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# Internationalisation of non-financial social and solidarity economy cooperatives: case study in Ecuador

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## Abstract

Internationalisation is a way for companies' growth and economic development in transition economies with the potential to contribute to a more sustainable world. Social and solidarity economy cooperatives (SSECs) have a lower internationalisation trend than developed economy companies due to their aversion to possible economic losses and lack of knowledge of the global market. This study aims to propose an internationalisation model for non-financial SSECs through factor analysis and evolutionary genetic computing to improve structural competitiveness within the framework of sustainable development in an emerging country. The study methodology includes: (1) information analysis related to internationalisation indicators; (2) statistical analysis of variables from the national survey of popular and solidarity economy organisations; (3) internationalisation model through a genetic algorithm; and (4) strategies related to sustainability. The results show internationalisation models with significant indicators such as number of partners, social capital, social benefit, access to international markets and employment. These models have goodness of fit with a high degree of precision (> 80%) and are a novel proposal to estimate the internationalisation of social capital cooperatives.

**Keywords** Social and solidarity economy, International expansion, Sustainability, Evolutionary optimisation, Socioeconomic development

## Introduction

Internationalisation is the adaptation of a company's operations, allocation, deployment of resources and organisational capabilities in international business environments [1]. This internationalisation process presents

differences between types of companies, cooperatives and ventures in developed and emerging economies due to different institutional, industrial and resource factors [2]. Emerging economies seek opportunities to address rural development and environmental impact challenges. Some social economy companies and cooperatives seek to increase their impact by expanding their markets on a large scale. Therefore, they consider it essential to seek geographical expansion because many communities present similar economic, political and social problems [3]. For example, social economy cooperatives in sustainable biofuel production [4], wine cooperatives [5] and agricultural systems [6]. Therefore, expanding the activities of social and solidarity economy cooperatives (SSECs) in the international context is crucial to achieving the sustainable development goals (SDGs). These cooperatives address social and environmental needs such as reducing

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poverty, improving quality of life, excluding marginalised sectors and reducing the impacts of climate change. Furthermore, the motivation for internationalisation in social and solidarity economy companies focuses on acquiring resources, innovation and expanding international markets [7].

The social and solidarity economy (SSE) integrates the participation of organisations such as cooperatives and associations or groups characterised by common ownership of the means of production and democratic management [8], aimed at prioritising human well-being, eradicating poverty and achieving sustainable development goals [9]. In this context, SSECs lead people-centred alternative or social and solidarity economy initiatives [10]. These SSECs defend principles and values of cooperation, solidarity, equity, sustainability and participation that promote social, economic and political transformation [11, 12]. The non-financial SSECs capture savings from members that make up the cooperative, subsidies and donations, and support for social benefit businesses through links between the SSE and local development [13]. In addition, they build non-capitalist economic practices based on solidarity and ethical relationships with emerging social transformative potential [14]. These cooperatives focus their structural competitiveness on developing their social capital linked to the cooperation and solidarity of their members [15]. For [16], access to knowledge networks is a component of social capital that explains the success of these cooperatives in the local and international context.

The internationalisation indicators of social economy companies consider that the emerging economy is not static [17], and exports are the main source of internationalisation in emerging countries [18]. Internationalisation positively relates to the company's size and varies according to the production, consumption or service industry [19]. In addition, the age of the companies has no impact on internationalisation [20]. However, there are internationalisation pressures on cooperatives' economic and social balance, such as SSE cooperatives' legislative and cultural differences [21], high tariffs [22] and corruption in the industry [23]. On the other hand, the performance of social economy cooperatives depends on structural and organisational variables such as concern for the environment, innovation and internationalisation [5]; natural capital management [24]; and configuration, objectives, types, results achieved and sustainability of the cooperatives [25]. All these variables linked to the SDGs achieve the economic development and prosperity of the sectors.

There are various studies oriented to SSE in emerging countries, but limited research on the internationalisation of SSECs. For example, Bretos et al. [26] conducted

an exploratory analysis regarding the internationalisation of 300 cooperatives globally based on indicators such as the size and evolution of cooperatives related to employment, geographical position and development sectors. This study found that cooperatives increased their turnover and employment levels, which are significant for international expansion in the context of the global economic crisis. Pérez-Suárez and Bustelo [27] analysed the need for internationalisation of social economy companies in Andalusia (Spain) through the importance of international orientation, company size, experience in the local market and innovation results. This study determined that the company's relative size influences export processes and that the sectors with the greatest external dynamism of the social economy are agriculture, fishing and the food industry.

Other authors, such as [28], explored challenges and opportunities for the globalisation of social economy cooperatives. They found the relationship between internationalisation and cooperatives supported by crucial aspects such as cooperative viability (e.g. strengths and weaknesses), promotion of local development and internationalisation tensions. On the other hand, Castilla-Polo and Sánchez-Hernández [29] applied an internationalisation model in agrifood cooperatives in Spain, using socioeconomic indicators such as responsible innovation, international orientation, prestige and cooperative performance to obtain strategic recommendations in the internationalisation process. In addition, Alon et al. [3] analysed the internationalisation of social economy companies based on drivers, processes, organisation and social and economic results of internationalisation to promote the emerging cross-border work of SSE companies. These authors highlight the contribution of local governments (e.g. financing, support structures and access to those in need) to the internationalisation process of cooperatives. However, Angulo-Ruiz et al. [30] found aspects that benefit and affect the internationalisation of indigenous social economy companies in Canada. They found that the links between economic networks and isomorphism increase the probability of internationalisation for this type of company, while the relations between social networks and government support decrease the likelihood of internationalisation. In addition, Chen et al. [31] analysed that innovation in non-profit agrifood organisations in China determines their absorptive capacity, affecting organisational performance.

On the other hand, in Ecuador, the study by Clark and Martínez [32] analysed alternative models of public certification for small associations in sustainable agricultural production. These certifications, public policies, social organisation and access to productive resources

are helpful indicators for developing new local, regional and global markets. Also, Loor Alcívar et al. [33] measured sustainability practices in Ecuadorian cooperatives through cooperative social balance and dimensions of corporate, economic, social and environmental identity to measure performance and promote the comprehensive development of Ecuadorian cooperatives. Salazar et al. [34] identified factors such as a shortage of financial support and economic benefits that impede commercialisation and poor access to international markets of an association of cocoa producers in Ecuador. These factors limit the innovation and social capital of these organisations.

These studies analyse some indicators of the internationalisation of social economy cooperatives, promoting their performance, development and access to international markets. During the last decade, the SSE has been an economic development alternative in some countries, especially emerging countries [35]. Some Latin countries, such as Ecuador, Peru and Bolivia, have followed similar economic policies in recent decades [36]. However, Ecuador has been characterised by seeking alternative economies of production, consumption and services based on natural resources to improve the sector's human well-being and economic development. The popular and solidarity economy is part of this country's economic sector. This alternative arose with an economic development model supported by the 2008 Constitution and aligned with the perspectives of Good Living (i.e. national development plan) [37]. The SSE of this country has generated jobs, poverty reduction and sustainable development practices through some organisations known as SSECs. However, some cooperatives must comply with the SSE principles, and others have generated international interest due to their cooperation practices, organisational strengthening, productive promotion and development of social capital [38]. In addition, the interest in access to international markets is one of the axes yet to be exploited in this region. Therefore, this article complements the research gaps in internationalisation models of non-financial SSECs. Under this approach, the following research questions are posed: (1) Is it possible to find an optimal model to predict the internationalisation of non-financial SSECs through a genetic algorithm? (2) What are the technical guidelines for internationalising non-financial SSECs from an emerging country in the context of sustainability?

This study proposes a model of internationalisation of non-financial SSECs through exploratory factor analysis and evolutionary genetic computing to improve structural competitiveness within an emerging country's sustainable development framework.

## Materials and methods

The research method analyses the internationalisation indicators of the scientific literature and the variables used in the national survey of non-financial SSECs. Subsequently, it performs statistical analysis for selecting variables for internationalisation models based on evolutionary computation. It proposes sustainability guidelines for decision-makers of non-financial cooperatives. Figure 1 presents the methodological scheme that consists of (1) information analysis, (2) statistical analysis, (3) internationalisation model and (4) sustainability guidelines.

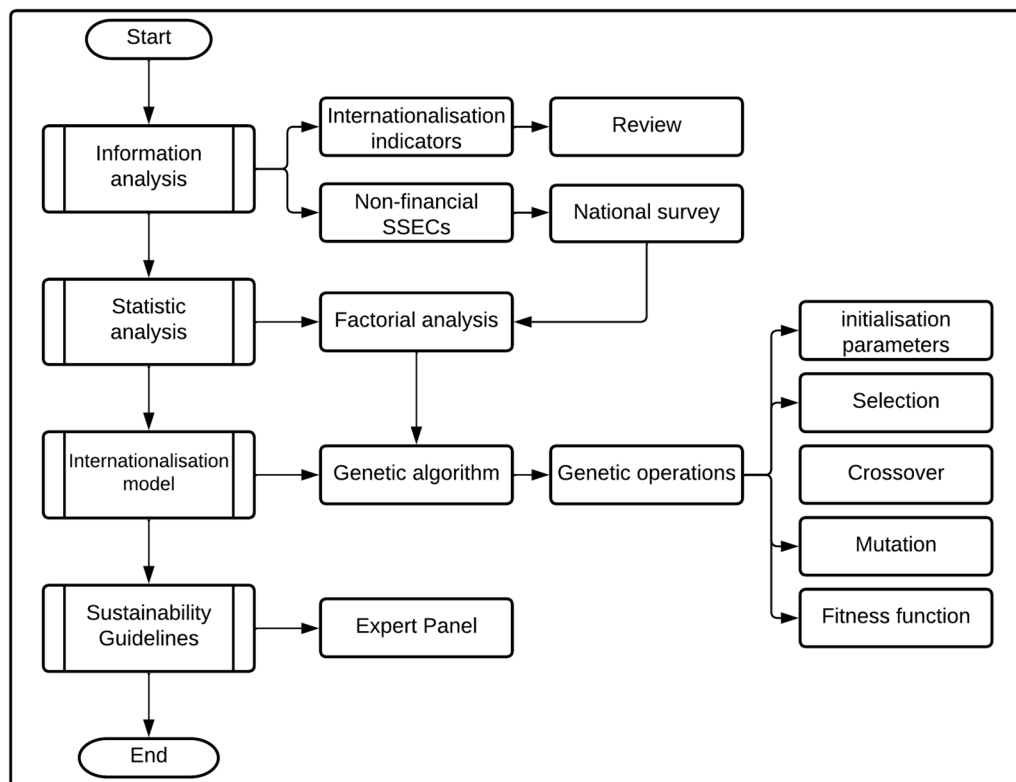
### Analysis of information on internationalisation indicators

This phase analysed the internationalisation indicators of the non-financial SSECs by reviewing the scientific literature of publications corresponding to the last 5 years (i.e. 2018–2023) (Table 1) [39, 40]. In addition, it analysed the variables used in the national survey (Table 2) associated with the indicators of internationalisation of literature. The survey was conducted on approximately 6000 popular and solidarity economy organisations in Ecuador in September 2019. The survey consists of (1) general information, (2) evaluation of principles, (3) characterisation of the organisation and (4) eradication of child labour [41, 42].

### Statistical analysis

The statistical analysis used a flat file with comma-separated values (CSV) [57]; it contains information on approximately 18 variables related to the national survey and 399 uniform and updated records that compile the characteristics of the non-financial SSECs of Ecuador [58]. The variables or indicators of internationalisation were selected based on the review of the scientific literature and convenience sampling due to the accessibility of the data for the analysis (see Table 2) [59]. In addition, the 399 existing non-financial cooperatives were filtered out of the 6000 popular and solidarity economy organisations. The flat file is imported into the RStudio program, version 4.1.2. This statistical program processes data through programmable codes and packages that facilitate its use [60, 61].

Subsequently, the exploratory factor analysis (EFA) was carried out on the data set containing the variables in Table 2 to obtain the most significant factors and variables of the non-financial SSECs. EFA is a multivariate technique that selects a group of interrelated variables (i.e. factors) that explain the significant covariation between the measured variables [62]. This study considered the following statistical parameters for factor analysis:



**Fig. 1** Methodological scheme of the investigation

**Table 1** Internationalisation indicators

N°	Indicators	Reference citation
I1	Prestige	[43]
I2	Geographic scope	[26, 43, 44]
I3	Performance	[45]
I4	Innovation	[5, 44]
I5	Company size	[5, 26, 46]
I6	Organisational culture	[47]
I7	Employment	[26]
I8	Technology/website	[46, 48–50]
I9	Vertical integration	[51]
I10	Social responsibility	[52, 53]
I11	Environmental concern	[54]
I12	Natural capital	[24]
I13	Social capital	[3, 50, 55]
I14	Social benefit	[3]
I15	Investment portfolio	[56]

**Table 2** National survey variables to non-financial SSECs of Ecuador

N°	Variables	Reference citation
V1	Number of female members	[41, 42]
V2	Number of male members	
V3	Initial social capital	
V4	Current social capital	
V5	Organisation group	
V6	Organisation class	
V7	Social benefit	
V8	Benefit economic (i.e. profits)	
V9	Trade certification	
V10	Product quality certification	
V11	Technology/website	
V12	Gender equality	
V13	Environmental permit	
V14	Environmental responsibility	
V15	Geographic reach	
V16	Marketing formation	
V17	Access to international markets	
V18	Employment	

- Data quality verification using the Bartlett sphericity test and the Kaiser–Meyer–Olkin (KMO) sampling adequacy test [63, 64]. The Bartlett test evaluates the similarity of the correlations of the variables through the correlation matrix; it suggests that the

variables share or do not share enough covariance to perform the EFA [65]. Regarding the KMO, it evaluates the variance according to the ranges:  $KMO < 0.5$  (unacceptable),  $0.5 < KMO < 0.6$  (causes concern) and  $KMO > 0.6$  (acceptable) [66].

- Extraction of factors through maximum likelihood because they explain the common variance between factors [67].
- Retention of factors through the Kaiser criterion and scree plot, where the eigenvalues of the variables  $> 1$  represent more variance [68].
- Rotation of factors using Varimax to increase the variance of the factors [69].

**Internationalisation model**

The factorial analysis generated a new database (i.e. flat file) with acceptably correlated factors (e.g. number of members, social capital, type of organisation and social benefit) for the elaboration of the genetic algorithm (GA). The algorithm was developed in the open-source programming language Python; this computational genetic model consists of genetic operators such as selection, crossover, mutation and fitness function [70] allowing to generate success models with internationalisation indicators for non-financial cooperatives.

**Chromosome representation**

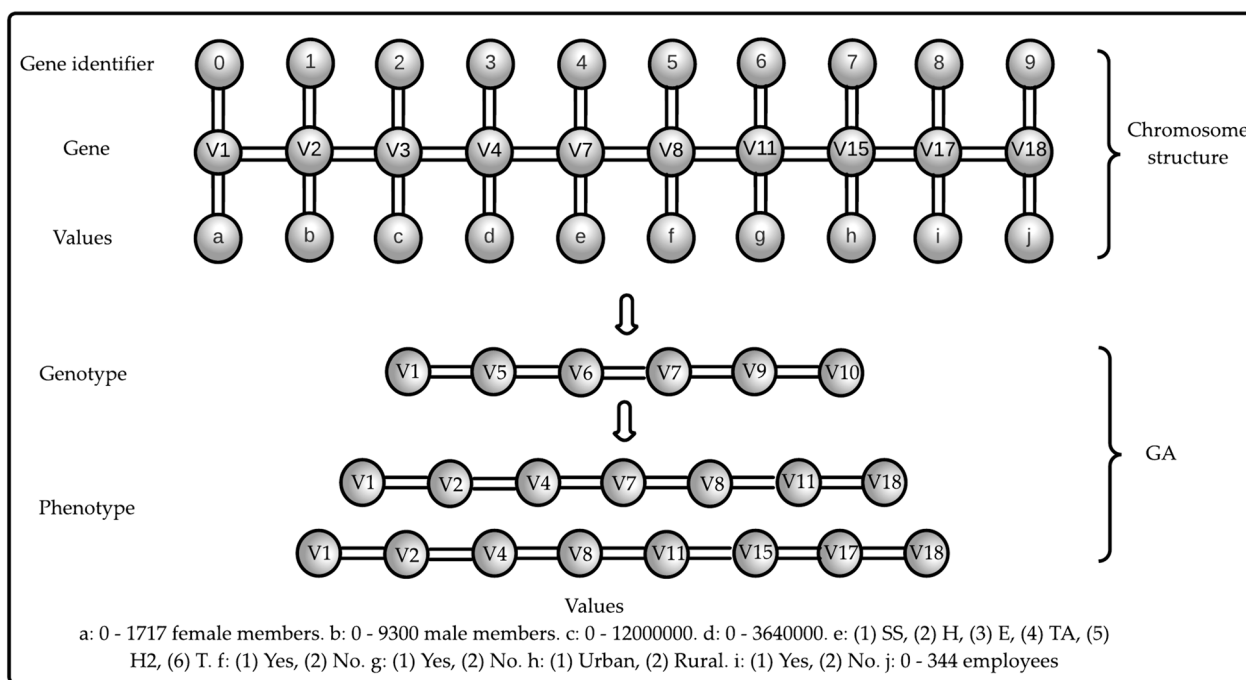
GA selects a population (i.e. a set of individuals) [71, 72]. An individual or chromosome represents a non-financial SSEC, a possible solution of a set of genes (i.e. internationalisation indicators or significant EFA variables). Figure 2 shows the representation of the chromosome and its genes. Compared with human genetics, the individual's DNA and physical characteristics correspond to GA development and solutions [73].

**Determination of initial parameters of the GA**

The values of the GA parameters, such as the initial population, maximum generation, crossover probability and mutation, are summarised in Table 3. These values are initial conditions adjustable to the stabilisation of the results of the GA [74]. The generation of the initial population considered the set of non-financial SSECs. The size of the population indicates the variability of possibilities of rapid convergence to an optimal

**Table 3** GA initial conditions

Parameters	Values
Population	399
Maximum generation	150
Crossover probability	0.8
Mutation probability	0.05



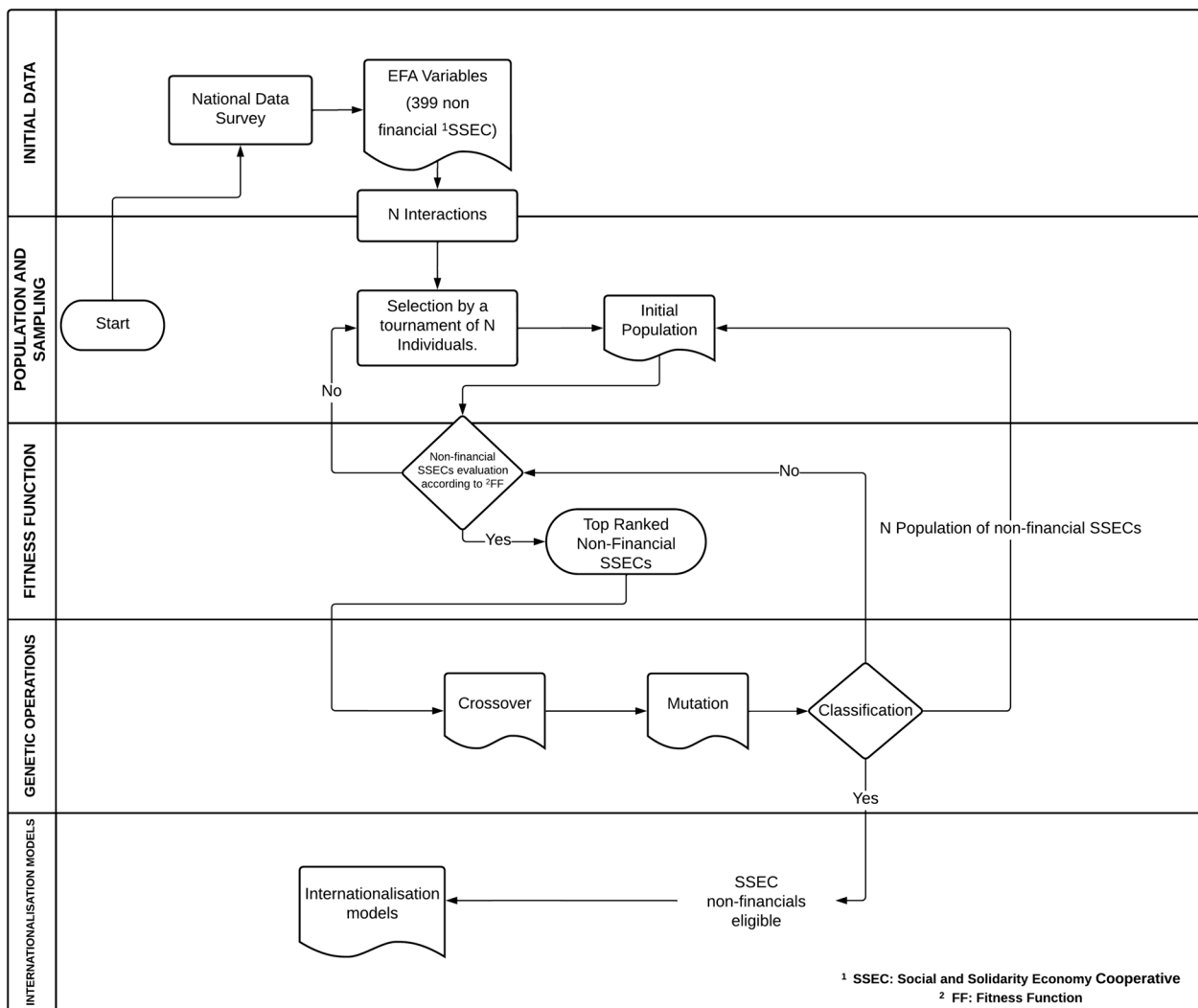
**Fig. 2** Chromosome representation. SS social security, H health, E education, TA technical assistance, H2 housing, T transportation

solution [75]. Furthermore, the generation of chromosomes (non-financial SSECs) ends when GA reaches its maximum iteration. The possibility of obtaining new solutions corresponds to the crossover probability (0.8). Regarding the probability of mutation, lower values are recommended because higher values delay the convergence of the GA [76].

**GA design**

The development of the GA used methodologies proposed by refs. [77–79] and considered the following processes: (1) initial data, (2) population  $\gamma$  sampling, (3) fitness function, (4) genetic operations and (5) internationalisation models (Fig. 3):

- Initial data using the flat file containing the internationalisation characteristics (i.e. significant EFA variables) of the non-financial SSECs.
- Population  $\gamma$  sampling: This process considered creating the initial population comprised of individuals (non-financial SSECs) and genes (internationalisation variables) based on  $n$  interactions. Generating the initial population of random individuals is the first step in a GA [80]. The sampling mechanism for this process is random [81]. That is, the tournament selection randomly chooses a non-financial SSEC with its best reproduction characteristics (genes), which is considered the winner of all the individuals in the sample.
- Fitness function assigns values to each individual's genes, obtaining a fitness value differentiating the best chromosomes [82, 83]. Table S1 shows the genes



**Fig. 3** Genetic algorithm design



and fitness values that this study considered. Subsequently, the fitness function is evaluated through the sum of the correctly classified fitness values.

- Genetic operations: This process uses reproduction operators such as, crossing and mutation for the eligibility of individuals [84]. The eligibility process of this study used the tournament selection operator to randomly select a percentage of individuals and choose the best ones, crossbreeding for gene exchange (non-financial SSECs internationalisation variables), and mutation for gene replacement [71, 85].
- In internationalisation models, after  $n$  generations, the GA generates the best estimates of internationalisation (Fig. 3).

#### GA validation

The GA validates the prediction of the success of the internationalisation of non-financial SSECs through statistics such as standard deviation, significance level, confidence level, confidence intervals and goodness of fit of the prediction models [86]. These statistics found accurate GA prediction probability results at 150 iterations [87].

#### Sustainability strategies

This phase carried out a SWOT-TOWS analysis to identify non-financial cooperatives' strengths, opportunities, weaknesses and threats in internationalisation. The SWOT matrix is the basis for generating strategic decisions, formulating policies and managerial decision-making [88]. Additionally, the participation of experts (e.g. academics and representatives of the sector's social and solidarity economy) through focus groups determined sustainability strategies for internationalising non-financial SSECs [89].

## Results

#### Exploratory factor analysis

EFA executed from the non-financial SSEC data set found a KMO of 0.81; the sample is adequate for the factor analysis, and the Bartlett sphericity test is significant ( $X^2 = 1797.13$ ) (see Table 4). Moreover, this indicates that the variables are strongly correlated and that the data set is suitable for analysis. The probability ( $p$ ) is less than 0.05, the data are correct, and normality is adequate to extract factors using maximum likelihood.

Figure 4 presents the appropriate number of factors through eigenvalue analysis. An unsuitable factor is considered when its eigenvalue is less than 1. According to the scree plot, this study finds that 1–8 factors represent the interrelationship between the variables. However, the

**Table 4** Bartlett and KMO test

	Statistic	Values
Bartlett	Approximate Chi-Square	1797.13
	Df	153
	$p$ value	0.000*
	KMO	0.81

Df degrees of difference

\* $p < 0.001$

four most significant factors are selected through factor retention and rotation.

To estimate the factor loadings, the 399 records corresponding to the characteristics of the non-financial SSECs were considered. Table 5 shows the four factors found by the EFA. These factors explain the significant relationship between the internationalisation variables of non-financial SSECs. The most correlated variables with estimated factor loads more significant than 0.3 are the Number of female members (V1), Number of male members (V2), Initial social capital (V3), Current social capital (V4), Social benefit (V7), Benefit economic (V8), Technology/website (V11), Geographical reach (V15), Access to international markets (V17) and Employment (V18). Therefore, this is the level considered for the significant impact of the factors on the variables.

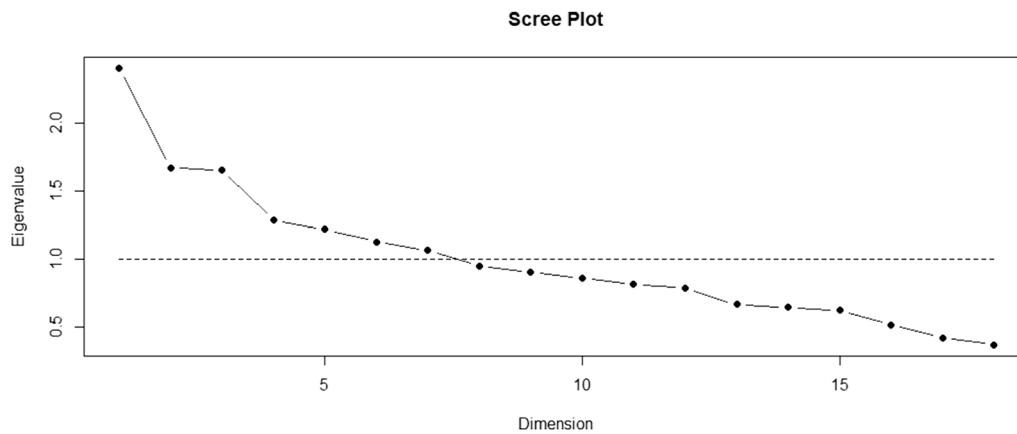
#### Internationalisation models

Table 6 presents the internationalisation estimation models of the non-financial SSECs, which consider the significance of the internationalisation variables. In this study, gene operations establish two models of internationalisation based on the analysis of the 339 non-financial SSECs in this sector.

The GA found two models with internationalisation characteristics. The first model considers the social capital of non-financial SSECs crucial, which varies depending on the number of male and female members. In addition, the social and economic benefits these cooperatives achieve, including job creation, increase the chances of internationalisation. Technology and digital media are indicators that contribute to various international processes. The second model contrasts with the first since it considers the geographic reach of these cooperatives and their impact on access to international markets. This last variable contributes to the structural competitiveness of these cooperatives, supporting their participation in international markets.

#### Internationalisation models dynamics

The dynamics of the internationalisation models explain the success weights of the best-selected chromosomes (non-financial SSECs) and their behaviour according



**Fig. 4** Eigenvalues and number of factors

**Table 5** EFA factor loadings

Internationalisation variables/factors	Factor 1	Factor 2	Factor 3	Factor 4
V1: number of female members			0.96	0.34
V2: Number of male members		-0.11	0.97	0.33
V3: Initial social capital	0.78			
V4: Current social capital	0.99	0.33	0.79	
V5: Organisation group				
V6: Organisation class				
V7: Social benefit	0.88	-0.32	0.34	0.44
V8: Benefit economic (i.e. profits)		0.83	0.19	
V9: Trade certification		0.38		0.43
V10: Product quality certification		0.41		
V11: Technology/website		0.30	0.37	0.81
V12: Gender equality			0.32	
V13: Environmental permit		-0.30		
V14: Environmental responsibility		0.32		0.36
V15: Geographical reach	0.48	0.46	0.78	0.83
V16: Marketing formation		0.43		
V17: Access to international markets		0.35	0.82	
V18: Employment		0.78	0.31	0.37
SS loadings	2.58	2.63	4.2	2.21
$\chi^2$	142.86			
<i>p</i> value	0.000*			

SS sum of the squares of the factor loadings

\**p* < 0.001

**Table 6** Internationalisation models of non-financial SSECs

No	Internationalisation models	Significant variables
1	$\sum_{i=1}^{399} \left( \prod_{i=1}^{399} (V1_i + V2_i)(V4_i) \right) + V7_i + V8_i + V11_i + V18_i$	V1, V2, V4, V7, V8, V11, V18
2	$\sum_{i=1}^{399} \left( \prod_{i=1}^{399} (V1_i + V2_i)(V4_i) \right) + V8_i + V11_i + V15_i + V17_i + V18_i$	V1, V2, V4, V8, V11, V15, V17, V18

*i* = 1–399 non-financial SSECs



to genes and weight. Table S2 presents the weights of the first selected cooperatives corresponding to the first internationalisation model. These weights indicate that 92% of the 25 cooperatives are in the first quartile due to the behaviour of their genes (internationalisation characteristics). In addition, they highlight a more significant number of male members than female members. These cooperatives have a social capital that comprises an approximate range of 14,000–56,000 US dollars. 80% of non-financial SSECs receive economic benefits; the most predominant social benefits are social security (52%) and health (28%). In addition, the model establishes that 64% of these cooperatives with the best ranking promote employment opportunities (from 60 to 120 jobs) and 88% use technology for national and international projection.

On the other hand, Table S3 shows that the second internationalisation model maintains some characteristics of the first model, such as the relationship between the number of female and male members. The social capital of these cooperatives ranges from 11,000 to 34,500 US dollars (84%). In addition, 76% of the best cooperatives have economic benefits. This model highlights the relationship and importance between geographic reach, technology and access to international markets; i.e. 84% of cooperatives belong to the rural sector, use technology for communication and visibility and have access to international markets. Also, 40% of these cooperatives promote employment according to their economic activities (e.g. agriculture, commerce, fishing and housing).

Figure 5 shows the behaviour of the internationalisation models according to their weights, which reflects a growing trend concerning the variability of the population. In the first 50 iterations, the models present a similar behaviour. The first model starts with high weights and ends with relatively low weights compared to the second model (Fig. 5a). Subsequently, after 100 iterations,

the dynamics change, making the first model more significant (Fig. 5b). Finally, the correlation between the internationalisation characteristics establishes that the first model maintains a growing trend greater than the second internationalisation model (Fig. 5c).

**Validation of internationalisation models**

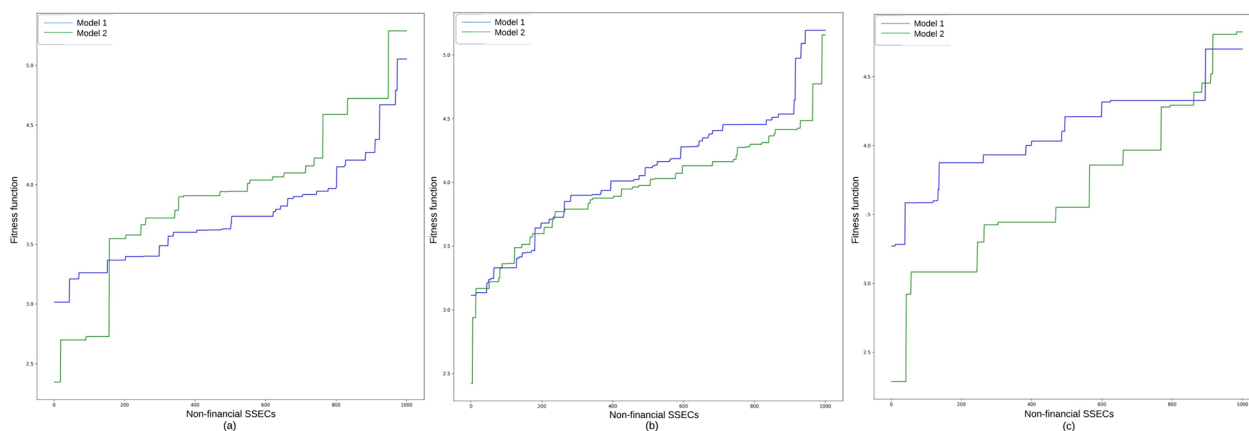
The validation of the internationalisation models considered the estimates of success generated by the GA through weightings of the variables that explain the internationalisation of the non-financial SSECs at 150 iterations. The correlation coefficient indicates the relationship that exists between the genes. The validation of the two models takes as a reference a level of statistical confidence of 95%. The statistical values of the internationalisation models present a standard deviation of 0.5 (model 1) and 0.3 (model 2). With confidence intervals of 0.04 and 0.03, respectively. Hence, it generated a goodness of fit of 89.1% for model 1 and 84.2% for model 2.

This validation finds that the two models estimate the internationalisation of non-financial SSECs with highly acceptable goodness of fit. However, the first model achieves more significance due to the interrelation between the number of female/male members, social capital, social/economic benefits, technology and employment.

**SWOT-TOWS analysis and strategies**

Regarding the analysis of non-financial SSECs in the context of internationalisation, Tables 7 and 8 show the SWOT and TOWS matrices, respectively, identifying significant factors of the social and solidarity economy.

Based on the strengths, weaknesses, opportunities and threats of non-financial cooperatives in the context



**Fig. 5** Dynamics of the behaviour of internationalisation models of non-financial SSECs. **a** 50 iterations. **b** 100 iterations. **c** 150 iterations

**Table 7** SWOT matrix of non-financial cooperatives in the context of internationalisation

Strengths	Opportunities
f1. New sources of formal employment for the country	O1. Regulations of the popular and solidarity economic model
f2. Distribution and production of products such as bananas, cocoa, flowers and shrimp	O2. External promotion of goods and services
f3. A large number of artisans in the country	O3. Innovation in the industrial sector
	O4. Cooperation agreements between the state and non-financial cooperatives
f4. Increase in manufacturing by tourism, fishing and agriculture	O5. Export of products
	O6. Human capitalism
f5. A greater percentage of urban geographic extension of the country	O7. Internet for internationalisation processes
f6. Legal mining cooperatives	O8. Linking and research projects with academia and local governments
	O9. Metaverse positioning (virtual contracts)
Weaknesses	Threats
W1. Labour exploitation	t1. Centralisation of wealth
W2. Informal associations or unions	t2. Transformation of cooperatives to corporations
W3. Labour demand in the rural sector	
W4. Lack of infrastructure for non-financial cooperatives	t3. Risk country
W5. Lack of training and specialised advice	t4. Citizen insecurity for new enterprises
W6. Discrimination of older adults and women in the organisation of cooperatives	

**Table 8** TOWS strategy matrix

Strengths + Opportunities	Strengths + Threats
f1O4O9. Implementation of labour flexibility policies	f1t3. Action plans to protect the country's labour sector
f2O2O5. Participatory regulation of export processes of solidarity products and services	f6t2. Monitoring plan for non-financial cooperatives
f3O6O8. Macro solidarity agreements between the population, academy and local governments	
f6O1. Implementation of development plans to improve the mining sector in the popular and solidarity economy	
Weaknesses + Opportunities	Weaknesses + Threats
W4O3O4. Improvement of infrastructures through coordination of the public and private sectors	W1W3t3. Regulation of jobs generated by non-financial cooperatives
W5O2O5. Internal/external trade training plan for popular/solidarity goods and services	W5t3. Develop advisory plans that promote the diversification of the country's productive matrix

of internationalisation and the relationship with the SDGs, Table 9 presents the strategies to mitigate the weaknesses of non-financial cooperatives in the internationalisation process.

**Discussion**

The models that estimate the internationalisation of non-financial SSECs used a genetic algorithm considering some internationalisation indicators from the scientific literature. This GA estimates the internationalisation success of non-financial SSECs through the optimisation and correlation of their genes, such as human capital (e.g. number of female/male members), social capital/benefit, economic benefit, technology/

website, access to international markets and job creation. Similarly, other studies use indicators that promote the internationalisation of SSE cooperatives. For example, the study by Castilla-Polo and Sánchez-Hernández [29] highlights that Spanish agricultural cooperatives opted to reinforce social capital and responsible innovation in the internationalisation process, managing to improve their reputation and performance. The study by Bernal-Jurado et al. [46] also establishes that Spanish wine cooperatives relate the technology/website with internationalisation processes such as export activity and website quality. In addition, Gonçalves and Rotta [90] revealed that Brazilian coffee cooperatives promote access to foreign markets and

**Table 9** Main strategic lines

SDGs	Strategies
	Promote the participation of the population in the production system
	Implement access to international markets
	Expansion of food production and distribution
	Implementation of contingency plans for a global health emergency
	Promote short and long-term enterprises
	Propose agricultural development plans
	Implement training for unions or associations
	Implement health plans for health emergencies
	Monitoring and supervision of resources for the health sector
	Ability to access specialised health services
	Improve production systems through sustainable agriculture
	Promote the development of special technical capacities in the productive sector
	Promote economic inclusion for marginalised groups such as children, older people and women
	Cooperation of universities with local governments
	Improve external relations
	Establish interconnection with human groups
	Participation of the human element and empowerment
	Promotion of transfer of knowledge and technology
	Promotion of equity
	Manage sources of financing for sustainable local development
	Expand the application of social projects
	Establish solidarity networks
	Strengthen cultural mindset
	Promote social inclusion with sources of work for the informal sector
	Promote cooperation and harmony between people
	Determine basic common good principles, with protection for all local social and economic systems

technological innovation to enhance their performance and internationalisation. Additionally, the country of the case study has not shown findings of internationalisation models of non-financial SSECs. However, this study highlights an internationalisation model with

significant variables that can be adapted to emerging countries with similar political, economic and social characteristics.

The GA of this study uses genetic operations, such as selection, mutation and crossing, to guarantee the best aptitude

of the indicators that explain the internationalisation of non-financial SSECs. The probabilities of genetic operations determined two successful models of internationalisation with possibilities for future solutions. The optimisation of the GA genes reached goodness of fit in the upper quartile of reliability for the internationalisation models (89.1% for the first model and 84.2% for the second model). This study presents a new proposal based on evolutionary computation but has yet to find similar research for its respective comparison. However, many optimisation applications use GAs to achieve precision in results from various sciences, for example: (1) assessment of groundwater potential (approximate precision between 76.8 and 85.6%) [91]; (2) cloud resource management optimisation (precision 44.1–58.1%) [92]; optimisation of bank loan decisions for credit restriction (36–50% reduction in loan selection time) [93]; and (3) optimisation of thermal performance in school buildings (80% accuracy) [94].

Some studies use different methodologies to explain the internationalisation of cooperatives. For example, the study by Ribas et al. [95] used bibliometric methodology to understand cooperative management practices in economic and social development. This study highlights human capital and social responsibility as strategic actions for the success of cooperatives. In addition, another study used an exploratory analysis of the internationalisation of several cooperatives worldwide, considering the size, turnover, geographical reach and employment generation as crucial aspects in the development of global activities in essential sectors such as agriculture, commerce and industry [26]. Different from the study by Flecha and Ngai [96], who used a communicative methodology to describe the social reality of the industrial cooperatives of Mondragón. These cooperatives followed strategies of capitalist companies, such as the establishment of mixed cooperatives, to establish their global expansion. However, they reveal that cooperative culture, worker participation, social capital and management are characteristics of cooperative globalisation. On the contrary, the study by Meliá-Martí et al. [54] applied a survey to 2489 Spanish agrifood cooperatives and regression analysis to demonstrate the incidence of gender diversity in these cooperatives. The results of this study show a positive relationship between cooperative implementation of gender diversity/gender equality management systems and highlight the significant effect of the export intensity of these cooperatives.

The internationalisation of SSE cooperatives analyses the viability of these social groups based on their strengths and the possible weaknesses that they can infer within the framework of globalisation. In addition, it evaluates the contribution to the development of local communities and their potential to participate in international markets [97]. Also, the internationalisation

process considers the economic and social characteristics of the cooperatives. The main limitation considered by the focus of this study is the non-existence of local non-financial SSECs (Ecuador) in internationalisation processes to carry out a comparative analysis with the predictions obtained in this research.

## Conclusions

The AFE and GA, developed in open source by RStudio and Python, respectively, estimate two internationalisation models for non-financial SSECs that highlight the optimal indicators of globalisation such as social capital (number of female/male members), social benefit, technology, employment generation, geographical reach and access to international markets. These significant variables present opportunities to improve the structural competitiveness of these cooperatives and promote their internationalisation.

The GA considered the characteristics of 399 non-financial SSECs with predominant production systems, such as agriculture, fishing, tourism, and housing, to determine internationalisation success with acceptable goodness of fit (89.1% model 1 and 84.2% model 2). The optimal characteristics can be replicated in future research under the context of internationalising social capital cooperatives in each country.

The best estimation model of this study (i.e. model 1) highlights the social benefit of non-financial SSECs related to social security and health (80%). In addition, they relate the success of these cooperatives to job creation (64%) and the use of technology (88%). These determinants are indicators of internationalisation with a high correlational charge that contributes to emerging countries' economic and social development. Therefore, future research on internationalisation variables is recommended through artificial intelligence techniques, such as artificial neural networks that optimise the international perspective of social capital cooperatives.

## Abbreviations

CSV	Comma-separated values
EFA	Exploratory factor análisis
GA	Genetic algorithm
KMO	Kaiser–Meyer–Olkin
SSE	Social and solidarity economy
SDGs	Sustainable development goals
SSECs	Social and solidarity economy cooperatives

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s43093-024-00339-z>.

Supplementary file 1  
Supplementary file 2  
Supplementary file 3

### Acknowledgements

Acknowledgement to the research project "Improvement of the production processes of goods and services of production cooperatives to increase the levels of competitiveness and sustainability of Zone 5" with code No. PFOC9-39-2023.

### Author contributions

MM, the first author, wrote the original draft, collected, validated and analysed the data and designed the methodology and revisions. RP, the second author, contributed to the conceptualisation, supervision, writing the original draft, data analysis, editing and revision. CE, the third author, contributed to the supervision, editing and revision. All authors read and approved the final manuscript.

### Funding

Not applicable.

### Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

### Declarations

#### Ethics approval and consent to participate

Not applicable.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare that they have no competing interests.

Received: 8 September 2023 Accepted: 12 May 2024

Published online: 23 May 2024

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