution of this cluster?

The methodology is the elaboration of a theoretical model that integrates the concepts of characteristics of the clusters and complex adaptive systems, then accordingly this theoretical model is elaborated a questionnaire, after that the questionnaire is applied to a wine and grape cluster, finally the main conclusions and recommendations are obtained.

The results of the research will be an important document for the actions, strategic decisions and improvement of the interactions between cluster agents.

I. INTRODUCTION

Several studies over the last decade have showed relationships between geographical enterprises agglomerations and competitivity and economical growth. Geography and proximity are fundamental factors to encourage the interactions.

Then it is possible to find in the same country regional spaces with a different economic dynamic such as Silicon Valley in USA that has more development than another American non technological area [12].

Now, there is a trend of reconfiguration of productive models [7] that is reflected in the formation of several enterprises conglomerations, spontaneous or projected; where these enterprises look for agglomerations economy and higher intensity interactions. Some of these interactions, those that look for and help the knowledge flow are more emphasized, in this paper, because the knowledge and the creativity are the biggest sources for the innovation and new product development [2].

In Peru, it is possible to identify some clusters experience like "Gamarra" for clothes, "Puente Santa Rosa" for flowers arrangements, "Villa El Salvador" for wood furniture, *"Caquetá"* for core and shoes, Ica for wine and grapes (see table 1). Some of these enterprises agglomerations are interesting, specially that of the Ica cluster which includes grape producers, wine and pisco processors, including technological innovation centers, research institutes, universities, and Ica regional government.

TABLE 1: CLUSTERS SIGNIFICANT IN PERU

Denomination	Sector	Geographic area
"Gamarra"	clothes	Victoria district
"Wilson"	software and graphical design	Lima´s Cercado
Pte. Sta. Rosa	flower arrangements	Rimac district
Ica´s grape	pisco, grape and wine	Ica región
Atem	metalmechanic	Los Olivos district
"Caqueta"	leather and footwear	Rimac-San Martín district
"El Porvenir"	footwears	Trujillo city
Furniture of wood	furniture of wood	Villa El Salvador district

Source: own production

A matrix model is used in this research. This model combines clusters characteristics and complex adaptive systems theory for the determination of the interactions, knowledge transfer, learning clusters and evolution of the cluster.

II. ENTERPRISES CLUSTERS

Porter [12] found that the clusters are groups of companies, in general of the same sector or correlated and complementary sectors and these in general share a certain geographical space. The above mentioned proximity, that characterize the companies of a cluster, contributes to major interactions between them. This involves exchanges of knowledge managing so we can talk of its own (proper) knowledge of the cluster or conglomerate. Here we might extrapolate the term ¨learning organization¨ or organization that learns for "learning cluster".

Audretsch [3] establish the difference between information and knowledge; where the first is easy capture and diffuse anywhere, while the knowledge for it tacit characteristic is more regional and local.

A cluster of companies can be seen as a place of operation which is strongly related to the tangible elements of the business such as machineries, equipment and, facilities; it can also be seen as a place of innovation of the intangible ones that develop in such a way the design of new products, in methods of manufacture, organizational systems, etc.

According Cooke et al [5] the clusters, where predominate the horizontal integration, have advantage over others vertical integrate enterprises in productivity and innovation due for a more interchange of tacit knowledge and the arising of new enterprises.

Clusters are spontaneous agglomerations of companies of a certain economic sector. Porter [12] emphasizes the importance of the motivation, relations, and knowledge in cluster such as elements of resistant and durable advantage competitive that can not easily be equaled by distant competitors.

Porter [12] also defines a cluster as a geographical place of coordination and complementarities between companies; there he presents it as an example the cluster of California's wine, which includes the wine producers itself, the grape planters, as well as the equipments suppliers for cultivators and processors. He also presents the Italian leather cluster that includes design and production. In the sector of services, there are the cluster of the movie industry in Hollywood, where the filmmakers are attracted and where the intensity of productions can be understood by the proximity of multiple actors.

Companies in the clusters, simultaneously, compete and cooperate, which guarantees competitiveness and sustainability. Obviously both actions coexist in different dimensions and between different actors. Porter [12] also sustains that the clusters have impact in the competitivity and in increasing productivity; in the speed of the innovation, in the interchange of knowledge between multiple actors, and in giving rise to new goals.

According to Altenburg and Meyer-Stamer [3] the clusters are common between traditional small enterprises and in intensive activities in manpower. It was treating of a social factory based on values shared by means of interactions where there is facilitated the diffusion of knowledge and innovation. They have been identified as the major ones ¨neck of bottle¨ that can have a cluster: the shortage of enterprising spirit, lacking in confidence, and barriers to the shared information.

It is easy to perceive that a cluster has a history of formation and development that can be understood by the models of construction social-technical of the actor-network. This is only possible with the participation of multiple actors who in gradual form, and following a vision shared, positioned themselves, in a space constructing communications networks, and transference of knowledge and confidence.

According to Mytelka [11] clusters can be classified, according to their degree of evolution, in informal, organized and innovative clusters. When studying cluster we found diverse variables, such as the auto-conformation of cluster in function of the time, the accumulated knowledge inside the cluster, the intensity of the interactions, the appearance of new companies, and the formation of partnerships.

It turns out to be opportune to differentiate the clusters of another type of conglomerates, particularly of the so called technological parks and incubators of companies. The difference between both rests on that in case of the above mentioned answer to a planning and up to an architectural suitable design, while the clusters are characterized by an evolution almost spontaneous. If we were doing an analogy: a garden is a technological park while a jungle is a cluster.

III. BOARDING OF THE CLUSTERS WITH COMPLEX SYSTEMS

The boarding with complex systems allows finding new and unpredictable models from the interactions between the parts of opened systems [9].

The dynamics of these systems can only be understood from the history of the system and not from the analysis isolated of the parts where the system history creates the conditions that project it in a certain path. Here a coincidence exists also with the systemic thought praised by Senge [15].

According to a boarding with complex systems there exist tidy models that arise from the added individual behavior like that of the flocks of birds in their migratory movements, by means of which there is achieved the common aim to move to a major speed, security and orientation. Also it could be showed the example of the bees with their implicit codes of communication identified by Saussure [14] where each agent interact and contribute to the function of all group.

An analysis from the complexity is based on (i) the observation and comparison of similarities in diverse dynamic systems; and (ii) in the study of changing models of ordering auto-organization and/or induced diversity.

We find changeable models of ordering in the form like the traffic orders in a city, the same one that is different depending on the time according to the growth of the above mentioned city.

Models of auto-organization are found, for example, in the formation of the mothers' clubs.

While models of induced diversity are found by us on having made grafts in some plants or the introducing of new species in determined ecological space.

Morin [10] also takes the concepts of complex systems towards the field of the communications as substantial element in the interchange of coherent information with the company strategy and a complex increasing nature.

According Fuller [6], the four main characteristics of the complex systems are: adaptation, evolution, positioning and interaction.

1. Adaptation. Implies learning, memory and change in the time.
2. Evolution. Presents alternatives, bifurcation, diversity and selectivity.
3. Positioning. Implies reaching achievements and aims like the surviving between competitors.
4. Interaction. Involves relations and co-evolution among agents in the system.

Ryan [13] present the following factors of the clusters that should be include in the analisis: social capital, validate the role of knowledge (all types on the continuum), activities to support innovation, technological change and industrial restructuring.

As a cluster is itself a complex adaptive system influenced by the actions of the enterprises in the system; then the proposed theorical matrix model considers as files the four characteristics of the complex systems, according Fuller [6], while as columns the appear the clusters characteristics that reflect the enterprises actions.

IV. PISCO (GRAPE BRANDY) PRODUCTION PROCESS

The pisco production process begins with the reception the grapes in the press. After that, it is sent to the grinding machine where the juice obtained will be pumped towards the fermentators in open tank. The fermentation of the most occurs in its own leavening or with active dry leavening.

During the fermentation the density and the temperature is controlled by means of the fermentation curve. This way, the moving of the most is periodically performed.

The fermented most will be sent, from the fermentators, to the distiller that uses gas as source of energy. Pisco will be obtained from the distillation of the fermented most.

V. CASE: ICA WINE AND GRAPE CLUSTER

300 km to the south from Lima is the region of Ica characterized by its pleasant climate, its plantations of grape and its warehouses of pisco and wine. This cluster, whose geographic boundary corresponds to the Ica region in the south of Peru, includes the planters of grape, producers of pisco and wine, and correlated industries. It is good to highlight that these activities represent 25% of Ica's regional economy.

This activity has been quite traditional in this region for 300 years ago. However, from the year 2002 - coinciding with the installation of the center of technological grape Innovation (Cite-Vid) - this cluster presents a strong dynamism [4].

Quite indeed, "cites" are centers of services and technological transference for the small enterprises of the geographical space in which they are located. These centers (public or private) are supported by the Peruvian Ministerio de Producción. The Cite-Vid offers service of production and transference of technology.

The Ica wine and grape cluster is analyzed according to the boarding of the adaptive complex systems.

A. Adaptation

It was showed the learning inside the cluster. There was the case of an entrepreneur who started his activities of production of pisco using the facilities of Cite-Vid, which was offering him a service of distillation and advising as for the type and quality of grapes to acquiring of the planters of the own conglomerate.

As time passed, this entrepreneur implemented his own facilities of production, his areas of crop fields, consolidated his brand "payet" and even he managed to gain international prizes.

The time of learning diminished notably, because he practically learned the whole process of production, the farming of the grapevine. He got to know the business quickly, thanks to the kindness of the agglomeration and the intense interactions in the cluster - especially with the Cite-Vid.

Also the learning in cluster is demonstrated when ex-workers of some warehouse have made their own warehouse later.

Then it is possible to identify tacit and codified knowledge inside the cluster that are reconfiguring constantly.

B. Evolution

The evolution of the cluster aims towards the exportation. In this sense, thanks to the initiative of the warehouse "Yanquiza", in 2003 pisco producers gathered in crowds in order to share a vat of 50 000 l. The members of this group were known from regional and national competitions.

Some changes regarding the evolution of the cluster are: that before the pisco had not a characterization, the grapes were sowed without planning, organizations were still not well established, there was very little use of the technology and equipment in the warehouses, qualification or technical attendance did not exist, Pisco producers were empirical and followed the tradition, and the technological change was rejected.

C. Positioning

From 2001 on, there have been remarkable developments in the subjects of technological and organizations improvements between the cluster companies.

Cluster competes with companies, and with clusters located in other regions and also of other parts of the world. There is a significant strong competition with Chilean producers, that meant that on February 08, 2003, "the Day of the Piscola" has been declared in Chile, while the same day was also declared as "National Day of the Pisco Sour" in Peru.

After that Peru aims the denomination of origin "pisco" for its products.

This strong competition has meant a major interest in the governmental organizations and of the academy in adhering and resting to the companies of the conglomerate. The insertion and participation of CiteVid is one of the most successful of these interventions.

This effort has been reflected in a growth of the sector; thus the entrepreneur of the warehouse "Yanquiza" indicates (J. Hernandez, personal communication, 09 of March, 2006):

"We have begun to export 20 small boxes, 30 small boxes and in 2004 up to 100 boxes"

D. Interaction

The co-evolution of the agents in cluster has meant the "mixture" continued and increasing of many actors (table 2)

Inside these agents, it is necessary to remark the participation of the center of technological innovation of the grape - CITEvid, that sticks fast in the conglomerate in the year 2001, as a means of intervention of the government, being in charge of transfering technology by means of the sale of services, to offer training and technical assistance, and that takes part in the normalization of products.

TABLE 2: ORGANIZATIONS OF ICA'S WINE CLUSTER

Organizations	Sector	Activities
SENASA	agrarian health	control of plagues and diseases
INIA	nourishing inventory	it fights against the phylloxera
DIGESA	quality control	quality piscos and wines
Asso. Produc. Uva	association	grape producers
Asso. Produc. Pisco	association	pisco producers
CITE-Vid	innovation center	technological transference.

Source: own production

TABLE 3: FACTORS OF CLUSTER BASED ON THE CHARACTERISTICS OF THE ADAPTIVE COMPLEX SYSTEMS

Charact. of complex systems / Clusters factors	adaptation	Evolution	Positioning	Interaction
Knowledge cumulated and learning	X			
Technological change		X		
Competitiveness			x	
Cooperation and collaboration				x
Activities to support innovation				x

Source: own production

VI. CONCLUSIONS

The results of the study allow identifying the tendencies and directions of growth of Ica's wine cluster, the insertion of new actors and its impact in the dynamism of cluster, the cumulative learning according to the cluster technological trajectory.

The evolution of this cluster is reflected in the growth of its exports and for the introduction of new technologies.

The wine cluster of Ica learns by means of the qualifications that offer the Cite-Vid, the interchange of tacit knowledge, and the conversion of articulated knowledge in tacit knowledge. In addition, the interactions have been fortified substantially.

The cluster nowadays competes internationally having fortified the obtaining of the denomination of origin for its main product (pisco).

The complex adaptive systems approach has permit identify multidisciplinary and systemic characteristics of this cluster.

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