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Structural Equations Model of the Concha Prieta (*Anadara tuberculosa*) Agribusiness Management and Value Chain Performance in the Ecuadorian Mangroves

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ABSTRACT

Mangroves are tropical and sub-tropical ecosystems that fulfill multiple beneficial functions for preserving life on the planet and the economic support of families living in their surroundings. Such is the case of the mangroves in Ecuador, in which the "Concha Prieta" (Anadara tuberculosa) is produced through the manual extraction of natural populations. However, this production system is threatened by deforestation and overexploitation. This research aims to formulate an agribusiness management model that impacts the A. tuberculosa's value chain performance levels using as validation tools the structural equations model. A non-experimental, cross-sectional, and ex-post-facto field research methodology was applied. The population under study was made up of the production chain participants, through a representative sample of 138 shellfish collectors, 12 managers of shellfish associations, 27 merchants, and 45 restaurants.

The study was carried out in the Jambelí archipelago, in El Oro province, Ecuador, in 2019. Likewise, a questionnaire for each stage of the research was designed and validated through experts' judgment. The collected data were processed and analyzed through the structural equations model, using SPSS and AMOS software. The result obtained shows an interdependence relationship between both latent variables, with a covariance index of 0.45, which allows us to infer that as the processes integrated into Agribusiness Management are improved, higher levels are reached in the Performance components of the mollusk value chain and vice-versa. In particular, the exogenous variable Agribusiness Management is related to the endogenous variables mentioned below, with their respective factorial load: Evaluation (0.72); Process innovation (0.69); Internal factors of innovation (0.67); Planning (0.65); Execution (0.58) and External factors of innovation (0.38).

Likewise, the exogenous variable Value Chain Performance is related to the endogenous variables mentioned below and their respective factorial load: Physical productivity (0.86); Economic productivity (0.83); Percentage indicator of net income (0.35); Operational profitability (0.21); Quality of life (-0.07) and Leadership in costs (-0.06). We conclude that the Agribusiness Management and Value Chain Performance constructs are interdependent and that the Physical Productivity and Evaluation indicators are the ones that have the most significant influence on this relationship. We recommend simulating these effects and relationships to propose improvement strategies to the said value chain.

Keywords: Bivalve mollusks, Environmental Processes, Mangroves, Quality of life, Ecuador

1 Introduction

Faced with a growing population worldwide, the challenge of producing supplies to satisfy their diet is crucial. Food and agriculture are essential for achieving the entire set of the Sustainable Development Goals-SDG (UN, 2015), many of them directly related to fisheries and aquaculture.

Thus, these activities can make an essential contribution to the achievement of the objectives mentioned above and especially to SDG 14: Conserve and sustainably use the oceans, seas, and marine resources for sustainable development (FAO, 2020). This document demonstrates the significant and growing role that these economic lines play in the provision of food, nutrition, employment, and the main challenges that need to be addressed despite the progress made on several fronts.

FAO (2020) highlights the urgent need to replicate and readapt policies and measures that have been successful in light of specific fisheries' realities and needs. It proposes developing new mechanisms to support the effective implementation of management policies and regulations aimed at the sustainability of fisheries and ecosystems as the only solution that will ensure that fisheries worldwide are sustainable.

To this end, the application of science-based fisheries and aquaculture management policies, together with predictable and transparent regimes for the use and trade of products at the international level, are expected to constitute minimum criteria for the sustainability of fishing and aquaculture.

Among the bivalve mollusks (oysters, mussels, clams, and scallops, among others) is the Anadara tuberculosa (Sowerby, 1833) (Arcidae), known in the Republic of Ecuador with the common name "Concha Prieta" (black shell). This mollusk is of great economic, social, and environmental importance in all the American Pacific coast countries that produce it.

FAO (2018) reports that bivalve mollusks represented 6% of the world trade in fish and fishery products in 2016, after fish and crustaceans. The most commercialized species are mussels, clams, combs, and oysters, being the Western Pacific ark (Anadara granosa), the only one of the same taxonomic genus as Anadara tuberculosa, which has relevance in bivalve mollusks' international trade together with A. tuberculosa. This shows its hierarchy in bivalve mollusks' international trade with 3% of the total, ranking it among the ten most internationally traded species.

The vast majority of commercially relevant bivalve mollusks are farmed. That is, various aquaculture production systems are applied. In this sense, for the year 2016, cultivated mollusks' world production reached 17,139 thousand MT of live weight (21.41% of the world aquaculture production, which was 80,131 thousand MT of live weight).

However, according to FAO (2018), world fisheries production reached a maximum in 2016 (approximately 171 million MT). Of this, capture fisheries production represented only 53.15% of the world total (90.9 million MT). It is observed that capture fisheries production has reached a ceiling that has stabilized at this maximum figure since the end of the 1980s. However, between 1961 and 2016, the average annual increase in world consumption of edible fish was 3.2%, which surpassed population growth that reached 1.6%. In per capita terms, edible fish consumption increased from 9.0 kg in 1961 to 20.2 kg in 2015, at an average rate of approximately 1.5% per year.

Capture fisheries production of groups of mollusks has been declining since the early 1980s. Such is the case of oysters and clams at the end of that decade and mussels in the early 1990s. These negative trends could be a consequence of pollution that reduces marine environments' quality and greater aquaculture production of some of these species (FAO, 2018).

The figures mentioned above show how fish and shellfish's world consumption has increased in recent years, to an apparent per capita consumption of 20.3 kg for 2016 (FAO, 2018). However, the catch remains stable at a ceiling, with a tendency to reduce in some particular cases of bivalve mollusks species. This situation generates a growing deficit, stimulating the overexploitation of fishing resources in different regions of the planet, causing environmental damage, production abatement, loss of competitiveness in fishing activity, and deterioration of fishermen's quality of life.

It should be noted that just as a maximum has been reported in the global fishery catch, particularly of bivalve mollusks, another maximum has also been recorded for A. tuberculosa in the Jambelí archipelago, El Oro province, Ecuador, the locality that is the subject of the present research (Figure 1).

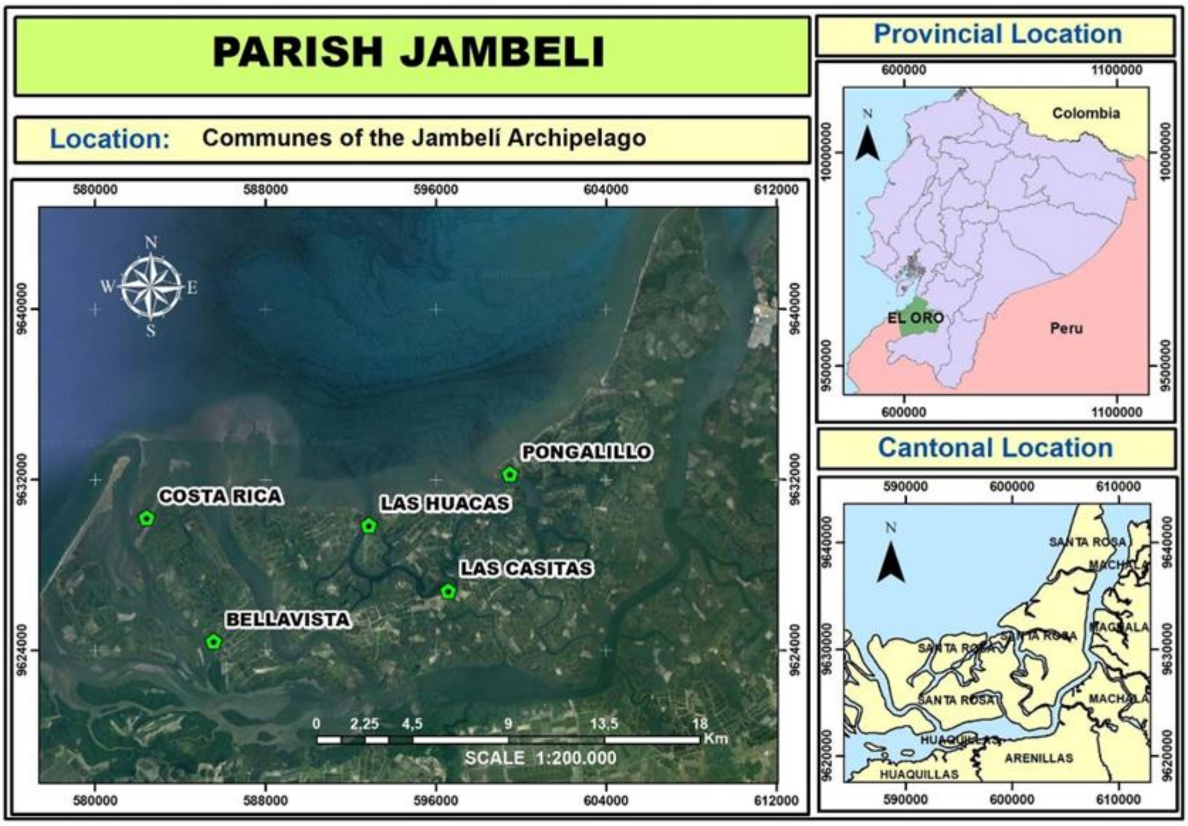

Figure 1. Study area: Jambelí archipelago, El Oro province, Ecuador.

(Source: Authors)

In this sense, it is noted that the Jambelí archipelago represents one of the most important shellfish capture areas in the Republic of Ecuador due to its high landing volumes (Zambrano et al., 2017). In 2011, a total catch was estimated in the main landing ports of the Ecuadorian coast in 30 million shell specimens, of which approximately 40% were extracted in the Jambelí archipelago (Mora et al., 2012). The data indicates that this area has relevant characteristics for studying the production chain of A. tuberculosa (PCAT).

The National Fisheries Institute of Ecuador (INP, 2018) reports that in May 2018, more than 50% of the shell resource measured specimens were below 45 mm (total length). This minimum size requirement enables each specimen to reproduce before being captured. The situation reflects the current degree of overexploitation of the resource coupled with the fact that mangroves' deforestation threatens natural populations. It is a clear sign that alerts the severe deterioration of the agribusiness model of A. tuberculosa in the área. Figure 2 graphically shows the causes and consequences of the agribusiness management problem in the *A. tuberculosa's* value chain.

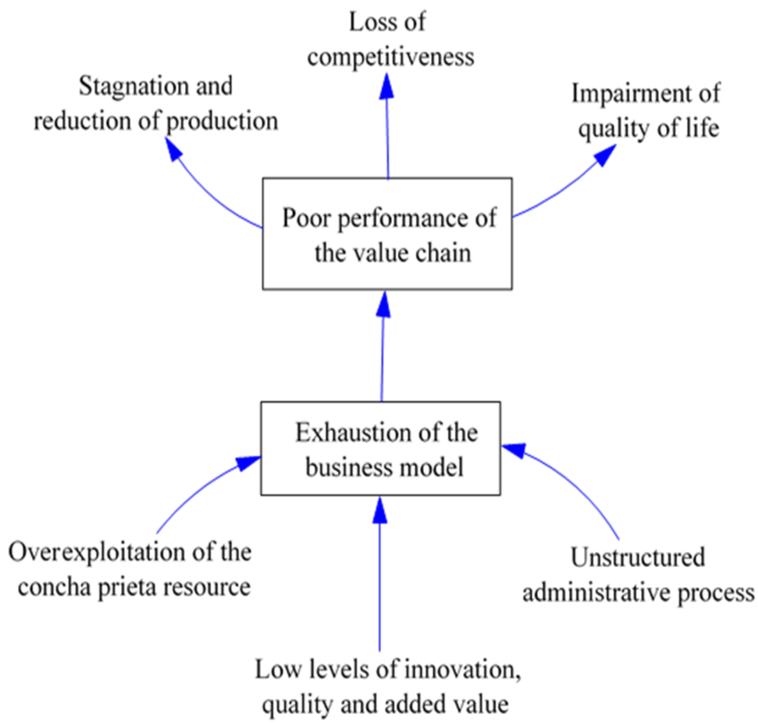

Figure 2. Tree of causes and consequences of the agribusiness management problem of the Anadara tuberculosa value chain (Source: Authors)

1.1 *Anadara tuberculosa* characteristics

A. tuberculosa is only distributed in the eastern Pacific from the Guaymas coasts, from Baja California in southern Mexico to the Bay of Tumbes, Peru (Keen, 1971), passing through Ecuador, Peru, Colombia, and the countries of Central America spreading through 6,350 km (Lazarich Gener, 2009).

This species is associated with the red mangrove Rhizophora mangle Linnaeus located in the intertidal zone, where it lives buried in the muddy soil. Mangroves constitute an ecosystem made up of trees or shrubs situated in the land/open sea interface of tropical and subtropical regions. Its distribution depends mainly on the tidal interval, geomorphology, topographic decline, and the water and soil salinity (Flores-Verdugo et al., 2007). Among the functions or values of this coastal wetland, the following stand out (MARNR, 1986):

• Biological value. It is one of the most productive ecosystems (primary productivity) due to the number of animal species it maintains, resulting in a high biodiversity. It acts as a biosphere reserve, housing organisms that seek food and shelter from predators and a safe area to fulfill their reproductive cycle.

• Environmental value. It forms a natural buffering barrier that protects the coasts from storm surge and hurricane-force winds and acts as a barrier against climate change. It prevents floods, controls erosion, forms soils, produces oxygen, stores carbon dioxide, and filters water.

• Economic value. In Ecuador, the mangrove ecosystem has represented the basis of the subsistence of many coastal communities. An essential economic activity is collecting and commercializing mollusks and crustaceans, a work source in low-income areas with limited job opportunities.

It is noteworthy that many commercially exploited species use the mangrove as a nursery and growth area from the first stages of their life cycle (among the mangroves' roots, they find protection and feed on larvae, postlarvae, and fry of fish and crustaceans) (Conabio, 2013).

• Cultural value. In Ecuador, many Afro-Ecuadorian, indigenous, and mestizo families, dedicated to artisanal fishing activities, collecting mollusks, crustaceans, wood for charcoal, and medicinal plants, have lived ancestrally linked to the mangrove ecosystem. Mangroves have enabled them with a particular worldview, customs, attitudes, eating habits, social and cultural relationships.

The mangrove ecosystem represents an open system that is highly vulnerable to various environmental stressors present at the continent/ocean interface (MARNR, 1986; Mitra, 2013).

Demographic growth, deforestation, modification of surface drainage, accumulation of garbage, and wastewater discharges have been identified as negative anthropic impacts on the mangrove, in addition to those generated by climate change, such as variations in mean sea level, flood events, tropical storms, rainfall, coastal erosion, ambient and water temperatures, atmospheric carbon dioxide concentration, coastal circulation pattern, and integrity ecology of neighboring ecosystems (Heredero, 2011).

More than 70% of the mangrove surface has been lost in Ecuador due to urban growth, tourist infrastructure development, and aquaculture (shrimp farms) in the last 40 years. However, it is estimated that there are still more than 156,000 hectares of mangroves (Fundación Heifer Ecuador, 2018).

An element to highlight in the A. tuberculosa's social importance is its nutritional value (Cruz et al., 2012). Orquera (1999) highlights its easy and safe location, its relatively constant production throughout the year, and the low investment and risks of failure in its extraction. However, shellfish collectors and other production chain participants have experienced a decline in their quality of life (IDB, 2018).

On the other hand, shell collecting activity presents a tremendous underlying social problem. Beitl (2010) has identified conflicts between shellfish and shrimp farmers, between associated shellfish collectors who have permits to extract the shell and other non-associated collectors who are not authorized to remove the shellfish, as well as insecurity and piracy. Likewise, Caicedo (2014) reports that in Esmeralda province, Ecuador, other social conflicts related to A. tuberculosa production arise. Among these conflicts, workers' massive entry from different economic sectors such as palm tree agriculture stands out. The supply of the Colombian workforce displaced by the armed conflict on the Ecuadorian border and the almost non-existent social security coverage for workers in the shellfish sector, together with low educational levels and a scant supply of public services, especially wastewater treatment, are additional issues to consider.

The interrelation established between the mangroves, the A. tuberculosa, and other species of economic and nutritional value such as the red crab (Ucides occidentalis), the mica or male shell (Anadara similis), and the mule leg shell (Anadara grandis), among other species, justify this research. The sustainable and competitive production of A. tuberculosa constitutes a way of preserving the mangrove ecosystem. In this research, we highlight the importance of the A. tuberculosa agribusiness as the main economic activity in the preservation of the mangrove ecosystem on the Ecuadorian coast through sustainable management.

Under the situation raised, Prado-Carpio et al. (2018a, 2018b, 2019) propose a theoretical model to characterize the main business aspects of A. tuberculosa with a prospective approach. The model considers the best scenarios and integrates the agribusiness management (ABM) constructs as an independent variable and the A. tuberculosa value chain performance as a dependent variable (Figure 3).

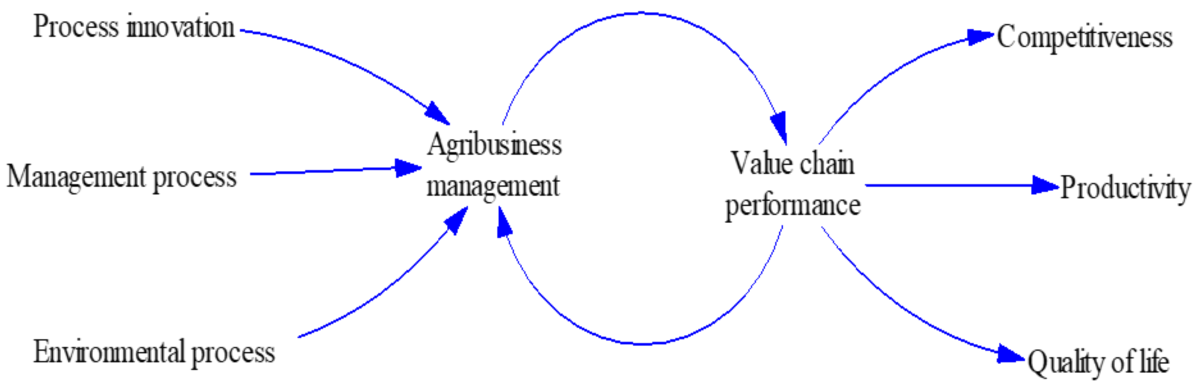

Figure 3. The theoretical model of relationships between agribusiness management and the A. tuberculosa value chain performance (Source: Authors)

In turn, the agribusiness management construct is made up of three dimensions: the management process, the innovation process, and the environmental process. Two relevant processes for the present and future of the A. tuberculosa business are added to the classic management process, the innovation processes, and the environmental processes. This way, we try to condense the best existing practices on the three dimensions and compare them with how they are currently managed in the Anadara tuberculosa production chain (ATPC).

Similarly, the performance construct of the A. tuberculosa value chain (ATVC) considers three dimensions: the productivity dimension, which is a systematic way of evaluating the results of management processes, adding the competitiveness dimension, which is more oriented to business perspectives and the quality of life dimension, aimed at knowing the benefits in living standards that the business generates for those who operate and manage it daily.

The research has been carried out under the premise that agribusiness management affects the A. tuberculosa value chain performance. Thus, this study's objective is to formulate an agribusiness management model that impacts the A. tuberculosa's value chain performance levels.

2 Research methodology

The descriptive methodology applied was quantitative (Tamayo, 2014), and its design was non-experimental, field, cross-sectional, and ex-post-facto (Sabino, 1992 and Hernández, 2004).

The population under study was composed of 886 individuals, made up of the strata of shell collectors, shell managers, merchants, and restaurants of the ATPC located in the Jambelí archipelago, in El Oro province, Ecuador, in the period January to October 2019. The type of sampling used was probabilistic, random, and stratified.

The sample size was estimated at 222 informants, through the formula proposed by Martínez (2005), which is the following:

$$n = \frac{\mathrm{PQ}}{\left(\frac{E}{Z}\right)^2 + \frac{PQ}{N}}$$

Where,

P: Probability of success (50%)

Q: Probability of failure (50%)

Z: Value of the normal standardized table associated with a 90% confidence level (1.65)

E: Maximum admissible error (4.8 %)

N: Population size (886)

Four similar questionnaires were designed to obtain information, validated (by expert opinion), and applied to each production chain link. These links comprised 138 shell collectors, 12 shellfish managers, 27 merchants, and 45 restaurant-cevicherías, which served to measure the agribusiness management variable (independent) and the value chain performance variable (dependent), and their respective dimensions and indicators. The structured interview method was applied.

The agribusiness management variable has three dimensions: management processes, innovative processes, and environmental processes. The Anadara tuberculosa value chain's performance construct has three dimensions: productivity, competitiveness, and quality of life, each of these has its subdimensions and indicators.

The questionnaire was structured by a classification section and another section of the variables under study themselves. The predominant measurement scale was the Likert scale with values from 1 to 5, representing the value of 1 (never), the value of 2 (almost never), the value of 3 (sometimes), the value of 4 (almost always), and a value of 5 (always), but also multiple scales and open questions for quantitative indicators. The data recorded in the questionnaires were processed using SPSS and AMOS software through univariate tests.

Likewise, the validity of the measurement scale of the questionnaire was verified with Cronbach's alpha of 0.778. In addition, exploratory factor analysis of principal components was performed to determine the dimensions that best describe the constructs, and with the confirmatory factor analysis each of the model variables was validated.

In this research, multivariate statistics of structured equations (SEM) were used due to the complexity of the phenomenon under study, the high number of indicators and variables evaluated, as well as the absence of a methodological and statistical reference for this managerial phenomenon in the academic and business literature. Therefore, the application of the structural equations model had the purpose of simplifying the analysis of the phenomenon under study.

3 Results and discussion

To formulate the structural equations model of the relationship between the Agribusiness Management and Performance of the Value Chain variables, the factor analysis or principal components achieved with the development of this research's objective were used as input information. For the case of the agribusiness management variable, the following expression applies:

Agribusiness Management = CF + HF + Super

Where,

CF: Creative Factors.- Process Innovation (PrI), Planning (Plan), Product Innovation (PtI), Evaluation (Eva), Execution (Exec), and Support (Supp).

HF: Human Factors.- External Factors (ExF), Leadership (Lea), and Internal Factors (IF)

Super: Supervision (Performance Evaluation).

Regarding the case of the Value Chain Performance variable, the factorial model produced the following result:

Value Chain Performance = PF + FF + LI

Where,

PF: Production Factors.- Physical Productivity (PP), Economic Productivity (EP), Differentiated Product (DP), and Market Segment (MS).

FF: Financial Factors: Unit Cost per Shell (UC), Cost Leadership (CL), and Operational Profitability (OP).

LI: Life and Income: Quality of Life (QoL) and Percentage Indicator of Net Income (PIN).

The factorial coefficients were statistically processed, obtaining two failed approximations of the model. The third attempt to develop the structural equations model was accepted since it met the methodological requirements (Figure 4).

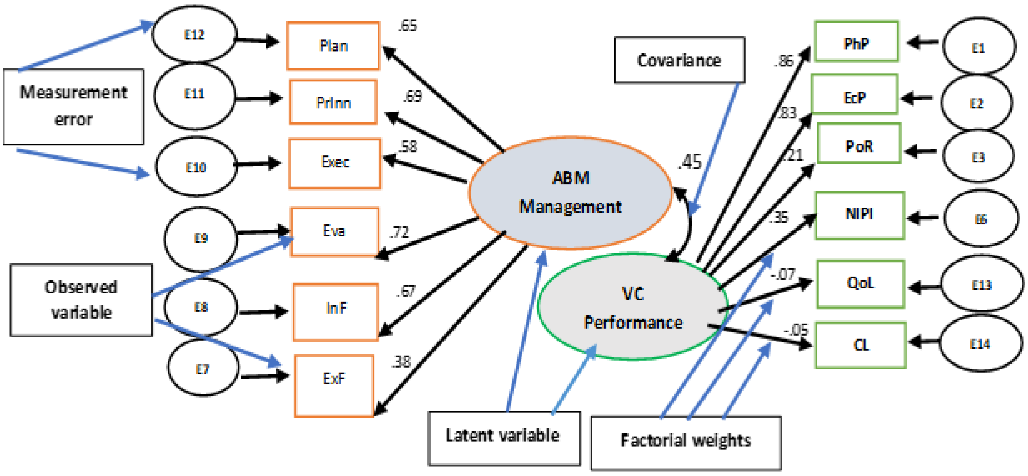

Figure 4. Path graph of the structural equations model of the relationship Agribusiness Management and Performance of the Concha Prieta value chain.

ABM: Agribusiness Management / Plan: Planning / PrInn: Process Innovation / Exec: Execution / Eva: Evaluation / InF: Internal Factors / ExF: External Factors.

VC Performance: Value Chain Performance / PhP: Physical Productivity / EcP: Economic Productivity / PoR: Operational Return / NIPI: Net Income Percentage Indicator / QoL: Quality of Life / CL: Cost Leadership.

This model met the conditions required by the structural equations system (Table 1), particularly the RMSEA, CFI, TLI, NFI, and AIC tests. However, it did not comply with the chi-square statistic (X2) since it is very sensitive to the sample size. With large samples (greater than 100 or 200 cases), it is relatively easy to reject the null hypothesis when the model achieves a good fit. This was the case in this research in which we handled 222 observations. For this reason, in addition to assessing its statistical significance, it is usually compared with its degrees of freedom, using the equation Chi-square/degrees of freedom (X2/dof), which should reach a value less than 3 (<3).

This indicator (Chi-square / Degrees of freedom, X2/dof) is conceptually the most attractive since it allows us to test the null hypothesis that all the errors of the model are null, so in this research, the null hypothesis was verified in this way for the sample used (Table 1).

Table 1.
Statistics of the goodness of fit of the structural equations model of agribusiness management and value chain performance of *A. tuberculosa*

	Absolute fit		Incremental fit			Parsimony fit			
Models	**Chi-square**	**RMSEA**	**CFI**	**TLI**	**NFI**	**PRATIO**	**PCFI**	**PNFI**	**AIC**
Value Obtained	0,000***	0,048*	0,922*	0,910*	0,901*	0,679**	0,451**	0,472**	383,328*
Reference Value	+0,05	-0,080	+0,90	+0,90	+0,90	+0,90	+0,90	+0,90	+ 200

*Complies with the requirement; ** Does not comply with the requirement; ***Complies with (X^2/dof<3)
Chi-C: Chi-square; **RMSEA:** Root mean square error of approximation, **CFI:** Comparative fit index,

TLI: Tucker–Lewis index, **NFI:** Normed fit index, **PRATIO**: Parsimony of RATIO,
PCFI: Parsimony of CFI, **PNFI:** Parsimony of NFI, **AIC:** Akaike Information Criteria.

Source: Authors, based on Escobedo-Portillo et al. (2016); Cupani, M. (2012); Ruiz et al. (2010)

Following Martínez-Soto et al. (2019), the graph's rectangles represent the observed variables or indicators in the applied questionnaire. The small circles represent the errors for those variables that have not been considered in the model. The bidirectional arrows represent the covariances between the latent variables and explain one variable's development when the other develops. The directional arrows come out of the latent variables represented by the ellipses, which constitute the correlations of the observed variables with the latent variable.

Regarding the analysis of covariances, the latent variables originate bidirectional arrows called covariances, analogous to the correlation and are defined as the non-directional relationship between the independent (latent) variables (Cupani, 2012). This is one of the structural equation model's main contributions over the factorial model since it establishes relationships between the latent variables, which does not happen with the factorial model. These relationships are of covariance or mutual interdependence.

A double-headed arrow represents this relationship, which means that the two phenomena covariate, that is, when one varies, the other also varies and vice-versa. There may be other variables that have not been observed and that enhance or attenuate this relationship (Ruiz et al., 2010).

For the structural equations model of agribusiness management and the A. tuberculosa value chain performance, a single covariance was obtained, which we discuss below:

Covariance between the latent variable Agribusiness Management (ABM) and the latent variable Value Chain Performance (VCP): In this relationship, the coefficient of variance was 0.45 positive, which indicates a moderate covariance, with relation to the maximum value of 1, among these latent variables under study. This result validates this research's main hypothesis, which has been endorsed in different scientific publications by Prado-Carpio et al. (2018a, 2018b, 2019, 2020a, 2020b). In a simplified way, it implies that as the processes integrated into the Agribusiness Management are improved (Managerial Process, Innovative Process, and Environmental Process), higher levels are reached in the VCP components of the A. tuberculosa (competitiveness, productivity, and quality of life) are obtained. Said improvement process receives feedback in a proportion of 0.45. In other words, to the extent that competitiveness, productivity, and quality of life increase their levels within the performance of the value chain, to the same extent with a coefficient of 0.45, management, innovative, and environmental processes improve within the agribusiness management of A. tuberculosa. These results and their interpretation are original findings since there is no research in the scientific literature that allows testing the results obtained for these two constructs, specifically in fisheries production, bivalve mollusks, and the A. tuberculosa. Therefore, some scientific references are presented below to test the relationships between exogenous and endogenous variables.

In the first place, the exogenous variable Agribusiness Management is considered, which affects the endogenous variables as follows:

• Agribusiness Management and Evaluation (0.72): In the structural equations model, the result was that the most influential endogenous variable was the Evaluation indicator, which is part of the management process, reaching a factorial weight of 0.72, which means that the increase in ABM levels affects directly proportionally with the increase in the evaluation processes. Facenda (2019) points out that periodically (either monthly, quarterly, or with the frequency required by management) an ex-post control must be developed after the execution. Through it, it is intended to carry out an evaluation that allows to identify deviations concerning the production and budgeting plans and investigate the causes of such differences to then be able to take the necessary corrective measures.

• Agribusiness Management and Process Innovation (0.69): Process Innovation was the indicator that reached the second-highest factorial coefficient, within the resulting structural equation model, with a factorial coefficient of 0.69 that indicates a positive and direct relationship between the endogenous variable Process Innovation and the exogenous variable ABM. This result is similar to that achieved by Cuevas-Vargas and Parga-Montoya (2018). They demonstrated that an adequate adoption of ICTs allows companies to increase innovation in their processes and that process innovation impacts business performance. In this case, process innovation is part of business management, according to the operationalization of the variables, which includes the following indicators: Work Methods / Logistic Systems / Equipment / Information Systems / Cost Management / Commercial Management.

• Agribusiness Management and Internal Factors of Innovation (0.67): a similar result was obtained by Vega et al. (2020), who, given the characteristics and relevance of agribusiness in Mexico, empirically evaluated 347 companies, to analyze whether Orientation to Learning (OL) and Organizational Commitment (OC) positively influence innovation and performance. The results indicated that there is a positive and significant effect between Orientation to Learning (OL), innovation, and from this to organizational performance. Precisely, these concepts and indicators are part of the internal factors sub-dimension, as indicated in the operationalization of the ABM construct, through concepts and indicators: Human Factor / Organizational Factor / Market Business.

• Agribusiness Management and Planning (0.65): Planning was the fourth endogenous variable, with the greatest influence within the model of structural equations of the ABM and VCP, with a factorial coefficient of 0.65. It indicates a direct and positive relationship between agribusiness planning and management. This result is similar to that reported by Villafuerte-Holguín et al. (2016), who outlined that planning is a basic instrument to reduce the risk of producing and distributing a product in a market. In this case, the A. Tuberculosa constitutes the food product that is the object of this research. Planning is a sub-dimension in this research and includes the following indicators: Information Management / Diagnosis / Strategy / Objectives / Time.

• Agribusiness Management and Execution (0.58): The execution sub-dimension reached a moderate to high factorial weight of 0.58. In this research it comprises Negotiation / Compliance / Harmonization / Optimization indicators. This result agrees with that reported by Alvarado Vélez et al. (2020), who indicates that the Execution function can compensate for the shortcomings in the planning process through a timely development in coordination with the workers' management phase.

• Agribusiness Management and External Factors of Innovation (0.38): The external factors constitute an endogenous variable that includes the indicators Financing and Fiscal incentives / Academic Cooperation / Public policies of innovation. It relates the exogenous variable ABM in a direct and moderate positive proportion of 0.38. It differs from that obtained by Peraza-Castaneda (2016), who points out that business management's internal factors have a more significant incidence than external factors. Therefore, in the model developed by these researchers, external factors were not included, but internal factors were incorporated with a high level of relevance, through the organizational dimension, with the sub-dimensions planning, R&D activities, and human capital as the main determining factors for business development.

In this group of relationships, sub-dimensions and indicators of the innovative process and managerial process dimensions predominate, leaving out of the model all the environmental process sub-dimension indicators. Therefore, the predominance of the innovative process and the managerial process variables in the factorial model of relationships between the ABM and the VC is evidenced.

Likewise, secondly, the *A. tuberculosa's* Value Chain Performance exogenous variable affects the following endogenous variables:

• Value Chain Performance and Physical Productivity (0.86): Physical Productivity (PhP) is the endogenous variable most closely related proportionally and directly to the exogenous variable VC Performance. This result is similar to that obtained by Fonseca-Carreño (2019), who reveals that the activities of the VC, production, transformation, and commercialization, are generated as a strategy to improve the living conditions of the rural households (shell collectors and others), which is based on the intensification of existing production patterns. We define intensification as "increased physical or financial productivity, including crops, livestock and other productive activities," for which production systems associate it with an increase in production performance, optimization of resources (raw materials, inputs, infrastructure), and efficiency in labor productivity. However, this increase in physical productivity must be related to the supporting capacity of the mangrove ecosystem.

• VC Performance and Economic Productivity (0.83): The second endogenous variable most strongly related to the exogenous variable VC Performance is Economic Productivity (EcP). A similar result was obtained by López et al. (2019), who verified this close relationship in a study on white shrimp.

• VC Performance and Net Income Percentage Indicator (0.35): Net Income as an endogenous variable within the structural equations model is also moderately related to the exogenous variable VC Performance in a moderate and positive proportion 0.35. This result is similar to that obtained by Díaz-Víquez et al. (2017), who identified income as a fundamental variable for determining the value chain's impact on agave production distillates' gross profit margin in Mexico.

• VC Performance and Operational Return (0.21): Operational Return (OR) is another endogenous variable of the structural equations model related to the exogenous variable VC Performance in a positive moderate to low proportion 0.21. This result is compatible with that indicated by Gómez-Areu and

Ordosgoitia-Ojeda (2016), who placed Operational Return as one of the most relevant indicators for determining favorable performance in projects that make up the production chain.

• VC Performance and Quality of Life (0.07): Quality of Life is another endogenous variable related to the exogenous variable VC Performance, in a negative and low proportion of -0.07. This result is consistent is not consistent with that reported by Álvarez Medina et al. (2017), who indicated that international competitiveness (part of the performance variable) is the result of a country's ability to design, produce and commercialize goods (such as shellfish) and services of higher quality and better price than its competitors, favoring the improvement in the quality of life in society. That is, it reaffirms the positive relationship between these variables.

• VC Performance and Cost Leadership (0.06): Finally, the endogenous variable Cost Leadership (CL) is also related to the exogenous variable VC Performance, in a low and negative proportion of -0.06. This result is not ratified by the findings obtained by Inocente-Vera and Lara-Baldeón, (2019), who affirm that the cost leadership strategies have faced competitiveness limitations of quinoa exports from Peru to Germany, improving the performance of said value chain.

In these last two cases, the coefficient obtained is minimal, tending to zero and its relevance in the formation of the model is almost nil.

In this second group of relationships, we must point out the presence of endogenous variables related to the dimensions competitiveness (cost leadership), productivity (physical productivity, economic productivity, operational profitability, percentage index of net income), and quality of life (QoL) of the VC performance construct.

4 Conclusions and recommendations

1. An interdependence exists between Anadara tuberculosa's ABM and VCP latent variables. This relationship prevails in the structural equations model beyond the creative, human, and supervisory factors for the ABM variable, and the productivity, financial, quality of life, and income factors for the VCP variable. These factors were absorbed by the latent variables validating the theoretical model of the research.

2. The model obtained projects a high degree of influence, in the case of ABM, on the sub-dimensions and indicators of planning, process innovation, execution, evaluation, internal innovation factors, and external innovation factors. Similarly, in VCP, its influence is oriented towards the sub-dimensions and indicators of physical productivity, economic productivity, operational return, net income percentage indicator, quality of life, and cost leadership. This model was statistically and methodologically validated based on what has been stated in this study.

3. The performance construct of the A. tuberculosa value chain as a dependent variable is highly influenced by the ABM construct through the dimensions of the managerial process, the innovative process, and the environmental process.

Recommendations:

• Simulate the A. tuberculosa management model obtained using suitable software.

• Develop a pilot test in a locality where the Shell collectors and other participants in the A. tuberculosa value chain are better organized, diagnose their situation, and apply an improvement plan based on the considerations made in this research.

• Promote creating a research and innovation network, both in Ecuador and in other Latin American countries that produce the Anadara tuberculosa, to exchange experiences and scientific and productive information, emphasizing the development of international markets and the preservation of the mangrove ecosystem.

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