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Structural equations modelling applied to the study of Communities Supported Agriculture (CSAs) located in the Southeastern region of Brazil

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Abstract
Food production is an increasingly relevant issue in the current framework associated with food and water security and future years projections. In addition, the production of organic food has gained significance in recent years, revealing a growing change in the population's consumption habits. The Communities Supported Agriculture (CSAs) play an important role in enabling productive areas for planting crops in agroecological and biodynamic standards. Given this, this study aimed to investigate the relationship between different CSAs variables located in the Southeastern region of Brazil to validate or not the hypotheses created. Thus, the study was designed as a descriptive research and quantitative approach, using an inductive logic survey. In addition, the methodology was set up with the support of the Structural Equation Modeling technique. The study confirmed the hypothesis (H1) that socioeconomic characteristics positively influence CSAs' performance. The limitations were associated with the method of data collection and the difficulties imposed by the Covid-19 pandemic.

Keywords: structural equation modeling; communities supported agriculture; agroecology.

Modelación de ecuaciones estructurales aplicada al estudio de Agricultura Apoyada por Comunidades (AAC) ubicadas en la región Sudeste de Brasil

Resumen
La producción de alimentos es un tema cada vez más relevante en el marco actual asociado a la seguridad alimentaria e hídrica y las proyecciones para años futuros. Además, la producción de alimentos orgánicos ha ganado importancia en los últimos años, revelando un cambio creciente en los hábitos de consumo de la población. La Agricultura Apoyada por las Comunidades (AAC), por sus siglas en inglés) juega un papel importante al habilitar áreas productivas para la siembra de cultivos con estándares agroecológicos y biodinámicos. Teniendo esto en cuenta, este estudio tuvo como objetivo investigar la relación entre diferentes variables de AAC ubicadas en la región Sudeste de Brasil para validar o no las hipótesis planteadas. Así, el estudio fue diseñado como una investigación descriptiva y con enfoque cuantitativo, utilizando una encuesta de lógica inductiva. Además, la metodología se configuró con el apoyo de la técnica de Modelado de Ecuaciones Estructurales. El estudio confirmó la hipótesis (H1) de que las características socioeconómicas influyen positivamente en el desempeño de las AAC. Las limitaciones estuvieron asociadas al método de recolección de datos y a las dificultades impuestas por la pandemia de Covid-19.

Palabras clave: modelos de ecuaciones estructurales; agricultura apoyada por las comunidades; agroecología.

1 Introduction

The production of healthy food has been one of the issues of concern for the population in the recent framework [1-3]. In this connection, agriculture has advanced in promoting cultivation techniques that have less impact on the environment and that provide higher-quality food [4,5]. Thus, the eating habits of many people could undergo positive changes, adding greater health and well-being to their lives, as well as reducing costs of eating outside the home [3,5].

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On the other hand, sustainable initiatives have sought transformations in agriculture, incorporating new trends in food production, based on agroecological, organic and/or biodynamic systems [6]. Consequently, Communities Supported Agriculture (CSAs) emerged as a new concept that aims to change people's relationship with food [7,5]. CSAs are partnerships established between farmers and a group of local consumers or co-producers [8,5]. In this relationship, responsibilities and risks of food production are shared, as only foods that are viable in that specific period are produced [9]. In addition, farmers' production and work are fully financed by periodic quotas charged to co-producers [4]. Another peculiarity of the CSA movement is the blind delivery of food, that is, the consumer does not choose the items that make up his food basket [10,5].

However, the green revolution and sustainable production patterns have been threatened by practices of irrational exploitation of crops to strengthen the bases of large-scale agricultural production [11]. According to the author [12], the Southeast region showed a growth of 8.4% in grain production comparing the years 2019 and 2020, reaching the level of more than 25 million tons produced by year. In addition, family farming has been jeopardized due to the low farmer's reward and high production costs, as well as the lack of labor to carry out the applicable activities [13].

Therefore, considering the relevance of the movement presented (CSA) and its continuous growth, there is a gap in the aggregation of its value based on the understanding of the variables that compose it and the relationship between them [14,5]. In this connection, the application of the Structural Equation Modeling (SEM) technique represents a way to interpret hypotheses built from the relationship of demographic, socioeconomic, agricultural, ecological origin variables, among others [15]. According to authors [16] and [15], Structural Equation Modeling can be based on regression, factor analysis, clustering or even multidimensional scaling methods, which can be confirmatory or just exploratory.

In this connection, this study aimed to investigate the relationship between different variables in the CSAs located in the Southeastern region of Brazil to validate or not the hypotheses developed. In addition, the study addresses the following research question: What are the relationships between variables of socioeconomic, agricultural and female participation dimensions in the performance of CSAs? Thus, we seek to contribute to the agroecological area, promoting a more technical environment based on knowledge and best production practices. To this end, the study was divided into an introductory section, followed by a contextual section on organic agriculture and CSAs, a section on the importance of food security, a hypothesis and research method section, followed by the methodology, results, discussion and, finally, the conclusion section, acknowledgments and bibliographic references.

2 Organic agriculture and Communities Supported Agriculture (CSA)

Organic agriculture, as well as other agroecological production patterns, represents an opportunity to reconstitute the population's healthy eating habits [6,5]. In addition, the sustainable appeal constitutes one of the bases for the evolution of land exploitation modes, to produce food with the least potential environmental impact [9]. In this framework, the philosophy of Communities Supported Agriculture is in line with the principles of low-impact organic agriculture and establishes an important commitment to valuing of farmers' work [17,5].

In this connection, valuing the farmers' work is a decisive aspect of the maintenance of CSAs [8]. Farmers allow the production of natural foods, without using agrichemicals and harvesting manually to reduce losses [14]. In this framework, food security emerges as one of the concerns of communities and organic farmers, who aim to serve with agricultural products a growing number of co-producers or members of CSAs and to minimize food losses and waste [18]. It is estimated that Brazil is the tenth country that wastes food in a total of 54 countries as reported by the United Nations Food and Agriculture Organization [18]. In addition, if waste were avoided, the country would be able to reduce its rate of people going hungry by up to 30% [18].

Food production has recently increased worldwide due to an expanding demand [18]. However, most of the food produced comes from mechanized processes and with the use of agrichemicals, as a large-scale production strategy [13]. The production of organic food has grown more slowly, which reveals a development gap in this area [19]. Hence, it is important that a support from local leaders who mobilize the population to participate in CSAs, as well as other initiatives of a sustainable nature, be implemented. In addition, the transformation of people's eating habits should be continued [20].

Currently, the implementation of technology combined with large-scale agriculture has harmed the continuity of family farming [13]. It is worth remembering some factors such as rural exodus - partly due to cultivation mechanization - as being the main factor responsible for reduced availability of labor in the farms [13]. Hence, the difficulties in maintaining agricultural properties that use family farming techniques increase [7]. On the other hand, in recent years, interest in the consumption of healthy foods has grown, whether motivated by changes in life habits or by concern about emerging environmental problems [3,5].

3 The importance of food security

Food security occurs when all individuals have physical, social, and economic access to safe, nutritious and quality food [21,22]. According to author [18], about 2 billion people were food insecure in the world, in 2019. Furthermore, food security is a current and comprehensive issue that involves other issues, such as social inequality [22,23]. In this way, the classification of food security levels represents an initial way to solve this impasse and occurs according to some fundamentals, namely, availability, stability, access, and consumption.

Availability refers to food production and even imports that are carried out, to meet local demands [18,23]. In addition, issues such as storage and food aid are included in this foundation, as a way of guaranteeing a satisfactory amount of food for everyone. At the same time, there is a strong concern about the eradication of hunger in the world, a fact that represents one of the UN's sustainable

development goals. According to data from authors [18], in 2019 almost 690 million people were hungry in the world, however, it is worth mentioning that more than a third of the amount of food produced on a global scale is wasted. In this way, there is a disagreement between the production and consumption of food in the world, which intensifies other issues, such as child malnutrition and growth delays.

Stability refers to the ability to anticipate moments of crisis, so food storage is of great importance to guarantee availability, in times of crisis [18]. In this context, both environmental and economic crises make it difficult to produce and access healthy foods [22,23]. This occurs because the cost of production is increased, either by the losses caused by bad weather or by the increase in the value of inputs, or even by scenarios of dollar appreciation [21].

Access is related to physical or socioeconomic issues. In this sense, there may be problems in production that impact the amount of food produced, making access difficult [18]. In addition, the lack of financial resources to purchase food is an impasse for the issue of access. It is worth mentioning recently the isolation caused by the pandemic of the new Coronavirus, which made it difficult to access and distribute food in different regions of the globe [18,24].

Consumption is the intake of food according to the particularities of everyone, considering their preferences and needs [18]. In this way, it is not only a matter of a balanced distribution of food from a quantitative point of view but also of a nutritional nature that addresses the needs of each citizen, in a personalized way [18]. However, given food scarcity in many regions where food insecurity reaches extreme levels, preference is not a main aspect, as food shortages are a greater concern [22].

4 Hypotheses and research method

4.1 Hypotheses

The generation of hypotheses in this study allows a clearer interpretation of the relationships between dependent and independent variable [25]. In addition, if these are confirmed or rejected, the study begins to contribute to decision-making associated with the context of the insertion of such variables [26]. It is worth mentioning the contributions in the construction of social and practical implications in the analysis, to generate knowledge to be used in the foundation of future studies [26,25].

Thus, the first hypothesis presented in this study was associated with the socioeconomic context in which the CSAs are inserted. According to authors [27] and [28], the socioeconomic context of CSAs includes some variables, among them, the time of existence of the CSA (TE), the annual income per farmers' family (AI), the average salary of farmers (ASF), the total available area for cultivation (AC), distance from the farms to the distribution center (DDC), number of members occupying positions in the governance structure (MGS) and number of occupational accidents (OA). Furthermore, according to authors [31], high performance of CSAs can be associated with low rates of work accidents, a long time of existence of the CSA, and a greater number of co-producers who are members of the governance structure. In this connection, the following hypothesis is proposed:

H1 = Socioeconomic characteristics (reflected by low occupational accidents and a high number of members in the governance structure) positively influence the performance of CSAs.

The second hypothesis of this study was linked to the agricultural dimension, which includes some variables, namely, farmers' experience time (FET), total number of products produced (ProdP), quantity of food wasted in the marketing process (Qty_FW), annual revenue for investments in technology (AR_tec), number of training courses undertaken by farmers (Tr_courses), amount paid by co-producers for food baskets (AP_basket)[29,30]. According to authors [30], high values for the variables 'farmers' experience time' and 'annual revenue for investments in technology' suggest a high performance of CSAs. In addition, farmers' training contemplates a new scenario for organic agriculture, as specialized labor raises the standard of production based on innovative techniques and, consequently, the productivity and performance of CSAs [31,30]. In this connection, the following hypothesis is proposed:

H2 = The number of training undertaken by co-producers positively influences the performance of CSAs.

Finally, the third and final hypothesis of this study was associated with the context of female participation in CSAs. According to authors [32] and [31], this dimension addresses some variables such as the number of female co-producers/members in the CSAs (Cop_fem), the level of education of women participating in the CSAs (Educ_fem) and the number of women managing the CSAs (Wom_manag). In addition, gender equality is a relevant topic to be addressed in the field of CSAs, given the importance that women have shown in sharing different skills, helping to reach new levels of performance for CSAs [31,32]. That said, the following hypothesis is proposed:

H3 = The number of female co-producers/members influences the performance of CSAs.

Given this, the proposed structural equation model was built with the help of SmartPLS 3 (Partial Least Squares) software, as shown in Fig. 1.

According to Fig. 1, the model presented contemplates a relationship of four constructs: Socioeconomic Characteristics, Farmer Training, Female Participation, and CSA performance. In addition, the Socioeconomic Characteristics construct is reflexive, that is, the socioeconomic characteristics of the CSAs are dictated by two predictor variables, in this case, the number of occupational accidents (OA) and the number of members occupying positions in the governance structure (MGS).

On the other hand, the other constructs are formative, demonstrating that the predictor variables form the basis for developing the constructs. The CSA performance construct establishes a relationship of dependence on the other constructs, which allows the generation of the previously listed hypotheses. Thus, the Farmer training construct is

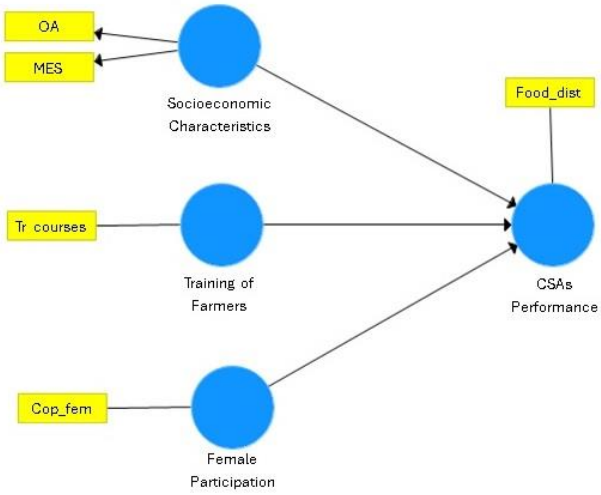

Figure 1. Proposed Structural Equation Model.
Source: Authors, 2023.

formed by the predictor variable number of training carried out by farmers (Tr_courses); the Female Participation construct is composed by the predictor variable number of female co-producers in CSAs (Cop_fem), and the CSA Performance construct is composed of the predictor variable amount of food distributed by CSAs (Food_dist).

4.2 Structural Equation Modeling (SEM)

The use of statistical analysis has been a recurring practice in scientific studies for the verification and interpretation of results [16]. In addition, the improvement of multivariate analysis techniques is an advance in the understanding of more complex situations, promoting the interrelationship between the variables and in some cases the causality effect between them [15]. In this connection, Structural Equation Modeling represents a general multivariate statistical technique that enables theoretical construction from latent constructs [35]. That is, the relationship between theoretical constructions is represented by trajectory or regression coefficients between observed or latent variables [33,16].

Structural Equation Modeling combines regression and factor analysis techniques [34]. In addition, it is a technique that allows the performance of simultaneous estimations and measurements, as well as the identification of direct and indirect effects between explanatory and response variables [15]. The use of trajectory diagrams is worth mentioning for the representativeness of structural equation models, where it is possible to graphically indicate the relationships between observed and measured variables [16].

Thus, on the one hand, regression analysis is a deterministic analysis technique, where the relationships between a dependent variable and one or more independent variables are estimated [36,16]. Factor analysis, on the other hand, contemplates the use of a covariance matrix to estimate the structural factor [35]. In addition, the covariance matrix aims to reduce the types of variables in the model [16]. Thus, factor analysis indicates that covariances between a set of observed variables can be justified by a reduced set of latent constructs [33,16].

5 Methodology

The scientific research methodology is a field that aims to evaluate the most suitable methods for each type of scientific research. In this connection, this study was descriptive research, as it was based on the description of information collected in a set of CSAs assessed. In addition, the study displayed a quantitative approach, supported by a survey, as data on scalar variables were collected from the characteristics and opinions of individuals from the CSAs. Finally, the study presented an inductive logic, as it started with punctual information for the generalization of knowledge within the analysis universe. This study can be replicated in other contexts of analysis.

The study followed the structure shown in Fig. 2 regarding the research stages. Thus, a literature review was carried out a priori on the topic of analysis, to assist in the construction of the theoretical framework and the understanding of the context and the relationships considered between variables and constructs addressed. Then, the theoretical conceptual model and the hypotheses to be tested were built. Subsequently, a structured questionnaire was developed for use in the research; it was composed of 36 questions, each one targeting an analysis variable. In other words, this study was based on obtaining primary data using questionnaires. In addition, these variables represent demographic, socioeconomic, agricultural, ecological, natural resources, food security, female participation, certification, and circular economy performance indicators. These are quantitative indicators.

Thus, a total of 25 questionnaires were distributed to CSAs in different municipalities in the Southeast region of Brazil corresponding to the universe of analysis, and 16 were answered correctly. In the next step, data from the 16 CSAs were tabulated using Microsoft Excel 2019, where it was possible to apply the Principal Component Analysis (PCA) technique using the statistical software R-Project 3.2.2. It is worth mentioning that the reduced number of analyses/questionnaires is that the development of CSAs is still in an embryonic phase in the Southeast region compared to other regions of Brazil, such as the Federal District, where there is a greater number of supporters. In general, the data collection stage took place during the period when the COVID-19 pandemic was in a critical period with a low rate of vaccinated people, which made the contact with some CSAs difficult.

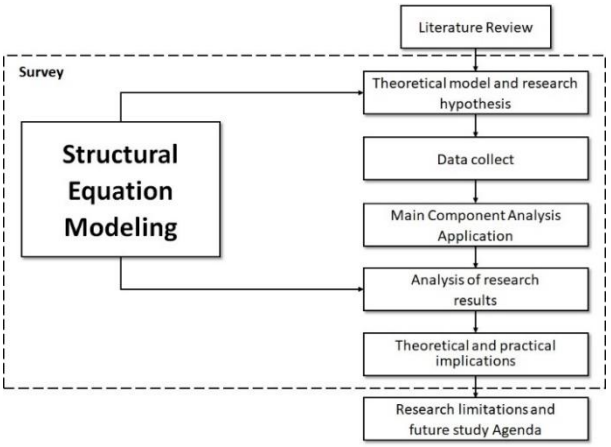

Figure 2. Research steps.
Source: Authors, 2023.

Considering the application of mathematical and statistical techniques, the analysis of the principal components can be stated according to the adapted formulation by authors [37] and [38] in Eq 1. In this case, Yi corresponds to the principal component, the number of variables being less than or equal to the number of principal components [40,41], that is, Yi= 1, 2, ..., p; e refers to the eigenvectors (e = 1, 2, ... p) and X to the original variables (X = 1, 2, ... p).

$$Y_i = e_{i1}X_1 + e_{i2}X_2 + \cdots + e_{ip}X_p \quad (1)$$

In this framework, the PCA was initially applied to the 36 original predictor variables, obtaining a variance of only 54%. The variables considered were: Male_gen (Quantities of men), Female_gen (Quantities of women), AGF (Age group of farmers), Coprod (Number of members/co-producers participating in the CSA), MPF (Number of members of the producer's family), TE (Time of existence of the CSA, in years), AI (Annual income per family, in reais), FAS (Farmer's average salary, in reais), AC (Total area of land available for cultivation, in hectares), DDC (Distance from the property to the distribution center, in km), MGS (Number of members occupying positions in the governance structure), OA (Number of occupational accidents), FET (Farmers' experience time, in years), ProdP (Total number of products produced for CSA, in units), Qtv_FW (Amount of food wasted in the marketing process (transport, handling, sale) in percentage (%)), AR_tec (Percentage of annual revenue spent on technology investment), Tr_courses (Number of training courses carried out, per year, in units), Land_size (Land size), Baskets (Number of food baskets), AP_basket (Monthly amount paid by members to purchase the food baskets, in reais), Ac_prod (Average production cost, in reais), Prod_capacity (CSA production capacity, in kg/hectare/month), F_consump (Fuel consumption (gasoline, diesel), per month, in liters), Pack_cons (Number of packages consumed, in units, month), Vol_Water (Volume of water consumed per month), Distr_P (Number of CSA distribution points, in units), Serv_radius (CSA service radius, in km), Food_dist (Average of food distributed per month (kg or units)), Food_prod (Average food produced per month (kg or units)), Dissem_channels (Number of dissemination channels (Sites, Instagram, Facebook...) used, in units), Part (Number of CSA key partners, in units), Cop_fem (Number of female CSA members/co-producers, in units), Educ_fem (Level of education of women, in years), Wom_manag (Number of women in CSA management, in units), Certif (Number of certifications of CSA producers, in units), RE_Expensas (Amount of financial investments made in renewable energy, in reais).

Therefore, only highly correlated variables in the first 3 principal components, with correlation equal to or greater than 70%, were selected, resulting in a set of 18 variables. Thus, PCA was applied again, obtaining a variance of 81%. The variables with correlation greater than 70% were selected, resulting in 11 variables. PCA was applied to the 11 variables, obtaining a correlation of 76%. From there, the variables were divided into two groups, 6 inputs and 5 outputs. Thus, the correlation between the two groups was obtained separately, and variables with a correlation greater than 60% were excluded, resulting in 7 variables, 4 inputs, and 3 outputs. Subsequently, the correlation between the remaining variables was calculated and those variables with a correlation below 1 were excluded, resulting in 5 variables, 3 inputs, and 2 outputs, with a variance of 94%. The selected variables were OA, MGS, Tr_courses, Cop_fem, and Food_dist.

In this sense, the result analysis step was performed using the Structural Equation Modeling (SEM) technique based on the 5 selected predictor variables. Data quality was addressed based on the elimination of variables with null or missing data. Thus, after verifying the quality of the data, an analysis of the proposed structural model was performed about its convergent and discriminant validity through Confirmatory Factor Analysis (CFA), as an accommodation strategy for the use of the model and its validation. Discriminant validity can be evaluated according to the value presented in the HTMT criterion (Heterotrace-Monotrace), where a value above 0.90 indicates that discriminant validity is not present. Table 1 corresponds to the observed values of the HTMT analysis for the approached constructs, in which all presented values are lower than 0.90, indicating the discriminant validity of all of them.

In addition, the reliability of the indicators was verified according to the criterion of cross-loading, where values greater than 0.708 suggest that each construct explains more than 50% of the variance of the indicator [16]. Given this, Table 2 corresponds to all factor loadings of the proposed structural model used in this study, which presented all values greater than 0.708 in their respective constructs (in bold) and lower in the others, indicating the reliability of the indicators.

Table 1.
Discriminant validity analysis based on the HTMT criterion (Heterotrace-Monotrace).

Variables	Farmers Training	Socioeconomic Characteristics	CSAs' Performance	Female Participation
Farmers Training	-	-	-	-
Socioeconomic Characteristics	0.560	-	-	-
CSAs' Performance	0.083	0.675	-	-
Female Participation	0.386	0.160	0.039	-

Source: Authors, 2023.

Table 2.
Confirmatory Factor Analysis (CFA).

Variables	Farmers Experience	Socioeconomic Characteristics
OA	0.376	**0.893**
Food_dist	-0.083	0.569
Tr_courses	**1.000**	0.469
Cop_fem	0.386	-0.130
MGS	0.453	**0.866**
Variables	**CSAs Performance**	**Female Participation**
OA	0.526	-0.042
Food_dist	**1.000**	-0.039
Tr_courses	-0.083	0.386
Cop_fem	-0.039	**1.000**
MGS	0.473	-0.194

Source: Authors, 2023.

Table 3.
Cronbach's Alpha, Average Extracted Variance (AVE), Composite Reliability (CR) and Correlations.

	Cronbach's Alpha	CR
Farmers Experience	1.000	1.000
Socioeconomic Characteristics	0.708	0.872
CSA performance	1.000	1.000
Female participation	1.000	1.000
	AVE	**Farmers Experience**
Farmers Experience	1.000	1.000
Socioeconomic Characteristics	0.773	0.469
CSA performance	1.000	-0.083
Female participation	1.000	0.386
	Socioeconomic Characteristics	**CSAs Performance**
Farmers Experience		
Socioeconomic Characteristics	1.000	
CSA performance	0.569	1.000
Female participation	-0.130	-0.039
	Female Participation	
Farmers Experience		
Socioeconomic Characteristics		
CSA performance		
Female participation	1.000	

Source: Authors, 2023.

Table 4.
Collinearity analysis.

Variables	VIF
AcT	1.429
Alim_dist	1.000
Ccap	1.000
Cop_fem	1.000
MEG	1.429

Source: Authors, 2023.

Discriminant validity was also verified by the Fornell-Larcker criterion, in which the square root of the Average Variance Extracted (AVE) must be greater than the correlations between the constructs of the model, as shown in Table 2. In the case of convergent validity, this was evaluated based on the values presented for the Average Variance Extracted (AVE) which must be greater than 0.50. Given this, the analysis suggested that the model of this study has convergent validity, according to Table 3.

Internal consistency was evaluated, according to the composite reliability criterion (Composite Reliability - CR), in which the values must exceed the minimum limit of 0.70. According to Table 4, the composite reliability scores for all constructs were greater than 0.70, indicating good internal consistency. In addition, a similar analysis can be performed, noting that Cronbach's Alpha values were greater than 0.70 in all constructs, also indicating good internal consistency. However, the composite reliability criterion offers a better estimate of the variance shared by its indicators, as well as an analysis from the perspective of factor loadings of the variables [34].

Finally, the analysis of the variance factor (VIF) was performed to verify the formative indicators. Given this, VIF values above 5 indicate critical collinearity problems, and it is recommended that this value be, if possible, lower and close to 3 [34]. According to Table 4, the VIF values presented for the variables were all lower than 3, indicating the existence of collinearity between indicators.

Thus, the study continued in its analysis with the discussion of results and presentation of theoretical and practical implications, limitations of the research, and proposal of an agenda for future studies.

6 Results

The present study was based on an analysis focused on CSAs located in the Southeast region of Brazil. A total of 16 CSAs were analyzed. In this sense, the sample revealed uniform values for the number of farmers of both sexes, in all analyzed CSAs. In addition, the farmers' age in the CSAs ranged between 26 and 60 years. According to the results obtained with the application of the questionnaire, the CSAs indicated proportionality relationships between the number of co-producers/members of the CSAs, the area available for planting, and the radius of service to the communities. In addition, an agreement was recorded between the number of food baskets distributed and the average annual income of farmers.

According to the answers obtained, the CSAs evaluated showed a direct relationship between the amount charged for food baskets to co-producers and the service range of the CSAs. Another variable that impacted the average value of the baskets, as shown in the research, was associated with electricity costs, which also revealed values directly proportional to the variety of food produced, the area available for planting and the demand of co-producers. About the rate of waste of food produced, the CSAs evaluated showed a reduced amount for the variable. Thus, the results indicated an average of 4% of waste generated among the evaluated CSAs. In addition, the greatest waste was associated with communities with a wide variety of food produced. In terms of partnerships established between communities and other institutions, a small number of partnerships were observed, including for dissemination channels. However, some CSAs with a greater number of key partners also presented high numbers for the disclosure channels used. In this sense, the study continued its analysis based on the 5 predictor variables selected from the Principal Component Analysis (PCA) technique. Thus, some relationships were verified, as shown in Fig. 3.

According to Fig. 3, to verify the predictive relationship between the constructs and the study hypotheses test, the structural model was reviewed. The results obtained with the PLS Algorithm indicated an explanation of the performance by the construct "Socioeconomic characteristics" in more than 90% of the variance. On the other hand, the constructs "Farmers' training" and "Female participation" presented explanation variances of -0.633 and 0.323, respectively. In general, the model presented a degree of explanation of 55.7%. This value is reduced, yet, this is justified by the number of constructs and variables addressed, which was also reduced. In addition, the full bootstrapping technique was used with 5.000 samples, with corrected and accelerated bias and a two-tailed test type with a significance level of 0.05, for the evaluation of the general adherence of the model. In this connection, Table 5 corresponds to the results obtained with this analysis. It is worth remembering that bootstrapping allows the evaluation of the relationships between constructs, as well as the validation or rejection of hypotheses.

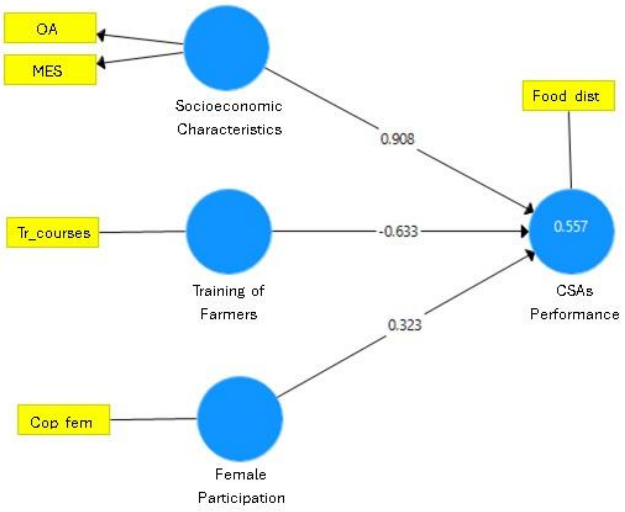

Figure 3. Result of the proposed Structural Equation Model.
Source: Authors, 2023.

Table 5.
Structural model analysis and hypothesis testing.

Hypothesis	T statistic	p-value	Signal found	Result
Socioeconomic Characteristics → CSAs Performance	2.033	0.042**	+	Accepted
Farmers' Experience → CSAs Performance	1.395	0.163	-	Rejected
Female Participation → CSAs Performance	0.755	0.45	+	Rejected

Note: ** Significant at 0.05.
Source: Authors, 2023.

According to Table 5, the model results accepted hypothesis 1, that socioeconomic characteristics (reflected by a low number of work accidents and a high number of members in the governance structure) positively influence the performance of CSAs. Concerning hypotheses 2 and 3, these were rejected with a significance level higher than 0.05 (p-value>0.05). In other words, there was a low influence of the number of farmers trained as well as the number of female co-producers on the performance of the evaluated CSAs.

7 Discussion

According to the study results, it can be inferred that in the Southeast region of Brazil, CSAs are still undergoing a process of adaptation and development, compared to other regions of the country, where the CSA movement is more advanced, such as, for example, in the Federal District. This fact is reinforced by the small volume of questionnaires distributed in this research, and out of a total of 25, only 16 CSAs presented complete answers to all questions. This indicates the lack of preparation and more elaborate planning on the part of CSA leaders, given the reduced time of existence of some communities. In addition, there are requirements to be met, so that communities can act within this movement, which are related to the production area, number of members, and governance structure, among others.

When it comes to the gender balance in the number of farmers for the analyzed sample, this is due to the existence of farmers' couples residing in rural properties, which in many cases end up building their families in the same place where the CSAs are installed. In this sense, this fact reveals the existence of different types of workers with different levels of experience. It is worth mentioning that in many cases the high age of farmers can mean a higher level of experience, which can positively reflect on good food production practices and internal management of CSAs [39].

Furthermore, based on the agreement between the number of co-producers and the area used for planting in the analyzed CSAs, this reveals that CSAs with a greater number of co-producers have greater demands for food production and, consequently, need larger areas for planting. In addition, the concept of CSAs superimposes sustainable production over conventional standards, without the purpose of making a profit from the activities, according to [31]. In this sense, there was agreement between the number of baskets distributed and the average annual income of farmers, which indicates the model's self-sufficiency in paying internal production costs, in agreement with the analysis by Ghosh et al. (2019) and authors [6].

In this context, food security becomes one of the concerns of the movement, more specifically directed to the pillar of availability, since production in sufficient quantity for consumption by co-producers and farmers must be met. However, a differential of the movement consists in the production of organic foods respecting the periods of cultivation. Thus, the baskets are assembled based on food grown in that specific period, and the respective co-producers will be able to choose only the amount of food inserted.

Regarding the relationship between the amount charged for the baskets and the service radius of the analyzed CSAs, the communities located in capital cities or in regions close to the CSAs reported higher fuel expenses and, consequently, a higher average value of the distributed baskets. Another variable that impacted the average value of the baskets, as shown in the research, was associated with electricity costs, which also revealed values directly proportional to the variety of food produced, the area available for planting, and the demand of co-producers, as authors [9] and [27] also point out.

When it comes to the rate of waste of food produced, the reduced values verified confirm one of the main characteristics associated with the contexts of food security and circular economy, which is the reduction of food waste [21]. Given that the food undergoes inspection processes by the farmers themselves to guarantee their quality, and the remains of food unfit for consumption are used in the manufacture of natural fertilizers administered in the planting of food.

To partnerships established between communities and other institutions, the small volume of partnerships, including for the dissemination of communities, reveals the existence of a development gap still to be filled by the Southeast region about improving the communication in these CSAs. Given this, this problem of prospecting members impacts the access

of new co-producers to the movement and, above all, their access to healthy and quality food. In this way, an indirect relationship is identified to one of the foundations of food security, in this case, people's access to food [39]. However, the reason for the lack of access may be related to the difficulty of prospecting, as well as financial issues, due to the high prices of baskets in some CSAs.

It is worth remembering the scenario experienced by CSAs during the pandemia caused by the new Coronavirus, in which, due to isolation protocols, there were difficulties on the part of community leaders in the financial and logistical administration of the flow of baskets [24]. In this case, the concept of stability, as the foundation of food security introduces the importance of planning for possible eventualities, such as economic and health crises, among others. However, what was observed was a lack of planning on the part of both the population and the analyzed CSAs, which generated consequences from the increase in the prices of baskets, caused by the increase in inputs and fuels, logistical problems due to the reduction of delivery points for compliance with health protocols, even reducing the number of co-producers, in some cases.

Thus, based on the results presented, it was verified an agreement with the literature in the field of CSAs by confirming the H1 hypothesis (p-value < 0.05) that socioeconomic characteristics (reflected by a low number of occupational accidents and a high number of members in the governance structure) positively influences the performance of CSAs. According to authors [28], greater integration between CSAs co-producers can be favored by the inclusion of new members in the communities' governance structure, so that they start to participate more actively in internal decision-making to promote greater performance and productivity. Furthermore, for the sample of this study, a direct relationship was found between the size of the CSAs and the number of co-producers included in the governance structure. The size of the CSAs can be verified based on the CSAs time of experience, the demand of co-producers, service range and available area for cultivation, for example [27].

Also, regarding hypothesis H1, according to authors [31], a reduced number of occupational accidents indicates a greater preparation of the CSAs regarding the effectiveness and execution of their processes. In addition, a direct relationship can be verified between the number of work accidents and the size of the CSAs, since a greater number of members/co-producers statistically suggests a greater probability of accident occurrence. In line with authors [31] and [27] conclusions, this study also identified a positive impact of the reduction of occupational accidents on CSAs performance.

In the case of hypothesis H2, there was a divergence between the literature and the result of the structural model reviewed. According to authors [29] and [30], the holding of courses and the participation of farmers in agroecological events can favor the process of implementing new technologies to expand both the food varieties and the volume produced by the CSA. In addition, the training of farmers is directly associated with the quality inspection systems implemented by the CSAs, helping to produce organic foods with high nutritional value [30]. However, the results presented rejected the H2 hypothesis. This indicates that, for the sample in question, few efforts were made in this direction for the training and qualification of farmers. Thus, a low influence of this construct on the performance of the CSAs assessed was verified.

Finally, based on the rejection of the third hypothesis, according to the author [32], female participation in CSAs has shown great relevance, given the presence of women in different sectors of activity in the communities. However, the study presented a divergent result, which may be associated with the low volume of co-producers in the CSAs reviewed, especially female co-producers, the low number of women occupying positions in the governance structure as well as their level of education, in many cases, they had completed only elementary and high school, without taking technical or higher education courses.

8. Conclusion

The present study achieved its purpose, establishing theoric relationships between constructs and variables addressed by the structural model developed. In addition, the study brought theoretical relations associated with the Structural Equation Modeling (SEM) method due to its multidisciplinary application, with adherence to different analysis contexts, including in the field of CSAs. In terms of social contributions, the study made it possible to share information on the organic agriculture model presented by the CSAs, helping to publicize such communities, besides promoting and encouraging new partnerships. Another social contribution was present in the understanding of the relationship between the production dynamics and pillars of CSAs and the fundamentals of food security. On the other hand, managerial contributions were associated with increased efficiency in the CSAs internal decision-making by the governance structure in place in each community.

It is worth mentioning that the study also had some limitations, among them the data collection method as well as the existence of missing data in the research, which were responsible for the exclusion of a few variables from the questionnaire, until the questionnaire was closed in 36 original predictor variables. In addition, another limitation was the difficulty in contacting CSAs during the COVID-19 pandemic, making face-to-face interviews impossible.

Finally, the study contemplated the proposition of an agenda for future studies. In this connection, a suggestion is to consider the 36 original predictor variables in the structural model to bring a broader and more robust approach to the relationships between variables and constructs. Another suggestion is to replicate the analysis to other regions of Brazil and carry out comparative studies between them.

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