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The impacts of environmental collaboration on the environmental performance of agri-food supply chains: a mediation-moderation analysis of external pressures

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ABSTRACT
Although researchers have investigated the relationship between inter-organisational collaboration and firm performance, there is scattered evidence on the relationship between environmental collaboration and environmental performance in agri-food supply chains. This study assesses the effects of environmental collaboration on five dimensions of environmental performance (greenhouse gas emissions management, energy management, food waste management, food safety management, and water footprint management) in agri-food supply chains, particularly when mediated and moderated by customer and regulatory pressures. This study used a survey of Chilean agri-food companies. The data were analyzed using partial least squares structural equation modelling. We found that environmental collaboration positively influences all five dimensions of environmental performance and that customer and regulatory pressures mediate this relationship. The dimension most affected by environmental collaboration was water footprint management. Finally, we provide recommendations for improving the environmental performance of companies in agri-food supply chains through collaboration.

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Agri-food supply chains; environmental collaboration; water footprint management; greenhouse gas emissions; food safety management; food waste management

1. Introduction

In today's global context, firms are expected to act sustainably with various stakeholders. A key challenge in the pursuit of sustainability is the extension of expectations to supply chain partners. To effectively extend sustainability concerns to suppliers, a firm should implement sustainable supply management (SSCM) (Sancha, Gimenez, and Sierra 2016), which has emerged as an approach to improve sustainable supply chain outcomes (Koberg and Longoni 2019).

Agri-food supply chains (AFSCs) differ from regular supply chains because of concerns about sustainability, food quality and safety improvement, and food waste (FW) reduction (Badraoui, Vorst, and Boulaksil 2020). In fact, there is currently increasing concern about the environmental effects of food production and consumption (Kamble, Gunasekaran, and Gawankar 2020), as well as growing external pressures to reduce the environmental consequences of agricultural production (Naik and Suresh 2018). Moreover, it is known that AFSCs have significant environmental impacts, highlighting the importance of collaboration among partners in improving supply chain sustainability (Krishnan et al. 2021).

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The positive effects of inter-organisational collaboration on supply chain performance have been observed in several previous studies (Asamoah et al. 2020; Malesios et al. 2020). However, environmental collaboration, which aims to jointly set environmental goals, share environmental planning, and work with business partners to reduce environmental impacts (Vachon and Klassen 2008), is yet to be explored (Barbosa et al. 2022). However, few studies have been conducted on this subject. Gölgeci et al. (2019) analyzed the effects of environmental collaboration using relational capability to improve environmental performance. Barbosa et al. (2022) found that an internationalisation orientation strengthens the effects of environmental collaboration on sustainable performance. Moreover, Kumar, Subramanian, and Ramkumar (2018) stated that only a limited number of studies have comprehensively discussed the link between sustainable performance and collaboration. These studies suggest that environmental collaboration may positively affect firms' environmental performance. Nonetheless, because environmental collaboration with third parties can be industry specific, focused research in the agricultural sector is necessary (Sharma et al. 2022).

According to Kleindorfer, Singhal, and Wassenhove (2005), environmental performance is defined as a firm's ability to fulfill environmental responsibilities. According to Kamble, Gunasekaran, and Gawankar (2020), the environmental performance of an AFSC is measured by the extent to which available natural resources are protected during the production, delivery, and consumption of agricultural products. Therefore, this concept involves critical performance indicators, such as the amount of greenhouse gas (GHG) emissions, water footprint (WF) management, energy savings, food safety, and amount of FW (Kamble, Gunasekaran, and Gawankar 2020). Previous studies have identified the potential impact of SSCM on some of the aforementioned environmental performance dimensions. However, there is limited evidence regarding the relationship between collaboration and several dimensions of environmental performance in the agricultural industry.

Customer and regulatory environmental requirements exert significant pressure on companies (Baah et al. 2021), which extend to supply chain partners who also need to act sustainably and comply with environmental norms (Seuring and Müller 2008). Pressure to implement environmental practices varies across countries and industries. In the agricultural sector, pressure may be higher because of the significant environmental impacts that the sector generates (Jazairy and Haartman 2019). Moreover, these pressures might also be higher when companies export their products to countries with more substantial pressures in favor of environmentally friendly practices (Amer 2023). Previous studies on collaboration and environmental performance have shown contradictory results (Davis-Sramek et al. 2022; Huang et al. 2016), and some gaps remain. Further investigation is required to determine whether customer and regulatory pressures mediate or moderate the relationship between environmental collaboration and performance in the agricultural sector.

To fill these research gaps, this study aims to assess the effects of environmental collaboration on the five dimensions of environmental performance (i.e. GHG emissions management, energy management, FW management, food safety management, and WF management) in AFSCs, especially when mediated and moderated by customer and regulatory pressures. To this end, this study adopted a quantitative methodology using a cross-sectional survey of Chilean agri-food companies. Data were analyzed using the partial least squares structural equation modelling (PLS-SEM) method.

This study is grounded in two complementary theories: the relational view (RV) and the natural resource-based view (NRBV). The RV suggests that firms' critical resources are embedded in interfirm interactions (Dyer and Singh 1998). Therefore, the relationships in which these firms are embedded may influence their performance. According to the RV, relation-specific assets, such as knowledge-sharing routines, complementary resources and capabilities, and effective governance, can be viewed as essential relational resources that firms should develop to compete successfully in different markets (Gölgeci et al. 2019). The relationship between environmental collaboration and environmental performance is explained by NRBV theory (Bae and Grant 2018). The NRBV highlights the potential for firms to generate unique sources of competitive advantage through engagement with nature (Graham 2018).

The findings of this research offer significant contributions to researchers, practitioners, and authorities and are summarised as follows. The first contribution is filling the gap in the extant literature on the relationship between environmental collaboration and environmental performance in AFSCs. The second contribution is the analysis of the mediating and moderating roles of regulatory and customer pressures in the relationship between environmental collaboration and environmental performance. Third, environmental performance is modelled and assessed as a five-dimensional construct. Fourth, this research motivates logistics managers to develop environmental collaboration to improve firms' environmental performance. Finally, the outcomes of this study can be used to recommend tangible policy actions for the Chilean authorities and other emerging economies.

2. Research hypotheses

Significant issues need to be addressed when managing AFSCs, such as the lack of involvement of small farmers, lack of stringent norms to control food safety and quality (Naik and Suresh 2018), lack of industrialisation, inadequate management, and information inaccuracy (Kamble, Gunasekaran, and Gawankar 2020). Collaboration among supply chain partners may help reduce these problems, especially for farmers with limited access to resources, technology, information, and skill development, to sustain their operations and improve the quality and availability of their food in the market (Dania, Xing, and Amer 2018). Collaboration occurs when stakeholders participate in processes with common rules and criteria to determine solutions for collective demands (Tseng et al. 2022). To build collaborative supply chains, it is essential to understand how firms share information, integrate processes, communicate, and jointly create knowledge with their partners (Cao, Vonderembse, and Zhang 2010). Hence, sharing information, incentives, responsibilities, risks, and joint product design are among the most common collaborative practices (Sudusinghe and Seuring 2022).

Environmental collaboration involves a joint effort to improve environmental performance at the supply chain level, where inputs from suppliers and customers are sought. This requires high levels of proactivity and commitment from the focal company (Graham 2018). Particularly, in pressured chain contexts, the lack of a shared culture makes it challenging to translate information on sustainability issues into collaboration (van der Heijden and Cramer 2017). Environmental collaboration positively affects environmental performance because of the focal firm's ability to share environment-related capabilities with supply chain partners (Bae and Grant 2018). In the case of AFSCs, firms must implement collaborative practices, such as goal alignment and the sharing of benefits, costs, risks, knowledge, and information, among producers and cooperatives (Despoudi et al. 2018) to reduce FW and other environmental impacts. In the agricultural sector, the effects of collaboration on sustainability are a hot topic for future research (Allaoui 2015). Further studies are required to understand the relationship between environmental collaboration and environmental performance. Therefore, there is a need to investigate how environmental collaboration among AFSC entities improves the environmental performance of food supply chains (Krishnan et al. 2021). These findings support our first hypothesis.

H1: Environmental collaboration has a positive influence on environmental performance.

Previous studies have identified some of the environmental impacts and issues that society faces today, such as climate change, scarcity of natural resources, biodiversity loss, deforestation, soil degradation, and issues related to water use (Quarshie, Salmi, and Leuschner 2016). The literature presents numerous examples in which environmental performance is significantly improved by optimising the use of natural resources and energy and reducing wastewater, electricity usage, and GHG emissions (Belhadi et al. 2020). Agriculture contributes to a substantial fraction of global GHG emissions, which are the outcome of a combination of agricultural activities and environmental impacts, such as intensive livestock, fertilisation, and land use (Baldoni, Coderoni, and

Esposti 2018). The AFSC generates GHG emissions at all stages, from the manufacturing and distribution of inputs used at the farm level to food processing, preparation, distribution, and waste disposal (Garofalo et al. 2017). This increase in GHG emissions has been attributed to an increase in agricultural output (Yan et al. 2017). Some agricultural activities are commonly considered to have an impact on GHG emissions; for instance, the use of pesticides and fertilisers for disease control (Pattara et al. 2017).

Methods used to mitigate GHG emissions include switching to low-carbon fossil fuels, reducing emissions, and increasing the use of renewable energy sources (Cansino et al. 2010). Previous studies have observed that the adoption of GHG management improves productivity and increases demand, encouraging investments in technologies for cleaner production and reducing costs and environmental risks (Cucchiella, Gastaldi, and Miliacca 2017). Further research is required to identify the means of reducing GHG emissions from agriculture (Yan et al. 2017). Environmental collaboration with supply chain partners might have a positive impact on mitigating GHG emissions of GHG due to imposed restrictions, knowledge sharing, and learning through innovative practices. This leads to our second hypothesis.

H2: Environmental collaboration has a positive influence on GHG emissions management.

Sustainable economic development is associated with increased energy efficiency (Zakari et al. 2022). Energy-intensive organisations are confronted with increasing pressure to improve energy efficiency and reduce energy consumption. Among the expected benefits of energy efficiency improvements are the mitigation of GHG emissions, positive employment effects, creation of business opportunities, reduction in primary energy dependence, and improvement in energy security (Cansino, Sánchez-Braza, and Rodríguez-Arévalo 2015).

Environmental performance can be improved by streamlining energy use in the agricultural sector (Shen, Balezentis, and Streimikis 2022). Li et al. (2021) stated that it is necessary to improve agricultural energy efficiency and accelerate the decoupling of agricultural development from fossil fuel energy inputs. The provision of energy efficiency and reduction in GHG emissions are necessary because energy efficiency reduces GHG emissions and the demand for energy imports (Zakari et al. 2022). Improvements in energy management are necessary to achieve global sustainable goals (Molinos-Senante and Maziotis 2022). In fact, energy management strengthens the effects of energy management practices on environmental performance (Patel, Shah, and Trivedi 2022). By developing collaborative relationships that focus on environmental purposes, companies can interchange technologies and processes to achieve enhanced energy management. Therefore, environmental collaboration can improve energy management. This leads to the third hypothesis.

H3: Environmental collaboration has a positive influence on energy management.

FW is a major global challenge, not only from an ethical and social point of view, but also from environmental and economic perspectives (Caldeira et al. 2019). Researchers expect FW to increase in such a way that it may affect countries' transitions to sustainable waste management (Ogunmoroti et al. 2022). Public, private, and social institutions have been working in this direction to generate and implement alternative actions (Diaz-Ruiz et al. 2019) to reduce FW, and consequently, the required use of agricultural land (Ogunmoroti et al. 2022).

Stakeholders have implemented FW reduction strategies across AFSCs (Annosi et al. 2021). FW reduction is a critical factor in AFSCs and must be considered in supply chain design and planning to achieve sustainable outcomes (Kumar et al. 2020). Environmental collaboration between suppliers and producers helps reduce the use of raw materials and waste generation. For instance, environmental collaboration within a closed-loop supply chain reduces waste by utilising returned used products as inputs for other processes (Krishnan et al. 2021). Additionally, environmental collaboration among different stakeholders in the supply chain encourages mutually supportive relationships to address the FW problem (Sánchez-Teba, Gemar, and Soler 2021). Moreover, environmental collaboration with technology providers based on complete data sharing and codesign positively impacts FW prevention (Ciccullo et al. 2021). Additionally, FW is more significant in supply chains where partners do not frequently coordinate operational activities (Annosi et al. 2021). This leads to the fourth hypothesis.

H4: Environmental collaboration has a positive influence on food waste management.

Food quality includes all the desirable properties that a food product is perceived as possessing by consumers. Previous studies have suggested that perceived quality is affected by food safety and environmental friendliness (Lagerkvist, Okello, and Karanja 2012). Food quality is assessed using chemical, psychosensory, nutritional, health, and safety standards (Pattara et al. 2017). Therefore, food safety is a critical aspect of food quality. Food safety is the assurance that the food produced and consumed will not cause harm or adverse health effects. Food can become unsafe because of the presence of chemical contaminants (Dzudzor and Gerber 2023). Food safety issues occur when human health threats are introduced during food production, processing, storage, and consumption, either by toxic or harmful substances or by technological or management factors during operations (FAO/WHO 1997; Gao et al. 2023). Contaminants that can render food unsafe include foodborne pathogens, chemical contaminants, pesticides, and other adulterants (Nordhagen et al. 2023). Depending on the level of contamination, these compounds can be detrimental to both human and animal health and adversely affect the sustainability of the industry (Montgomery, Haughey, and Elliott 2020). Thus, fertilisers and pesticides should be reduced because their use results in soil pollution, which adversely affects human health and ecosystems (Krishnan et al. 2021).

Food safety issues can be significantly reduced by following good agricultural practices. Recently, food safety problems have been related to improper firm behavior in the supply chain in pursuit of economic advantages (Gao et al. 2023). Thus, AFSCs play a crucial role in ensuring food safety, because actions taken at every echelon of the chain can impact food safety in markets and homes. Strategies across value chains must consider food safety and environmental sustainability (Feliciano et al. 2022). Hence, food safety is the collective responsibility of all stakeholders (Dzudzor and Gerber 2023). Environmental collaboration can foster food safety management (Despoudi et al. 2018). Strategic alliances, information quality, trust, and commitment are all significantly related to food safety management (Ding et al. 2014). Cooperatives are one mechanism for fostering environmental collaboration in AFSC. They are responsible for decisions regarding the coordination of food safety requirements among customers, cooperative firms, and farmers (Kirezieva et al. 2016). Hence, environmental collaboration could reinforce food safety management due to pressure from supply chain partners towards environmental goals, as well as information exchange, knowledge acquisition, and resource integration resulting from collaborative relationships. This leads to the fifth hypothesis.

H5: Environmental collaboration has a positive influence on food safety management.

Agriculture is the primary consumer of water worldwide (Novoa et al. 2019). The WF is an indicator of water resource use that allows the determination of the volume of water directly or indirectly consumed or polluted for the production of a good or service (Novoa et al. 2019). WF management is defined as the use of policies and actions at the strategic, tactical, and operational levels that support mitigating the WF of a product across its entire supply chain (Aivazidou et al. 2015, 2016). It is critical for promoting environmental sustainability in AFSCs (Vanham and Bidoglio 2013). In AFSCs, WF management methods can be adopted to guarantee that supply chain partners comply with sustainability standards and goals (Tsolakis et al. 2014). Previous research has identified that WF assessment studies at the supply chain level are somewhat limited (Aivazidou et al. 2016) and that the full potential of WF management along supply chain partners needs to be seen (Hoekstra, Chapagain, and Oel 2019).

Severe water pollution caused by agricultural overexploitation threatens sustainable development. Therefore, it is necessary to optimise wastewater treatment efficiency and reduce the discharge of pollutants into the environment (Ly et al. 2022). Environmental collaboration that promotes water resource management practices is effective in solving regulatory and environmental challenges (Xu et al. 2022). Previous research has identified the need to foster collaborative relationships and extend the adoption of WF management initiatives to supply chain partners (Barbosa and Cansino 2022) to improve firms' environmental performance. This allowed us to propose our sixth hypothesis.

H6: Environmental collaboration has a positive influence on water footprint management.

An increasing number of firms are experiencing significant stakeholder pressure to incorporate green practices into their operations and supply chains (Wang et al. 2018). Stakeholder pressure adds complexity to the management of an already challenging multi-tiered supply chain. Therefore, institutional pressures push firms to adopt and maintain environmental initiatives and produce environmentally friendly products and services (Esfahbodi et al. 2017). Huang et al. (2016) found that regulatory and customer pressures, the two most important types of institutional pressures, affect sustainable organisational initiatives.

Empirical evidence shows that customer pressure stimulates businesses to adopt green management practices, which may improve competitiveness by differentiating their products from those of their competitors and enhancing their reputation and image (Chen and Liu 2019). Customers can motivate firms to adopt green practices by exerting pressure. Therefore, customers represent externally oriented drivers of green supply chain practices (Wang et al. 2018). Hence, consumers' responses to and preferences for environmentally responsible products put pressure on firms to adopt green practices (Yenipazarli 2019). Although environmental collaboration does not establish formal rules, it helps to develop cultural expectations and a clear vision of customer pressure, thereby affecting a firm's perceived customer pressure (Ke et al. 2009). Therefore, the effects of customer pressure on the relationship between environmental collaboration and performance must be clarified. On the one hand, environmental collaboration might increase awareness of customer pressures, which will, in turn, increase firms' environmental performance (i.e. a mediating effect). However, customer pressure may strengthen the effect of environmental collaboration on environmental performance (i.e. a moderating effect). This context is grounded in the presentation of this study's hypotheses.

H7 and H8: Customer pressures mediate (H7) and moderate (H8) the effect environmental collaboration has on environmental performance.

Huang et al. (2016) stated that customer demand may not be sufficient to improve environmental performance, especially in underdeveloped countries where the consumption of green products is not as strong as in developed countries. In addition, some customers may not accept the high prices of environment-friendly products. Thus, other types of pressures may be necessary to stimulate green consumption and production. Not only do customer demands have great potential to force organisations into action, but so too do regulatory standards. Regulations and compliance standards impose other types of pressure on companies (Yenipazarli 2019). Regulatory pressures have led firms to pay close attention to their environmental alignment with SSCM. For instance, quota regulations, statutory entitlements of electricity plants, and price regulations are usually adopted (Cansino et al. 2010). In fact, pressures exerted by government agencies and national or international regulators are deemed to be the major driving forces that influence the adoption of SSCM practices (Esfahbodi et al. 2017).

To promote environmental collaboration among supply chain partners, focal firms may exert pressure by establishing strict guidelines and procedures for sustainability (Ke et al. 2009). This may increase firms' perceptions of the existence of regulatory and normative pressures. Although regulatory and customer pressures have been previously studied, some gaps still exist. For manufacturing companies, Huang et al. (2016), for instance, found that while customer pressure has a significant positive impact on collaborative networks, the impact of regulatory pressure on these networks is not significant. Davis-Sramek et al. (2022) found that environmental regulatory

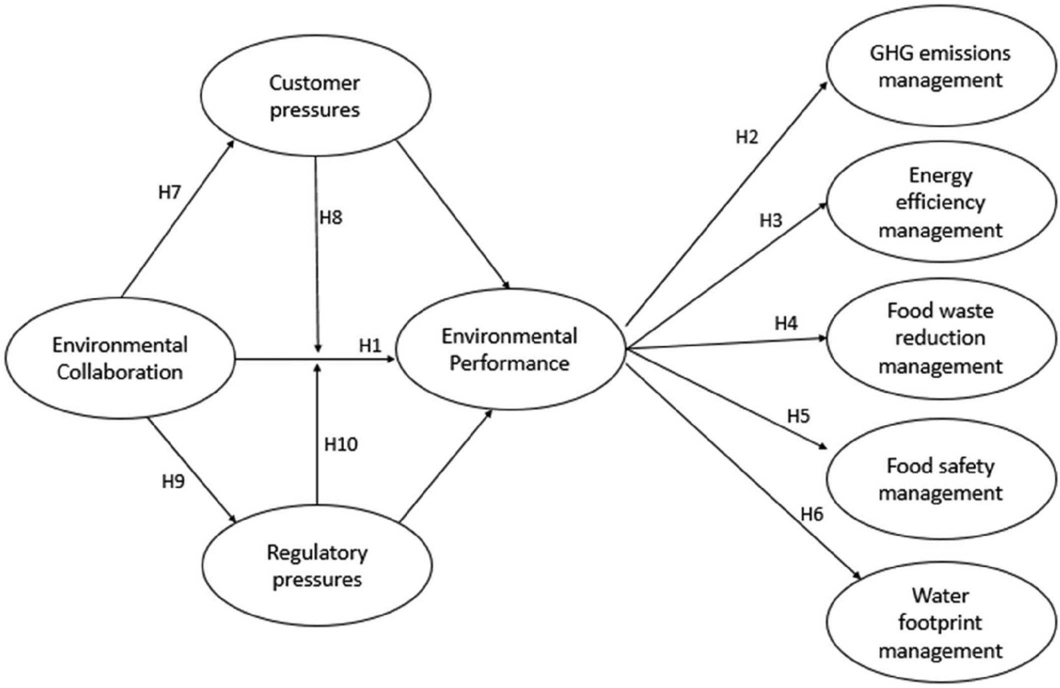

Figure 1. Research model.

pressures do not increase the effects of an environmental strategic focus on environmental supplier collaboration. Hence, when environmental collaboration is observed, firms are more conscious of existing regulatory pressures, which may increase their environmental performance. In this context, regulatory pressures may have a mediating or moderating effect on the relationship between environmental collaboration and environmental performance, leading us to present the study's final hypotheses.

H9 and H10: Regulatory pressures mediate (H9) and moderate (H10) the effect environmental collaboration has on environmental performance.

According to the hypotheses presented, Figure 1 illustrates our research model.

3. Methodology

This study adopted a quantitative methodology using a cross-sectional e-mail survey of Chilean agri-food companies. For this study, all survey measurement items for each construct were retrieved from the extant literature, using the following references: environmental collaboration (Gölgeci et al. 2019; Vachon and Klassen 2008), environmental performance (Kamble, Gunasekaran, and Gawankar 2020), Energy management (Belhadi et al. 2020), food safety management (Lagerkvist, Okello, and Karanja 2012), FW management (Diaz-Ruiz et al. 2019), WF management (Barbosa and Cansino 2022), GHG emissions management (da Rosa, Lunkes, and Brizzola 2019), customer pressures (Chen and Liu 2019; Wang et al. 2018), and regulatory pressures (Huang et al. 2016; Solomon, Ketikidis, and Koh 2019). Items were measured on a five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree. Appendix A presents the measurement items for these constructs.

The survey was administered to professionals working in Chilean producing firms in the agricultural sector. The survey was distributed to professionals with the support of the National

Table 1. Descriptive characteristics of firms and respondents.

		Number of Respondents	%
Company size	Small size	47	38.6
	Medium and large size	75	61.4
Main crops	Fruits	60	50.0
	Grapes	24	20.0
	Vegetables and legumes	17	14.2
	Olives and nuts	13	10.8
	Cereals and oilseeds	11	9.2
Country region	Metropolitan	43	35.2
	Maule	24	19.7
	Bernardo O´Higgins	23	18.9

Agriculture Society (SNA – *Sociedad Nacional de Agricultura* – in Spanish) and the Chilean Association of Agricultural Engineers (*Colegio de Ingenieros Agrónomos de* Chile – in Spanish). The SNA brings together a large number of producers, professionals, associations, and federations linked to Chilean agriculture and agribusiness with the aim of ensuring the general interests of the sector, such as representing farmers in defense of their common interests, promoting public policies that stimulate competitiveness and entrepreneurship in agriculture, promoting the formation and training of human capital, and stimulating good labour relations. Non-response bias was addressed by sending follow-up e-mails to respondents every 10 days during the data collection stage.

The survey was administered to company owners, chief executive officers (CEOs), directors, managers, coordinators, and supervisors of Chilean agricultural companies. The final sample consisted of 122 respondents. In terms of the hierarchy of survey participants, 21 respondents (17.2%) were CEOs, board members, or company owners. Twenty-four respondents (19.7%) were directors, mostly in logistics and supply chains, sustainability, and marketing. Most participating firms are in regions where most of the country's agricultural production is present. Table 1 shows the profiles of the participating firms.

After the questionnaire was distributed, the data were analyzed using the PLS-SEM method suitable for the analysis of the research model (Hair et al. 2017). To adopt this method, researchers must transfer constructs and their hypothesised relationships into a structural model (Benitez et al. 2020). The PLS model was evaluated using a PLS module for R called the PLSPM (Sanchez 2013) in two stages: evaluation of the measurement model and evaluation of the structural model. The first stage consisted of unidimensionality, convergent validity, and discriminant validity analyses. The second stage involved testing the structural model and verifying the structural relationships represented by the model hypotheses. In order to do so, path coefficients were determined for each relationship, as well as the coefficient of determination (R^2). The overall fit of the research model was evaluated using a bootstrap test of overall model fit.

4. Results

4.1. Measurement model evaluation

Harman's single-factor test was used to assess common method variance (CMV). All indicators for each construct were loaded into a factor analysis to check whether a single factor emerged, resulting in the majority of the covariance among the measures (Tehseen, Ramayah, and Sajilan 2017). In this study, the first unrotated factor captured only 16% of the variance in the data, which is less than the acceptable threshold of 50% (Tehseen, Ramayah, and Sajilan 2017). Thus, no single factor emerged, indicating that CMV was not an issue.

Skewness and kurtosis were assessed to check for data normality. It is recommended that these two measures should range between −2 and +2 (Dash and Paul 2021; Hu and Bentler 1999). The values obtained from these normality tests fell within these threshold values, indicating no violation of the normality assumptions of the sample data.

Table 2. Unidimensionality test results.

Constructs	Cronbach's α	DG Rho	1st Eigenvector
Environmental Collaboration (COL)	0.918	0.937	4.280
Customer pressures (CUS)	0.899	0.926	3.573
Regulatory pressures (REG)	0.809	0.868	2.841
Environmental performance (ENV)	0.927	0.935	10.016
Energy management (ENE)	0.866	0.918	2.367
Food safety management (FSM)	0.813	0.862	3.345
Food waste management (FWA)	0.832	0.873	3.744
Water footprint management (WAT)	0.841	0.881	3.624
GHG emissions management (GHG)	0.908	0.932	3.671

The evaluation of the measurement model comprised unidimensionality, convergent validity, and discriminant validity analyses. Table 2 presents the results of the unidimensionality tests. All Cronbach's alpha and Dillon–Goldstein (DG) rho indices were greater than 0.70 and greater than one, repsectively, as recommended (Hair et al. 2017; Sanchez 2013). The first eigenvector metric involves an eigenanalysis of the correlation matrix for each set of indicators. Unidimensionality was observed when the first eigenvalue was larger than one. Unidimensionality increases when the first eigenvector surpasses the value of one. Its evaluation is performed by considering the remaining eigenvalues to determine how unidimensional a block of indicators is (Sanchez 2013). Table 2 shows that the first eigenvector values were greater than the recommended threshold.

To evaluate the convergent validity of reflective constructs, we used the indicators' outer loadings. All indicators presented outer loadings greater than 0.708, as recommended (Hair et al. 2017). The results of the convergent validity analysis are also shown in Appendix A.

Two approaches are frequently used to assess discriminant validity: cross-loadings and the Fornell-Larcker criterion (Fornell and Larcker 1981). Our results show that each indicator's outer loading on the associated construct was greater than any of its cross-loadings on other constructs. The results of the Fornell-Larcker criterion also suggested that each construct was more strongly associated with its indicators than with other constructs. The leading diagonal entry in Table 3, which represents the square root of the AVE, was found to be greater than the inter-construct correlations. Hence, we argue that the model constructs demonstrated sufficient discriminant validity.

4.2. Evaluation of the structural model

After running the PLS-SEM algorithm, estimates were obtained for structural model relationships (path coefficients). The most commonly used measure for evaluating structural models is the coefficient of determination (R^2 value) (Hair et al. 2017). Figure 2 shows the path coefficients and R^2 values obtained for the structural model.

A non-parametric bootstrapping approach was used to evaluate the precision of the PLS parameter estimates. The results in Table 4 indicate that all path coefficients were significant in the bootstrapping test ($p < 0.0001$). All the hypotheses (H1–H6) were confirmed. Hypotheses H7 and H9, which consider mediation effects, and H8 and H10, which consider moderation effects, are discussed below.

To analyze whether customer and regulatory pressures mediate the relationship between environmental collaboration and environmental performance, we used two different methods. First, we evaluated the size of the direct individual effect of environmental collaboration on the environmental performance of each absorbed mediator. We used the variance accounted for (VAF) to determine the size of the indirect effect relative to the total effect. The indirect effect of customer pressures on the relationship between environmental collaboration and environmental performance was calculated as 0.17 (0.59×0.28) (direct effects were presented in Table 4). In addition, the VAF was calculated by dividing the total indirect effect by the indirect and direct effects ($0.17/(0.17 + 0.37) = 0.31$). The indirect effect of regulatory pressure on the relationship

Table 3. Loadings.

	COL	CUS	REG	ENE	FSM	FWA	WAT	GHG
COL	**0.853**							
CUS	0.591	**0.847**						
REG	0.691	0.511	**0.764**					
ENE	0.637	0.588	0.655	**0.884**				
FSM	0.454	0.520	0.530	0.556	**0.733**			
FWA	0.596	0.482	0.528	0.519	0.478	**0.688**		
WAT	0.667	0.624	0.595	0.654	0.605	0.648	**0.736**	
GHG	0.601	0.373	0.506	0.502	0.337	0.538	0.642	**0.857**

between environmental collaboration and environmental performance was calculated in the same way, and a VAF of 0.36 was obtained. According to Hair et al. (2017), VAF values between 0.20 and 0.80 are indicative of a partial mediation.

The second mediation analysis procedure followed the recommendations of previous studies (Edeh, Lo, and Khojasteh 2023; Hair et al. 2017; Nitzl, Roldan, and Cepeda 2016). Since the research model proposed in this study has two mediation relationships, we ran a multiple mediation analysis in which the exogenous construct of environmental collaboration exerted its influence on the endogenous construct of environmental performance through more than one mediating variable (customer and regulatory pressures). By considering all mediators simultaneously, a comprehensive view of the influence of the exogenous construct on the endogenous construct was obtained. To do so, we tested the significance of each indirect and direct effect between environmental collaboration and environmental performance. To assess the significance of the direct and indirect effects, we ran a bootstrap test with 10,000 bootstrap subsamples and analyzed the 95% bootstrap confidence intervals. Table 5 shows the mean bootstrap values. Because the 95% confidence interval did not contain a value of zero, the effects were considered significant. Moreover, as all path coefficients were positive, the mediation relationships (H7 and H9) were confirmed and classified as complementary

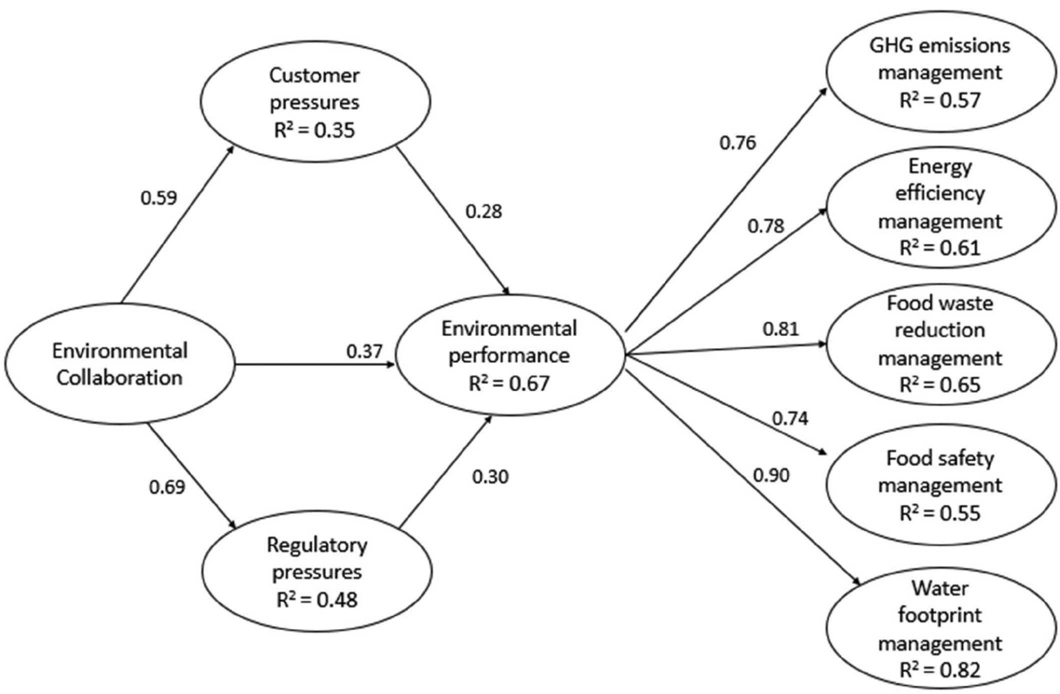

Figure 2. Path coefficients and R^2 values for the structural model.

Table 4. Path coefficients and *p*-values for the structural model.

Relationship	Path coefficients	Hypothesis no.	Hypothesis supported?
COL → ENV	0.37	H1	Yes
ENV → GHG	0.76	H2	Yes
ENV → ENE	0.78	H3	Yes
ENV → FWA	0.81	H4	Yes
ENV → FQA	0.74	H5	Yes
ENV → WAT	0.90	H6	Yes
COL → CUS → ENV	0.59/0.28	H7 (mediation effect)	Yes (partial mediation)
CUS → (COL→ENV)	−0.13[(ns)]	H8 (moderating effect)	No
COL → REG → ENV	0.69/0.30	H9 (mediation effect)	Yes (partial mediation)
REG → (COL→ENV)	−0.09[(ns)]	H10 (moderating effect)	No

Notes: (1) Bootstrapping results (*p*-values): $p < 0.0001$; (2) ns = not significant.

Table 5. Bootstrap data for the hypothesised mediated and moderated effects.

Mediation hypothesis	Bootstrap value	Standard error	95% interval (lower level)	95% interval (upper level)
H7 (COL -> CUS)	0.621	0.067	0.471	0.733
H7 (CUS -> ENV)	0.292	0.069	0.168	0.443
H9 (COL -> REG)	0.705	0.046	0.622	0.778
H9 (REG -> ENV)	0.306	0.067	0.164	0.419

(partial) mediations (Edeh, Lo, and Khojasteh 2023; Hair et al. 2017), corroborating the results of the first mediation procedure.

Finally, to assess the possible moderating effect of customer and regulatory pressures on the relationship between environmental collaboration and environmental performance, we used a product indicator approach. This method creates a new latent variable representing the interaction between exogenous and moderator variables by multiplying the measurement items of the independent latent variable by those of the moderator. After applying this method, we observed that the moderating product construct did not significantly affect environmental performance. Hence, H8 and H10 were rejected.

5. Discussion

The results provide strong evidence that environmental collaboration among companies positively influences each of the five environmental performance dimensions assessed. In addition, we found that customer and regulatory pressures mediate this relationship. The results showed that environmental collaboration can explain 67% of the variance in environmental performance, highlighting the importance of environmental collaboration in achieving environmental performance. This is in accordance with Gölgeci et al. (2019), who found that environmental collaboration has a positive effect on environmental performance, and Barbosa et al. (2022), who observed that environmental collaboration affects sustainable performance. However, our study extends the previous research by assessing the impact of environmental collaboration on five dimensions of environmental performance (GHG emissions management, energy management, WF management, food safety management, and FW management). Additionally, our study answers calls to quantify the effects of environmental collaboration (Chauhan et al. 2022) and conduct more research on emerging economies and the environmental impact of supply chains (Barbosa et al. 2022; Seuring et al. 2022).

Hypothesis H1, which states that environmental collaboration positively affects environmental performance, was confirmed. This result is in line with previous studies that show that collaboration stimulates the circular economy and green initiatives in supply chains, thus improving sustainability performance (Despoudi 2021; Sudusinghe and Seuring 2022). Based on the mutual trust among stakeholders, collaboration promotes the sharing of environmental expertise, knowledge, information, and goals (Bhattacharya and Fayezi 2021). It also facilitates knowledge gathering by increasing transparency and improving data quality (Bustos and Moors 2018). Additionally, environmental collaboration among supply chain partners contributes to sharing risks and benefits and reducing the costs and negative impacts of regulations concerned with sustainability (Chauhan et al. 2022). Moreover, environmental collaboration favours transparency, which is essential for accurately reporting progress in SSCM initiatives (Wren 2022).

Previous research has indicated that the environmental dimensions assessed in this study have not received equal attention from scholars. A previous study identified waste management and GHG emissions as the most frequently discussed environmental outcomes (Guo et al. 2022; Sudusinghe and Seuring 2022). Hence, other dimensions, such as WF management and food safety, have not been thoroughly discussed in the context of collaborative supply chains. Therefore, a thorough assessment of the impact of environmental collaboration on the different dimensions of environmental performance is an important contribution of this study.

This study identified a positive and significant impact of environmental collaboration on GHG emission management, confirming H2. This result aligns with that of Zhang, Du, and Wang (2018), who found that collaboration helps supply chain firms share important information about reducing GHG emissions. Environmental collaboration through the sharing of information on the carbon footprints of production processes is essential for reducing GHG emissions. Moreover, collaboration reduces supply chain inefficiencies and improves environmental and financial performance (Ramanathan, Bentley, and Pang 2014). The findings of this study also address other researchers' concerns that there is surprisingly little understanding of the adoption of supply chain collaboration to reduce the impact of GHG emissions (Ramanathan, Bentley, and Pang 2014).

We also observed a positive and significant effect of environmental collaboration on energy management, confirming H3 and corroborating previous research that stated that energy and the responsible use of resources are central topics of collaboration, and that resource sharing and collaborative sustainable production practices increase access to sustainable energy (Chauhan et al. 2022). This finding is also aligned with that of Borg and Yström (2020), who stated that, although challenging to achieve, environmental collaboration among supply chain actors increases energy efficiency. Environmental collaboration is beneficial to energy management for several reasons: it increases investments and the implementation of measures among partners (Borg and von Knorring 2019), increases knowledge about correlated energy use, helps remove barriers to energy efficiency, and increases transparency among supply chain partners (Haraldsson and Johansson 2019). However, scholars have stated that although research on this subject has increased over the last few years, the number of studies and knowledge about these relationships is limited. Therefore, further studies addressing the effects of collaborative practices related to energy management are required (Borg and von Knorring 2019; Borg and Yström 2020). This study aimed to fill this gap in the literature.

FW poses a significant threat to the environment and food security. In addition, as FW increases, other environmental burdens, such as carbon and WFs, also increase (Ogunmoroti et al. 2022). Our study also showed the positive and significant impact of environmental collaboration on FW management (H4). This finding is consistent with previous research, which found that sharing information, incentives, and jointly using technology reduces postharvest waste (Bustos and Moors 2018). Despite being challenging (Despoudi 2021), environmental collaboration initiatives can reduce the amount of FW in the production and distribution stages (Surucu-Balci and Tuna 2022), improve supply chain efficiency (Annosi et al. 2021). In supply chains, collaboration between farmers and logistics distributors supports FW reduction by avoiding temperature fluctuations and providing pre-cooling during storage and transport to keep perishable products fresh and avoid FW (Bhattacharya and Fayezi 2021). Additionally, environmental collaboration supports FW reduction by implementing information-related mitigation strategies with a technological focus (Magalhães, Ferreira, and Silva 2022)

This study identified a positive and significant impact of environmental collaboration on food safety management (H5), which is in line with previous studies that found that sharing efforts could provide extra resources to stakeholders to improve food safety (Bhattacharya and Fayezi 2021). However, the impact of environmental collaboration on food safety management was the lowest among the four dimensions of environmental performance. This can be explained by the contradictory effects of collaboration on food safety. On the one hand, collaboration reduces travel distances and the number of required vehicles if several orders are picked up by a single vehicle. However, food safety may deteriorate because consolidating shipments could lead to longer travel durations, detours, and additional loading activities (Fikar and Leithner 2021).

Our study found that environmental collaboration has a substantial impact on WF management (H6). This impact was the highest among the five environmental dimensions evaluated in this study. Aivazidou et al. (2016) noted that collaboration with water-friendly partners is a strategic decision for supply chain stakeholders. This is an essential contribution of this study because the relationship between collaboration and WF management has rarely been studied. Guo et al. (2022) observed that the WF has rarely been considered in past research compared to GHG emissions in sustainable supply chain contexts. Lyu et al. (2021) stated that although collaboration for sustainability has become relevant for sustainable water management, it remains a poorly understood research area.

Finally, among the different paths through which regulatory and customer pressures can lead to improvements in firms' environmental performance, we found that developing collaborative relationships under these pressures can lead to improvements in environmental performance (H7 and H9). Our study showed that these types of pressures do not moderate but mediate the relationship between environmental collaboration and environmental performance. Our study extends the previous research by showing that some of the effects of environmental collaboration on environmental performance are exerted through regulatory and customer pressures. Hence, aligned with Ke et al. (2009), our study shows that more intense environmental collaboration fosters a shared vision of increased customer and regulatory pressures, which in turn affect firms' environmental performance. Thus, when firms develop collaborative relationships regarding environmental initiatives, supply chain partners share a stronger perception of more intense pressure from customers and regulations. This stronger perception promotes a virtuous cycle, in which companies feel more inclined to implement environmental initiatives.

Among institutional pressures, regulatory pressure is the most critical factor that drives environmental initiatives (Esfahbodi et al. 2017). Therefore, laws and regulations, government policies, and organisations' guidelines can affect firms' adoption of sustainable activities. Regulatory pressures force organisations to improve their sustainable practices. They play a vital role in firms' decision-making owing to strict regulations in some sectors (Trujillo-Gallego, Castro, and Sellitto 2021). Although previous studies demonstrated that firms' responses to government regulation can yield increased competitive advantages (Bamgbade, Kamaruddeen, and Nawi 2017; Esfahbodi et al. 2017), a recent study showed that regulatory pressures had a negative effect on the adoption of sustainable practices (Saeed et al. 2018). Our study recommends that equal attention should be paid to both types of pressure, although regulatory pressures seem to have a slightly more significant influence on environmental performance. This aligns with a previous research finding that environment-related regulations encourage supply chain actors to work collaboratively (Ramanathan, Bentley, and Pang 2014).

5.1. Practical contributions

Our study answers the calls made by several scholars to assess the effects of environmental collaboration on different dimensions of environmental performance. In addition, our study contributes to the literature on this subject by examining these relationships in emerging economies, particularly in Chile, a country that, like several others, is expected to suffer from several consequences of ongoing climate change. Our study found that environmental collaboration has considerable effects on WF management in the AFSC, which is an exciting outcome for several countries.

Chile presents some characteristics similar to those of other emerging economies, which allows us to generalise the outcomes of this study to broader contexts. First, Chile is a major exporter of agricultural products. Second, the country faces serious challenges related to the use of water for agriculture. Chile has experienced uninterrupted and severe drought since 2010, with a mean rainfall deficit of 20%–40%. Climate projections suggest that drought frequency and intensity may also increase in different regions of the world (Zambrano et al. 2018). The agricultural industry is one of the primary consumers of water resources worldwide (Novoa et al. 2019). Thus, agri-food water resource management is a topic of increasing interest (Jia et al. 2019) in several countries. Third, the Chilean agricultural sector has developed in the country based on collaborative relationships between importers and exporters as well as among other partners. Agricultural commodities are primarily developed by specialised exporters or multinational enterprises, which establish contracts with large numbers of farms. Exporting firms provide farmers with specialised equipment, credit, technical assistance, and insurance (Berdegué et al. 2001). Farms often form cooperatives for input supply and domestic and international marketing (Fleming and Abler 2013). Finally, as an emerging economy from Latin America, it offers a different context than European, North American, and Asian countries (Vinicio et al. 2019), where research in this field has been more intense. Owing to these characteristics and the fact that Chile is one of the most important economies in South America, it is a suitable scenario for this study.

In the specific case of Chile, this study identified opportunities for improvement in environmental performance. Firm performance in the GHG emissions management dimension was considered low (mean < 3; see Appendix A). Firms should also improve the implementation of FW initiatives, such as redistributing food to social entities and developing donation programs to minimise biowaste. Higher performance was observed in the food safety management dimension, probably due to the restrictions and expectations of countries that import agri-food products. Public policies should aim to reduce GHG emissions from the agricultural industry and improve FW reduction management programs. The outcomes of this study can be used to recommend tangible policy actions to the Chilean authorities, focusing on research topics presented in programs promoted by the Chilean Ministry of Agriculture. This is the case with the National Program for Sustainable Consumption and Production (Chile 2017), which aims to promote sustainable food systems by reducing the environmental footprints and negative social impacts of food products. The program also aims to reduce the loss and waste of food throughout the value chain and promote the incorporation of more sustainable practices into the processes, products, and services of the food value chain. One tool to achieve these objectives is the Plan of Adaptation to Climate Change in the Agricultural Sector (Chile 2013), which is also influenced by the outcomes of our research. This plan aims to strengthen the planning and management of water resources to optimise water use in agriculture, establish measures to address climate change, and promote research programs.

Moreover, scholars have called for more research in countries outside Europe and the United States because sustainability initiatives in supply chain environments are context-specific (Jia et al. 2018). In addition, southern countries need to transition towards sustainability in their agri-food systems (El Bilali 2019). By identifying the impact of environmental collaboration on several environmental dimensions, this study stimulates the development of collaborative relationships among supply chain partners to produce different types of environmental benefits.

5.2. Managerial contributions

One significant managerial contribution of this study is that it fills a gap in the extant literature on the relationship between environmental collaboration and environmental performance in AFSCs. Most researchers have narrowed the concept of firm performance to economic performance (Sudusinghe and Seuring 2022), and investigating environmental performance fills this gap. The second contribution is the observation of the mediating role of regulatory and customer pressures in the

Table 6. Recommendations for the development of collaborative relationships in environmentally-focused AFSCs.

Collaboration mechanisms	Recommendations
Information sharing	Firms should share product specifications concerned with environmental requirements. Firms should share production forecasts with partners to reduce waste, facilitate planning, and be flexible when necessary.
Goal congruence	Firms should establish common goals for the reduction of GHG emissions, energy use, WF management, and FW management. Firms should establish common standards and guidelines for the reduction of GHG emissions, energy use, WF management, and FW management. Firms should establish common policies regarding the use of pesticides and chemicals to reduce soil and water pollution.
Incentive alignment	Firms should establish economic incentives associated with achieving environmental goals.
Collaborative communication	Firms should communicate environmental performance indicators that are of interest to supply chain partners (e.g. WF management and GHG emissions management).
Joint knowledge creation	Firms should collaborate to develop innovative strategies to improve their environment-focused activities (e.g. waste reduction, water reuse, food safety improvement, and energy use reduction).
Joint planning/Jointly development of strategic plans	Firms should jointly plan their activities to avoid surpluses and waste. Firms should jointly plan their operations to optimise resources and comply with common standards.
Joint investments	Firms should jointly invest in technologies to reduce the environmental impacts of their operations.

relationship between environmental collaboration and environmental performance. Moreover, a unique characteristic of this study is that environmental performance is modelled as a five-dimensional construct. The impact of environmental collaboration on each of these dimensions (GHG emissions management, energy management, FW management, WF, and food safety management) was also determined. To the best of our knowledge, this gap in the literature remains unclear.

This study also contributes to the field of logistics management by highlighting the importance of involving the entire supply chain in the development of environment-focused initiatives through collaboration among partners. These initiatives include establishing common environmental objectives and requirements, implementing waste- and energy-reduction plans, and promoting cleaner production. Hence, this study shows that managers should promote the management of integrated processes, the flow of materials, and the sharing of environmentally related information along the entire supply chain to increase firms' environmental performance in each of the five assessed dimensions.

Firms can develop collaborative relationships through various mechanisms. Table 6 depicts some of the mechanisms that are usually found in the extant literature (Cao, Vonderembse, and Zhang 2010; Daugherty et al. 2006; G. Kumar and Banerjee 2014; Nyaga, Whipple, and Lynch 2010; Simatupang and Sridharan 2002). Based on these mechanisms and the findings of this study, we provide managerial recommendations for improving the environmental performance of companies in AFSCs through environmental collaboration.

5.3. Theoretical contributions

This study makes several theoretical contributions to the literature. The proposed research model extends the literature by exploring the relationship between environmental collaboration, regulatory and customer pressures, and environmental performance. To the best of our knowledge, no prior research has investigated these constructs in a research model similar to that proposed in this study. It also contributes to the RV theory by assessing the effects of collaborative relationships on environmental performance. The RV theory considers environmental collaboration to reflect strategic mutual environmental interdependence between supply chain partners, considering environmental supplier collaboration as an inter-organisational capability (Aboelmaged 2018).

The outcomes of this study reinforce the RV, since competitive advantage is achieved when an organisation is able to transform environmental actions into environmental alignment with internal and external stakeholders. Moreover, the resources provided by relationships with suppliers can directly contribute to developing firms' competitive advantage (Andersén 2021) by increasing their environmental performance.

This study also contributes to the NRBV theory, corroborating that managing sustainable initiatives supported by collaboration leads to a competitive advantage obtained through environmental performance. This study incorporated collaboration as a relational element that positively affects environmental performance in five dimensions. Researchers have stated that differentiating the effects and contributions of sustainability practices on companies' competitive advantage is essential (Ahmadi-Gh and Bello-Pintado 2022). The NRBV is grounded in some strategic capabilities, such as pollution prevention, product stewardship, and sustainable development, which have more recently been split into clean technology and the base of the pyramid (BoP) (Hart and Dowell 2011). Pollution prevention focuses on the control and minimisation of waste. Product stewardship takes stakeholder engagement in the entire firm's production chain into account. Sustainable development is related to a long-term commitment to market development and investment (Hart 1995; Mishra et al. 2019). Clean technology strategies are related to the development of competitive advantages for future positions in the face of current disruptive changes. The BoP focuses on meeting the unmet needs of the people experiencing poverty. While pollution prevention and product stewardship focus on incremental improvements for greater environmental efficiency in today's products and processes, sustainable development focuses on future technologies and markets (Hart 1995; Hart and Dowell 2011).

In this study, the NRBV is considered an appropriate theoretical lens to explain the engagement of the entire supply chain in collaborative relationships with environmental purposes because it considers stakeholder collaboration as a primary condition for proactive environmental management (Alt, Díez-de-Castro, and Lloréns-Montes 2015). Research on the NRBV has shown the importance of considering resources that are not fully controlled by the focal firm, which can directly contribute to competitive advantage (Andersén 2021). The NRBV is extended because this study incorporates environmental collaboration as a relational asset to address the strategic capabilities of the NRBV theory. We observed that environmental collaboration leads to the development of resources that are rare, inimitable, valuable, and non-substitutable in five dimensions of environmental performance, particularly considering the capabilities of pollution prevention and product stewardship present in the NRBV.

6. Conclusions

This study assesses the effects of environmental collaboration on the environmental performance of agri-food companies, especially when mediated by regulatory and customer pressures. This study found a positive and significant impact on five dimensions of environmental performance: GHG emission management, energy management, FW management, food safety management, and WF management. A greater effect was observed in WF management, indicating that environmental collaboration has great potential to improve firm performance in this area.

6.1. Limitations and suggestions for future studies

This study has some limitations typical of quantitative research. First, it relied only on a quantitative method to collect data and analyze the research model. Future research should use qualitative methods, such as focus groups and interviews, to provide a deeper understanding of the model's relationships and to support the understanding of how collaborative relationships are developed and which collaborative practices influence the environmental performance of most firms. Second, this study focused only on Chilean agricultural companies. Although we understand that the country's current economic situation is similar to that of other emerging economies, and consequently, our findings could be extended to these countries, the analysis of this research model in developed countries could yield exciting findings. Third, we used a cross-sectional survey to assess the proposed research model. Longitudinal studies can also be used to assess the effects of collaborative initiatives on environmental performance over time.

In addition to exploring these limitations, future research should also explore the role of digital and Industry 4.0 technologies on environmental performance through collaboration. This will improve our understand of how agricultural firms have been using technology to foster collaborative relationships and how they have been influenced by technology. It is also fundamental to investigate the barriers and enablers of environmentally focused collaboration in AFSCs. It is known that collaborations fail for various reasons, such as incompatible corporate culture, lack of trust, and inadequate integration of information systems. Understanding the barriers that hamper collaboration in AFSCs may help companies overcome these obstacles.

We also propose that future studies should explore the benefits of WF management beyond the environmental performance of AFSCs. Since water risks, such as droughts, can cause significant losses to agri-food companies (Zhou et al. 2018), the adoption of WF management initiatives could bring benefits to organisations in addition to the outcomes related to firms' environmental performance. The lack of coordinated initiatives with supply chain partners to face the pressures exerted by external stakeholders negatively affects the reputation of the firm and its supply chain (Czinkota, Kaufmann, and Basile 2014). Supplier collaboration based on environmental factors positively benefits firms' reputations (Quintana-García, Benavides-Chicón, and Marchante-Lara 2021). Therefore, owing to the pressures exerted by customers regarding the adoption of green practices, we propose that future studies should explore the effects of WF management on the reputation of agricultural firms.

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author, [MWB]. The data are not publicly available to avoid compromising the privacy of research participants.

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Appendix A

Loadings, AVE, and descriptive data

	Items	Item description	Loadings	AVE	Mean	Std. Dev.
Customer pressure	CUS1	Our customers prefer environmentally friendly products.	0.774	0.718	4.20	0.96
	CUS2	Our customers continuously pay attention to our firm's environmental behaviour.	0.852		3.68	1.02
	CUS3	Our customers seek companies that have environmentally responsible suppliers.	0.881		3.76	1.06
	CUS4	Our customers are increasingly aware of environmental issues.	0.860		4.17	0.84
	CUS5	Our customers believe that environmental protection is important.	0.863		4.19	0.85
Regulatory pressure	REG1	Our company is concerned about legal risks.	0.695	0.583	4.39	0.77
	REG2	Our company is concerned about government supervision.	0.752		4.25	0.87
	REG3	Our company feels the pressure of regulatory compliance to GHG emissions	0.793		3.67	1.06
	REG4	Our company feels the pressure of regulatory compliance to oil and other hazardous materials spills	0.817		4.03	0.98
	REG5	Our company feels the pressure of regulatory compliance to engine standards upgrades.	0.754		3.72	0.98
Environmental collaboration	COL1	Our company cooperates with its suppliers to achieve environmental objectives.	0.767	0.729	3.63	0.98
	COL2	Our company provides its suppliers with design specification that include environmental requirements for purchased items.	0.793		3.33	0.98
	COL3	Our company encourages its suppliers to develop new source reduction strategies.	0.876		3.11	1.08
	COL4	Our company cooperates with its suppliers to improve their waste reduction initiatives.	0.902		3.25	1.02
	COL5	Our company works with its suppliers for cleaner production.	0.877		3.48	1.05
	COL6	Our company collaborates with its suppliers to acquire materials, parts and/or services that support its environmental goals.	0.895		3.37	1.07
Food safety management	FSM1	Our company uses clean (uncontaminated) water for crop irrigation.	0.804	0.538	4.19	0.95
	FSM2	Pesticides are always used at the rates indicated on the labels or recommended by the manufacturer.	0.804		4.42	0.84
	FSM3	Our company complies with pre-harvest storage periods to minimise specific pesticide residues in harvested products.	0.796		4.41	0.91
	FSM4	Manure and compost are incorporated into the soil before planting fruits/vegetables to prevent nutrient loss, whenever recommended.	0.548		3.81	0.94
	FSM5	Biopesticides and/or organic fertilisers are used instead of chemicals.	0.601		3.73	1.00
	FSM6	Our company controls compliance with the legal limits of pollutants from the use of pesticides, chemical fertilisers, and water sources from the perspective of human health.	0.819		4.25	0.96
	FSM7	Pesticides are only applied upon evidence of infestation by insects	0.709		3.87	1.13
Energy management	ENE1	Our managers invest in energy-efficient technologies	0.896	0.782	3.77	1.03
	ENE2	Our organisation prefers energy saving processes	0.888		4.01	0.97
	ENE3	We update our process continuously for energy efficiency	0.868		3.52	1.06
Water footprint management	WAT1	Our company promotes and adopts national and global standards for water footprint accounting, traceability, and assessment.	0.796	0.542	3.40	1.13
	WAT2	Our company promotes the measurement of the water footprint throughout the supply chain, cooperating with	0.781		3.30	1.07

(*Continued*)

Continued.

	Items	Item description	Loadings	AVE	Mean	Std. Dev.
		partners to be able to generate records of the volume of water used in manufactured products.				
	WAT3	Our company implements processes that mitigate the risk of contamination, avoiding or minimising the use of substances (metals, pesticides, fertilisers, etc.) in products that may be polluting for water.	0.777		3.98	0.98
	WAT4	Our company establishes water auditing and control systems	0.731		3.68	1.02
	WAT5	Our company invests in water-efficient technologies.	0.639		4.15	0.94
	WAT6	Our company reuses and recycles wastewater.	0.615		3.10	1.21
	WAT7	Our company identifies the local risks of its impact on the water supply.	0.787		3.62	1.09
GHG emissions management	GHG1	Our company establishes economic incentives (variable remuneration, differentiated salary adjustments, bonuses, premiums, etc.) associated with performance targets in GHG emissions management.	0.728	0.733	2.57	1.10
	GHG2	Our company measures and reports GHG emissions.	0.884		2.78	1.28
	GHG3	Our company seeks opportunities to reduce GHG emissions.	0.852		3.25	1.18
	GHG4	Our company incorporates GHG emissions into the process of systematically evaluating the environmental aspects and impacts of its activities.	0.894		2.92	1.12
	GHG5	Our company follows specific processes and procedures for the management of GHG emissions	0.909		3.04	1.14
Food waste management	FWA1	Our company has improved the planning of agricultural activities to avoid surpluses.	0.600	0.573	3.89	0.88
	FWA2	Our company shares production projection data at the cooperative level.	0.619		3.32	1.09
	FWA3	Our company seeks alternative sales channels for harvest surpluses that do not meet the standard required by the main business.	0.539		3.52	1.08
	FWA4	Our company applies voluntary actions to reduce avoidable food waste in the food industry.	0.762		3.60	1.03
	FWA5	Our company redistributes food that is fit for consumption, but not for sale, to soup kitchens or social entities using the company's own transport.	0.666		2.73	1.16
	FWA6	Our company develops a donation program to minimise biowaste.	0.731		2.64	1.10
	FWA7	Our company shares primary production data with other agents in the chain (partners and clients) so that they are increasingly flexible in product size standards, in order to avoid wasting food that does not meet these standards.	0.769		3.07	1.14
	FWA8	Our company has developed a food waste reduction plan.	0.773		2.95	1.11