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Covid-19 and Innovation in Agrifood Systems of Latin America and the Caribbean

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Abstract

The agrifood supply chain of Latin America and the Caribbean (LAC) stands out for its resilience to the COVID-19 pandemic, and multiple studies have been conducted to analyze the differential impacts of the pandemic across firms and sectors. Less is known regarding the strategies implemented for business continuity during this catastrophic shock. The purpose of this study was to analyze the responses toward innovations of the LAC agrifood supply chain to the COVID-19 health emergency using data gathered from agribusinesses from 22 LAC countries. The study contributes to the literature by taking a comprehensive look at the responses of businesses along the LAC agrifood chains, and it is also one of the first longer-term quantitative assessments as it considers responses from the first and second years of the pandemic. The results from our two surveys show that over 70% of agribusinesses implemented innovations, revealing firms' positive and prompt reactions. Although most innovations were longer-term, in many cases, innovations were only temporary. Statistical analyses suggest that the likelihood of implementing longer-term innovations is associated with the agrifood segment, the agrifood chain stage, receiving long-term public or private support, having access to credit, and positive future perspectives about business conditions.

Introduction

The coronavirus disease of 2019 (COVID-19) caused not only many deaths but also substantial disruptions in global and local economies. Restrictions on the mobilization of people and goods, and changes in consumer behavior caused disruptions in many supply chains, including in the agrifood sector (Arita et al., 2022; Bellemere et al., 2022). Nevertheless, previous research has shown that the agrifood sector stood out for its resilience to COVID-19, particularly in the Latin American and the Caribbean (LAC) region. In fact, several research reports in 2020 provided an account of the strength of the agrifood sector in the region amid the COVID-19 pandemic, showing the adverse effects of the pandemic were smaller for the agrifood chains than for other economic sectors (FAO & ECLAC, 2020a; FAO & ECLAC, 2020b; Cano et al., 2020).

The effects of COVID-19, however, were not the same for all agrifood chain actors. They depended on many factors, including the agrifood chain type or segment (i.e., the agricultural product they are related to), stage (i.e., production, processing, logistics and distribution, input suppliers), business size, and location, among others. Reardon and Swinenn (2020) pointed out the differential impact between global and domestic food supply chains, and between chains and stages that are labor and capital-and-knowledge intensive. They noted that disruptions due to the COVID-19 pandemic in the agrifood sector were concentrated in labor-intensive chains and stages. Also, global food supply chains were more resilient than domestic chains as this type of chains are capital-intensive and are generally managed by large enterprises. Regarding global supply chains, Arita et al. (2022) also refer to the lower income elasticity of food demand and the lower levels of the supply chain fragmentation of agricultural products relative to manufacturing and other merchandise trade as possible reasons for the stability of agricultural trade.

In terms of the supply chain type, for example, Arita et al (2022) found that trade of high value agrifood products like meat (seafood, beef, poultry, and pork) were the most negatively affected by the pandemic, while staple grains (rice, soybeans, and other bulk commodities) were positively impacted. Engemann and Jafari (2022) also found that the trade of many staples and essential foods like fruits and vegetables was the least affected. A study by FAO and ECLAC (2020a) in the LAC region reported a large decrease in the export value of labor-intensive and perishable food products like live animals, fruits, and vegetables (between January and June 2020). On the other hand, agro-industrial products, including soybeans, sugar, and their derivatives, showed growth in exports, followed by such primary products as eggs and dairy.

This diversity of effects likely led to various responses, depending on the agribusinesses' resilience capabilities.[1] In the face of COVID-19, many businesses in the agrifood sector might have used ex-post or coping strategies like selling assets, increasing debt, or even resorting to plant or business closure. Others might have turned to adjusting their actions for business continuity; that is, they would have resorted to innovation (van Hoek, 2020; Barrett et al., 2021). However, little is known regarding the strategies implemented by the agrifood sector enterprises for business continuity during this catastrophic shock. Thus, the main purpose of this study was to analyze the responses toward innovations of the LAC agrifood sector[2] to the COVID-19 health emergency. The study also evaluates the heterogeneity of these responses across agrifood supply chain actors and their evolution through time.

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[1] The terms "agribusiness" and "enterprise," "firm", "business" or "company" of the agrifood chain are used synonymously. The terms refer to small (e.g., an individual agricultural producer), medium, or large (e.g., a dairy processor belonging to an international company) business units that carry out productive and/or commercial activities with agricultural, fisheries, and/or forestry product(s).

[2] For the purposes of this study, the agrifood sector is made up of the segments of traditional tropical crops, cereals, legumes and oilseeds, livestock and poultry, fruits and vegetables, ornamentals, fishing and aquaculture, and silviculture.

This study contributes to the literature by taking a comprehensive look at the responses of businesses in the LAC agrifood chains as it includes companies involved in the production, processing, distribution, and support of the supply chain of the different agrifood segments of the region. This study also constitutes one of the first longer-term quantitative assessments of the agrifood value chains, as it considers responses from the first and second years of the pandemic. The results of this study are expected to shed light on the ability of LAC agrifood businesses to respond to emergencies and how they adjusted their operations for business continuity.

Literature review

In this section, we first summarize studies evaluating the LAC chain's ability to respond to the pandemic. Second, we review studies documenting strategies used in response to the health emergency. Finally, we summarize studies exploring the relationship between business expectations about the future and the adoption of response strategies to disruptions.

According to a study conducted in ten study regions of five LAC countries, agrifood chains would have adjusted to continue functioning during COVID-19 (Albacete, 2021). Through exploratory interviews, most individuals indicated that the agrifood' businesses were able to continue operating after adjusting their operations. They either had to weather some disruptions (between 21% and 57% of the respondents in the different territories), or they had to introduce significant changes to keep operating (between 30% and 63% of the respondents).

The ability to respond to a catastrophic type of risk like the COVID-19 pandemic would depend on the risk management behavior of a firm having ex-ante strategies; for example, supplier redundancy and flexibility, as well as product diversification (Barret et al., 2021; Reardon & Swinnen, 2020). Nevertheless, factors like size and market orientation may limit or condition the

availability of such ex-ante strategies. Reardon and Swinenn (2020) pointed out that, in developing countries, domestic supply chains are the most prevalent in food provision, and these chains are dominated by SMEs, which have been less-equipped to face the COVID-19 shock.

The ability to respond to shocks also depends on available social capital and national and territorial factors like public policies and institutional innovations that facilitate ex-post measures. Regarding the latter, the Interamerican Development Bank (IDB, 2020) suggested that countries with more mature innovation ecosystems and more developed institutional capacities can react faster and more effectively to the economic consequences of COVID-19.

Several studies reported strategies used along the agrifood chains to respond to the COVID-19 health emergency. These strategies have included biosecurity measures, actions for maintaining access to labor and increasing supplier flexibility, and technological innovations for replacing labor with machines or maintaining or regaining access to markets, among others (Reardon & Swinnen, 2020; van Hoek, 2020; Barret et al., 2021). E-commerce is one of the most prominent innovations adopted to reach consumers in the middle of multiple restrictive national policies. The growth of e-commerce was notably accelerated for large companies and SMEs, the latter when stimulated by governments and NGOs (Reardon & Swinnen, 2020).

Expectations about the future have been found to play a significant role in adopted strategies. A survey conducted in 2020 by Beroe, a procurement market intelligence service, found that a large percentage of companies worldwide (64%) expected the situation to go back to normal in just a few months (within 3 to 6 months). This perception affected the quality of their reactions to COVID-19, as over 40% had not made provisions for coping with supply disruptions (van Hoek, 2020).

Companies with a longer-term view would have taken advantage of the disruption to implement product, process, and/or management innovations, leading to greater efficiency and resilience to future disruptions, such as those expected due to climate change. For example, in their review of challenges, opportunities, and potential solutions for the post-covid era, Rowan and Galanakis (2020) analyzed the European experience to accelerate sustainable innovations that favor climate change mitigation amid the COVID-19 pandemic, like the efforts to increase the ecological use of peatlands. Di Vaio et al. (2020) pointed out the importance of implementing artificial intelligence technologies to increase productivity and efficiency during COVID-19, aligning these technologies to reach higher goals related to food security and the reduction of environmental damage. As these authors suggested, one of the advantages of implementing artificial intelligence would be the required redesigning of the business model, including risk reduction. A report by FAO and ECLAC (2020c) also emphasized the opportunity afforded by the COVD-19 pandemic to change production technologies to satisfy both the increasing need for food and the need to reduce the environmental impact of food production.

As can be seen, very little is known about the reaction of agribusinesses in LAC during the COVID-19 pandemic, or about the specific strategies that different actors along the supply chains implemented for business continuity during this catastrophic shock. Most publications have centered on recommendations to businesses for facing the COVID-19 pandemic, or they have gathered information on the impact of the pandemic, mostly on trade. Some responses of agrifood chain actors have been reported based typically on anecdotal evidence, and they are mostly related to developed countries.

Hypotheses

The implementation of innovations should vary depending on several key factors. Based on the literature, we formulate three hypotheses to guide our research objectives:

- *Hypothesis 1:* Innovation would be more common among those supply chains, supply-chain stages, and actors that the pandemic had impacted the most. Thus, more innovations would be expected in domestic supply chains, downstream stages and SMEs. Also, more innovations would be expected in higher value agrifood products such as meats, and labor intensive and more perishable products as live animals, fruits, and vegetables.

- *Hypothesis 2:* The reception of support from government or private sources and credit access would have facilitated (or influenced) the implementation of innovations.

- *Hypothesis 3:* Expectations about the future should be related to the duration of the innovations implemented during the COVID-19 pandemic. Agribusinesses with a view reflecting a more positive attitude toward the future amid the COVID-19 pandemic are expected to be more likely to have implemented longer-term or continuous innovations (i.e., innovations that continued during the second year of the pandemic).

Methodology and data collection

The study used data from two online surveys conducted in 2020 (between June and August) and 2022 (between March and June), designed to gather information on the impacts of COVID-19 on agribusinesses and their responses. The surveys were distributed via social media advertisements, emails, and WhatsApp messages to reach the largest possible number of participants. Because of this sample design, the surveys are considered and analyzed as two different cross sections. The 2020 survey collected impact and response data related to the same

year it was conducted, while the 2022 survey collected data on impacts and responses in the year 2021. Respondents from 22 countries in LAC[3] participated in the surveys.

Survey respondents were individuals working in the LAC region's agrifood sector. Since respondents self-selected to participate in the study, this results in a convenience sample; hence, study results only apply to participants and may not be representative of the population of agribusinesses in the region. Still, the study provides a supply chain view of the impact and responses of an important number of agribusinesses in LAC to the COVID-19 pandemic.

Two types of actors in the agrifood sector were targeted: main actors and supporting actors. Main actors included producers, intermediaries, processors, traders, exporters, importers, and suppliers of inputs or services (business owners or employees). Support agents comprised government officials, policymakers, extension agents, academics, analysts, and consultants. The answers of support actors referred to the companies they supported.

Survey questions analyzed in this study are those related to the adoption of innovations since the beginning of the pandemic. The total number of complete responses used to study reactions to innovations to the COVID-19 health emergency was 1,354 in 2020 and 1,183 in 2022. The main question used to measure agribusinesses' responses was, "Has the company where you work or that you support adopted innovations or made an incursion in any of these activities since the COVID-19 pandemic started?" The possible responses were not mutually exclusive and included: delivery to the end consumer, adding value to the product, using digital technology for buying/selling, and product diversification. In the second survey, two options were added to the

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[3] These include Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Haiti, Honduras, México, Nicaragua, Panamá, Paraguay, Perú, Puerto Rico, Dominican Republic, Surinam, Uruguay, and Venezuela.

responses: use of labor replacement equipment and input substitution. Other options of responses in both survey years were "other," "none," or "don't know."

In addition, there were two different entries for each of the alternatives in 2021. The first one referred to temporary innovations; that is, innovations implemented at the beginning of the pandemic but that no longer applied at the time of the second survey. The second type of innovation referred to innovations that continued to be used at the time of the second survey. This second type of entry was interpreted in the study as a longer-term innovation. Table 1 shows summary statistics of the alternatives to the innovation question in both years.

The variables used to test the stated hypotheses included the agrifood supply chain stage and segment (i.e., which agricultural product is referred to); participation in exporting markets; size of the business in terms of the number of employees; receipt of support from either public or private sector; credit access; and perceptions about of the future amid the COVID-19 pandemic. Table 2 provides a detailed description and summary statistics of the variables of interest.

The statistical analyses conducted included descriptive statistics and Probit regressions. The analyses aimed to identify businesses more prone to innovate, the preferred types of innovations, the change in innovation strategies between the years 2020 and 2021, and the factors associated with the probability to innovate.

Results and discussion

Sample characteristics summary statistics

Most of the respondents in the survey represented businesses in the agricultural producer stage of the supply chain (over 50% in both years), followed by agrifood processors, actors in logistics and distribution, and input suppliers. Regarding the agrifood sector most businesses

represented in the sample were related to livestock and poultry, and fruit and vegetable production (at least 40%), followed by businesses associated with traditional tropical crops, cereals, and legumes and oilseeds (between 20 and 37%). The participation of actors in ornamentals, fisheries and aquaculture, and silviculture represented between 6 and 8% in 2020 and between 7 and 11% in 2021. Agrifood segments were not mutually exclusive in our survey, recognizing that it is common that agribusinesses in LAC are related to more than one agricultural production activity.

In both years, agribusiness owners represented about half of all respondents and employees the other half. The largest proportion of firm size was micro (less than 10 employees), representing 46% of the sample in 2020 and 32% in 2021. Female respondents were slightly under 30% of all participants in both years. The average age of our respondents was 40 years old, and most were professionals, holding at least a degree as technicians.

Regarding the LAC sub-regions, we had more participation from businesses in South America during the first survey (52%), but in the second survey, the participation of those in Central America and Mexico was higher (59%). In both years, respondents in the Caribbean were fewer than 3%.

The different types of innovations considered in the survey and their frequency are summarized in Table 1. Among the respondents, 77% reported adopting at least one innovation in 2020, and 88% reported doing so in 2021. In addition, in 2021, 42% of agribusinesses implemented at least one temporary innovation and 72% at least one longer-term (or continuous) innovation (Table 2). Most respondents reported more than one innovation, so percentages add up to more than 100%.

Descriptive statistics show that the most common innovations were delivery to the end consumer, use of digital technology for buying or selling, and product diversification, but there

were differences between 2020 and 2021. Delivery to the end consumer stood out in 2020 and among temporary innovations in 2021, but its relative importance was smaller among continuous innovations in 2021, where technology and product diversification were the most likely innovations. In addition, product value added had a more significant role as a continuous innovation in 2021 compared to 2020. These results suggest that delivery to the end consumer was, for many agribusinesses, only a temporary type of strategy used during the sanitary emergency and its resulting mobilization restrictions, which disrupted the logistics of most agrifood chains. Still, it became a long-term strategy for a large share of respondents. On the other hand, these statistics also suggest many agribusinesses took advantage of the lessons of the COVID-19 pandemic and continued redesigning their operations, incorporating more use of digital technologies, and making incursions into product diversification and value-added strategies.

Types of innovations

Figures 1 and 2 show the types of innovations reported by agrifood sector in 2020 and 2021 (continuous innovations), respectively. In 2020, the fruit and vegetable segment stood out among all supply chains for its percentage of delivery to the end consumer (60% of businesses applied this strategy) and product diversification (42%). These results likely reflect the difficulties faced by labor-intensive production stages working with perishables, where actors cannot store products, creating the need to shorten the supply chain and to consider other types of production for risk diversification. Following in adoption of delivery to the end consumer in 2020 were fisheries and aquaculture (57%) and livestock and poultry (55%). In general, the strategy of delivery to the end consumer was chosen by between 48% to 60% of agribusinesses in all agrifood sector in 2020, while the percentages were only between 34% and 46% in 2021, reflecting a reduction in the use

of this strategy as previously mentioned, possibly related to lighter government restrictions on consumer's internal mobility.

The ornamentals and fisheries and aquaculture segments stood out in using digital technologies for buying or selling in 2020, and fisheries and aquaculture also stood out in added value to their product. In 2021, the use of digital technologies was the largest compared to other strategies, and this result held for all segments. That year, the segments with the more prominent selection of product diversification were ornamentals, fruits and vegetables, and fisheries and aquaculture. Input substitution and labor replacement equipment were alternatives added in the second survey. The selection of input substitution ranged from 22% to 30%, with the largest percentage among agribusinesses in the fisheries and aquaculture segment. In the case of equipment to replace human labor, the percentages were very similar among all agrifood segments (between 17 and 19%).

Figures 3 and 4 show the results of types of innovations implemented by the agrifood supply chain stage. In both years, we observed that the use of digital technologies is much larger for processors, suppliers of inputs and services, and those actors in logistics and distribution (between 49% and 56%), compared to agricultural producers (less than 40%). This result reveals the usual lower capacity and/or access to this type of technology that affects the primary producer stage of agrifood supply chains. Also, food processors stood out for adding value to the product and in 2021, a larger proportion of businesses in this stage, compared to the other stages, innovated using input substitution.

Hypothesis testing

In this section, we test the previously formulated hypotheses regarding factors that may be associated with the decision to innovate. We show the results of three Probit regressions corresponding to the first and second surveys. For 2020, the dependent variable was the implementation of at least one type of innovation. For 2021, we estimated two models capturing the likelihood of implementing at least one type of continuous innovation and the likelihood of implementing at least one type of temporary innovation. Table 3 shows these results.

Hypothesis 1

The Probit regressions offered some evidence in favor of Hypothesis 1. Consistent with the descriptive statistics previously analyzed, most impacted agrifood segments in the sample (due to the characteristics of their production process and/or of their product), such as fruits and vegetables and livestock and poultry, were found to be more likely to innovate in 2020 (8.2% and 13.8% more likely to innovate, respectively), although the result holds only for fruits and vegetables in the 2021 continuous innovations Probit regression (participating in the fruit and vegetable segment increased the probability of innovation by 9%). We also saw that, as expected, participating in commonly export-oriented chains like traditional tropical crops is not associated with the probability of implementing innovations.

Regarding the supply chain stages, downstream stages were expected to be more likely to implement innovations. Probit results indicate that all stages with activities taking place after primary production, and those providing inputs and services to producers or processors, were more likely to implement continuous innovations in 2021 (at least 8% more likely to innovate compared to the agricultural production stages). This was also found for food processors and suppliers of inputs/services regarding the implementation of innovations in 2020 (at least 7% more likely to

innovate relative to the agricultural production stage). These results are consistent with our descriptive statistics analysis (Types of innovations section).

In line with our first hypothesis, smaller companies were expected to be more likely to implement innovations. Probit regression in 2020 showed evidence in favor of this hypothesis, as the marginal effects coefficient was negative and significant for company size (increasing the category of company size at one level would decrease the likelihood of implementing innovations by almost 3%). The result held for temporary innovations in 2021 (-4%), but not for continuous innovations. This result may reflect the larger flexibility of smaller companies to implement some—perhaps small—changes in a short period; at the same time, it reveals their lower capacity to implement longer-term innovations.

Results regarding Hypothesis 1 seem to show, on the one hand, that most impacted firms were more likely to implement innovations (domestic oriented, labor intensive, and more perishable-product supply chains, downstream stages, and smaller-size agribusinesses). On the other hand, the results may reflect the larger innovation capacity of some actors, like that of food processors, and the smaller capacity of SMEs to implement longer-term innovations.

It must be noted too that firms in Central America were more likely (7%) to implement at least one type of longer-term innovation relative to South American actors in 2021, while 2020 results suggest that within the sample observed, agribusinesses in the Caribbean were less likely than those in South America to implement innovations. In addition, in 2021, support actors were 8% more likely than main supply chain actors to report that the firms they support had implemented temporary innovations, but they were 6% less likely to report at least one type of continuous innovation regarding those agribusinesses. This result may be reflecting the more imperfect

knowledge of support actors relative to main chain actors regarding the evolution of agribusinesses' decisions.

Hypothesis 2

Table 2 shows that 37% of the 2020 sample benefited from at least one type of support program (external support coming from either the public or private sector or NGOs). This percentage was 35% among respondents in 2021; however, we also differentiated between temporary and continuous support (i.e., support that continued at the time of the survey) in that year. 31% of the 2021 sample had received temporary support, and only 15% received continuous support. Table 4 details the types of support received in each case (survey year and temporary or continuous condition). For those receiving support in 2020, preferential loan rates stand out as the most frequent type of support (37%), followed by training services (29%). Among those receiving temporary support in 2021, debt restructuring (47%), flexibility in labor laws (44%) and preferential loan rates (44%) were reported more frequently, while for those receiving continuous support, training services are by far the most reported type of support (53%) followed by flexibility in labor laws (32%) and preferential loan rates (28%).

Probit results provide evidence of the association of support from either the public or the private sector to the implementation of innovations, as the marginal coefficient was positive and significant in both survey years. Particularly, in 2021, we can see the relationship of each type of support (temporary or continuous) with the implementation of innovations.[4] We find that those who received continuous support were 15% more likely to implement continuous innovations, and this was the variable with the largest marginal coefficient in the model. On the contrary,

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[4] Although several agribusinesses had access to both temporary and continuous support, the correlation coefficient between these two variables was not high (0.35).

beneficiaries of continuous support were 12% less likely to implement temporary innovations. Temporary support was not significant in any of these two regressions, which adds evidence that the type of support that is associated to longer-term innovations is a continuous type of support. In 2020, the marginal coefficient implied a 9% higher likelihood of innovating for those receiving external support.[5] .

The variable of access to credit was only included in the second survey. Table 2 shows that slightly above half of the respondents in 2021 had access to credit from either formal or informal sources, formal credit access being more prevalent (47%) than informal credit (20%). In the Probit regression, both types of credit were included separately.[6] Results revealed the importance of having access to credit to be able to implement innovations. The coefficient was positive and significant for both types of credit in both regressions (continuous and temporary innovations), but access to formal credit relates more strongly than access to informal credit with the implementation of continuous innovations (10% for formal credit vs. 6% for informal credit). In contrast, the estimated margins of informal credit for the likelihood of implementing temporary innovations was larger than that of formal credit (11% for informal credit vs 8% for formal credit).[7]

Hypothesis 3

The surveys also gathered the perception toward the future (expected scenario for the company one to two years from the time of the survey). Figure 5 shows the percentage frequencies

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[5] An interaction term between firm size and support was included to see if the effect of support was stronger for smaller agribusiness but the term did not turn out significant in any of the regressions, therefore it was not included in the models.

[6] Although several agribusinesses reported access to both types of credit, the correlation coefficient between these two variables was not high (0.28).

[7] An interaction term between firm size and credit was included to see if the effect of credit was stronger for smaller agribusiness but the term did not turn out significant in any of the 2021 regressions, therefore it was not included in the models.

of the response alternatives. Adaptation to new circumstances was the most common answer in 2020, while the increase in production levels stood out in 2021. These two categories added up to 61% in 2020 and to 68% in 2021, and they are considered to reflect positive attitudes toward the future when compared with the other categories, which reflect a more neutral, negative, or uncertain perspective.

The hypothesis that there may be a relation between a more positive attitude toward the future and implementing innovations, especially continuous innovations in 2021, found evidence in the Probit regression. We found positive and highly statistically significant marginal coefficients in both survey years. In 2020, those with a positive attitude were 7% more likely to implement innovations, while in 2021, they were 11% more likely to implement longer-term innovations. This variable did not turn out to be significant in the regression regarding temporary innovations in 2021, adding evidence to the association of this variable to longer-term but not to temporary innovations.

Summary and Conclusions

Our study found that a large percentage of supply chain actors in LAC implemented innovations in both survey years (77% in 2020 and 88% in 2021), and a large part of the innovations in 2021 were continuous (longer-term) innovations (82% of those applying at least one type of innovation). This reflects the fast reaction of agribusinesses in the region, which allowed them to continue to operate, as well as their attitude toward taking advantage of the opportunity to implement longer-term innovations.

Still, close to 30% of the respondents in 2021 either did not apply any type of innovation (12%) or applied only temporary innovations (16%). Limitations like short-term thinking, cost-reduction behavior (van Hoek, 2020), and the slower growth in digitalization compared to other

regions of the world (Agudelo et al., 2020), together with structural economic factors like inequalities in the access to key innovations (Barrett et al., 2021), could have been an important hindrance for innovation and risk management for many of LAC's supply chain actors, affecting their ability to respond and/or the quality of their responses.

The finding that most impacted actors have been more likely to innovate reflects what we can call reactive innovations, which in many cases can be temporary or require only small investments. This tended to be the case for small businesses like micro and small enterprises and for those agribusinesses in chains where the products are more perishable.

Our results also confirm the importance of having access to external support, which is consistent with the understanding that the implementation of innovations in a business does not take place in isolation; rather, it requires a favorable context with the involvement and support of other actors (Berdegué & Fuentealba, 2011; Albuquerque, 2015). These findings also reveal the importance of continuous support to encourage longer-term innovations. Similarly, access to credit was strongly associated to the implementation of longer-term innovations in 2021.

Finally, we found evidence of a relationship between implementing innovations, especially longer-term innovations, and a positive perspective of the future. Although a positive attitude is expected to influence innovation, determining the direction of the influence would require further study as, in this case, the implementation of innovations and the type of such innovations could have given the respondents a more positive perspective for the future. Notwithstanding, a positive attitude toward the future is expected to motivate not only longer-term innovations but also innovations that take higher objectives into account, like climate change, food security, food safety, and sustainability. The acknowledgment of what the future holds, together with a positive attitude, would be a first step for addressing the necessary transformation of our agrifood systems.

Barret et al. (2020) emphasized that to reach such transformation, a bundle of socio-technical innovations is required; that is, the implementation of mutually reinforcing technological, sociocultural, and policy innovations, with the participation of all stakeholders that respond to the requirements of each agrifood system.

Further research would help to broaden the analysis of innovations of agribusinesses in LAC, by looking more specifically into the types of innovations implemented and into the motivations for investing in longer-term innovations. The use of representative samples of the population of businesses in each agrifood stage in LAC is also recommended. Moreover, a future work should focus on the study of causal effects of support programs, access to credit and perspectives about the future on agribusiness innovation, as this study only assesses the association between these variables.

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Table 1. Types of innovations

Types of innovations	2020 (%)	2021	
		Temporary (%)	Continuous (%)
Delivery to the end consumer	48	26	39
Adding value to the product (washing, packing, processing, etc.)	25	17	31
Using digital technology for buying/selling	43	17	45
Product diversification	33	16	40
Use of labor replacement equipment	-	0	17
Input substitution	-	0	23
Other	2	1	1
None	14	3	4
Don't know	6	3	2

Table 2. Summary statistics of the sample characteristics

Characteristics	Description	2020	2021
Total observations		1,354	1,183
Age -Mean (Standard deviation)		39.9 (14.5)	40.7 (14.2)
			Percentage (%)
Gender			
Male		70.1	71.7
Female		29.9	28.3
Type of actor			
Main actor	Owners or employees in agribusinesses (producers, processors, suppliers of inputs/services, intermediaries, logistics, exporters, importers, production technicians)	61.0	67.1
Support agent	Government officials, policymakers, extension agents, the financial sector, academics, analysts, NGOs, and international cooperation.	39.0	32.9
Education			
Middle school or below		4.8	0.5
High school		4.5	0.9
Professional	Technicians, BS, graduate degree	90.8	98.6
Relationship with the company			
Owner		51.3	46.0
Employee		48.7	54.0
Agrifood segment			
Traditional tropical crops		30.4	36.5
Cereals		31.2	27.2
Legumes and oilseeds		20.4	19.5
Livestock and poultry		43.8	40.0
Fruits and vegetables		43.7	40.7
Ornamentals		6.7	11.1
Fisheries and aquaculture		8.0	9.6
Silviculture		6.0	6.9
Agrifood supply chain stage			
Agricultural producers		62.1	53.2
Agrifood processors		14.6	20.9
Input suppliers		10.1	12.7
Logistic and distribution		13.2	13.3
Region			
South America		52.3	37.3
Central America and Mexico		42.5	59.4
The Caribbean		2.9	1.9

Exporters	Export part or all their production	33.6	34.6
Company size (Employees)			
Micro	Less than 10 employees	46.1	32.4
Small	10-49 employees	17.2	16.4
Medium	50-200 employees	8.6	10.8
Large	More than 200 employees	14.6	22.3
Innovated	Implemented at least one type of innovation	77.0	88.0
Temporary innovation	Implemented at least one type of temporary innovation	-	41.6
Continued innovation	Implemented at least one type of continued innovation	-	72.1
Received support	Support from the public or private sector or NGOs in the form of preferential access to credit, subsidies, and training, among others (in 2021, reception of benefits from programs destined to the household were added to the response alternatives)	37.3	35.3
Temporary support		-	30.6
Continuous support		-	15.1
Access to credit	Accessed to credit from either formal or informal sources	-	51.7
Formal	Accessed to credit from formal sources	-	46.5
Informal	Accessed to credit from informal sources	-	20.2
Perception of the future	The perspective of the more likely future for the company. The answers considered for this variable are that the expectation is an increase in production levels or an adaptation to new circumstances	60.6	67.6

Table 3. Probit regression results for the probability of implementing innovations

Variable	2020 (Probability of implementing innovations)			2021 (Probability of implementing continuous innovations)			2021 (Probability of implementing temporary innovations)		
	Margins dy/dx	Standard error	P-value	Margins dy/dx	Standard error	P-value	Margins dy/dx	Standard error	P-value
Support actor	0.043	0.026	0.103	-0.062**	0.029	0.034	0.082**	0.033	0.014
Food processors	0.119***	0.035	0.001	0.082**	0.034	0.017	-0.011	0.039	0.771
Suppliers of inputs	0.071*	0.041	0.081	0.086**	0.043	0.045	0.002	0.048	0.973
Logistics and distribution	0.051	0.037	0.168	0.080*	0.041	0.053	-0.037	0.046	0.424
Central America and Mexico	0.026	0.025	0.294	0.074***	0.026	0.005	-0.006	0.030	0.845
Caribbean	-0.125*	0.067	0.063	0.028	0.102	0.783	-0.104	0.121	0.389
Exporter	-0.005	0.027	0.856	0.043	0.031	0.158	-0.042	0.034	0.216
Size (#employees)	-0.027**	0.011	0.016	0.008	0.011	0.443	-0.036***	0.012	0.003
Traditional tropical crops	0.040	0.028	0.150	-0.004	0.029	0.902	0.010	0.032	0.760
Cereals	0.001	0.029	0.976	0.043	0.033	0.200	-0.026	0.037	0.484
Legumes and oilseeds	0.049	0.035	0.163	-0.003	0.040	0.933	-0.009	0.044	0.841
Livestock and poultry	0.082***	0.026	0.001	-0.004	0.028	0.884	-0.017	0.031	0.579
Fruits and vegetables	0.138***	0.025	0.000	0.093***	0.029	0.001	0.052	0.032	0.108
Ornamentals	-0.016	0.052	0.755	0.002	0.046	0.962	-0.041	0.051	0.424
Fisheries and aquaculture	0.022	0.047	0.648	0.041	0.048	0.394	-0.036	0.052	0.494

	Coef.	SE	p	Coef.	SE	p	Coef.	SE	p
Silviculture	-0.023	0.053	0.671	-0.022	0.054	0.685	0.097	0.062	0.118
External support	0.089***	0.025	0.000						
External continuous support				0.147***	0.041	0.000	-0.117***	0.045	0.009
External temporary support				-0.022	0.030	0.469	0.030	0.035	0.381
Positive future perspective	0.072***	0.024	0.002	0.110***	0.027	0.000	-0.038	0.032	0.227
Formal credit				0.097***	0.027	0.000	0.081***	0.031	0.008
Informal credit				0.064*	0.035	0.067	0.107***	0.038	0.005
Number of observations	1,170			1,071			1,071		
Area under ROC curve	0.700			0.689			0.644		

Note: Asterisks (***, **, and *) indicate significance level of 1%, 5%, 10% respectively.

Table 4. Types of external support among those who received at least one type of support

Type	2020 (%)	2021	
		Temporary (%)[a]	Continuous (%)[b]
Preferential rates for loans	37.2	43.9	27.5
Debt restructuring (terms and interest rate)	20.2	47.2	18.1
Flexibility in labor laws	26.7	44.2	32.0
Cash subsidies	21.4	34.5	15.2
Preferential access to credit	23.4	31.5	15.7
Direct input subsidies	25.2	34.5	15.7
Training services	29.3	38.7	52.8
Government purchase of products	14.1	26.8	14.6
Family-focused support programs	-	32.9	20.2
Received any type of support	37	31	15

[a] Percentages are based on those who received at least one form of temporary support.

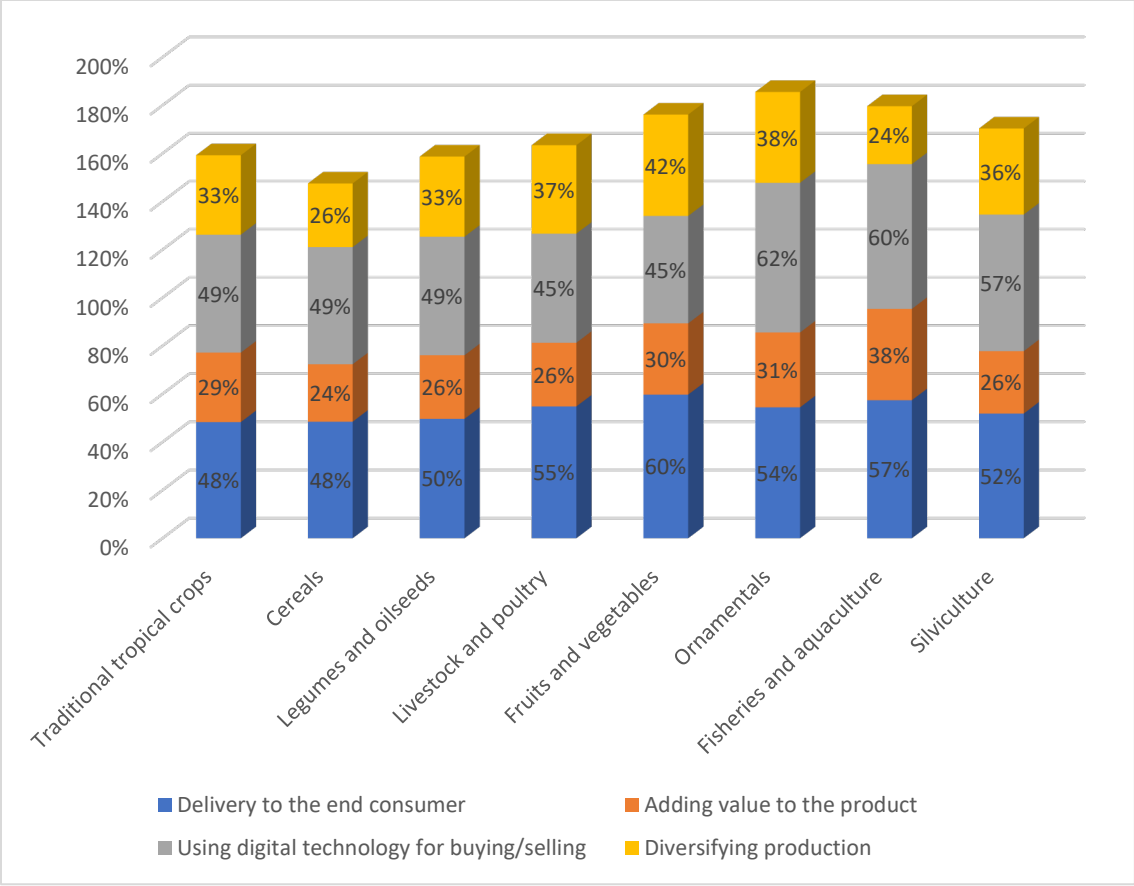[b] Percentages are based on those who received at least one form of continuous support.

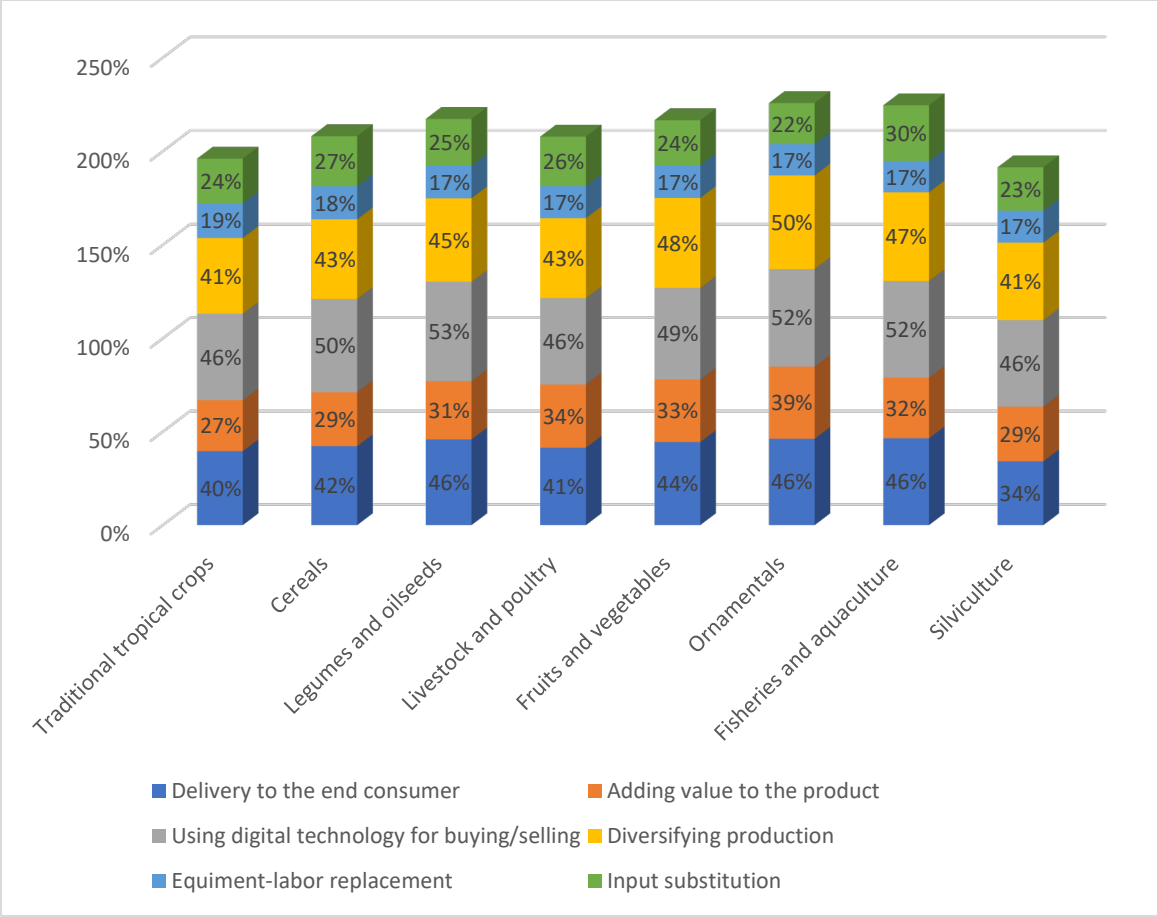**Figure 1. Types of innovations by segment of agrifood sector in 2020**

Figure 2. Types of continuous innovations by segment of agrifood sector in 2021
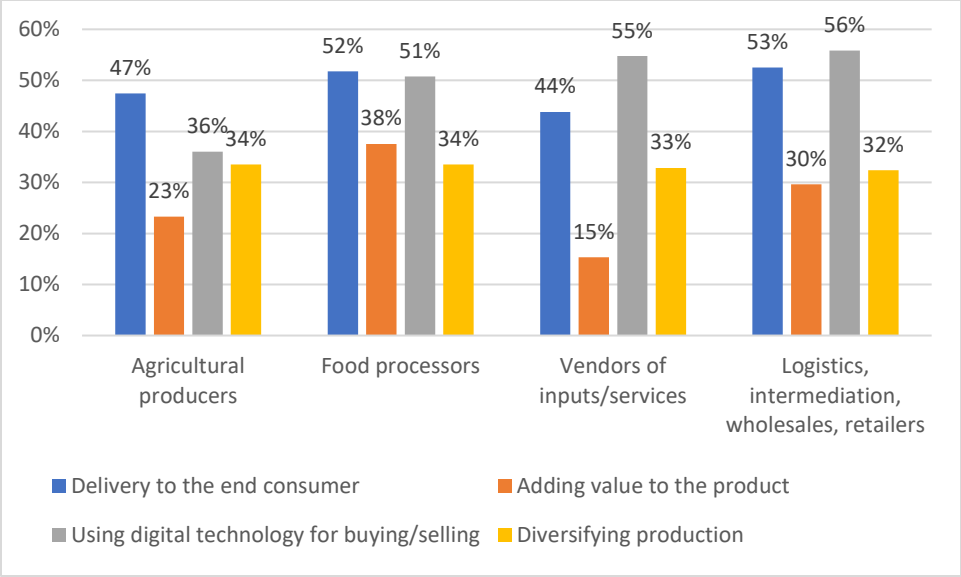
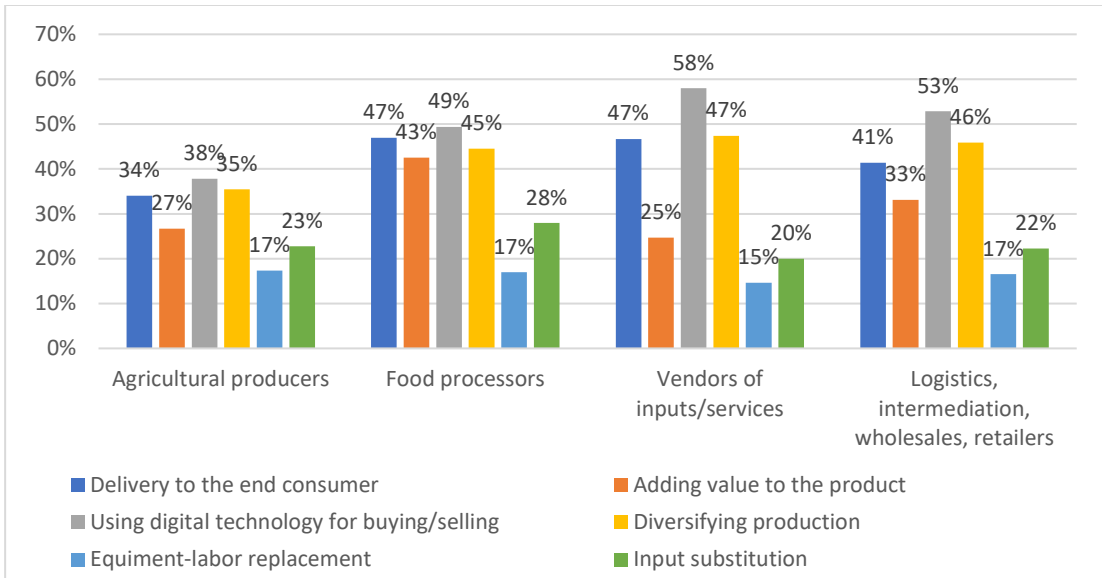**Figure 3. Types of innovations by agrifood supply chain stage in 2020**

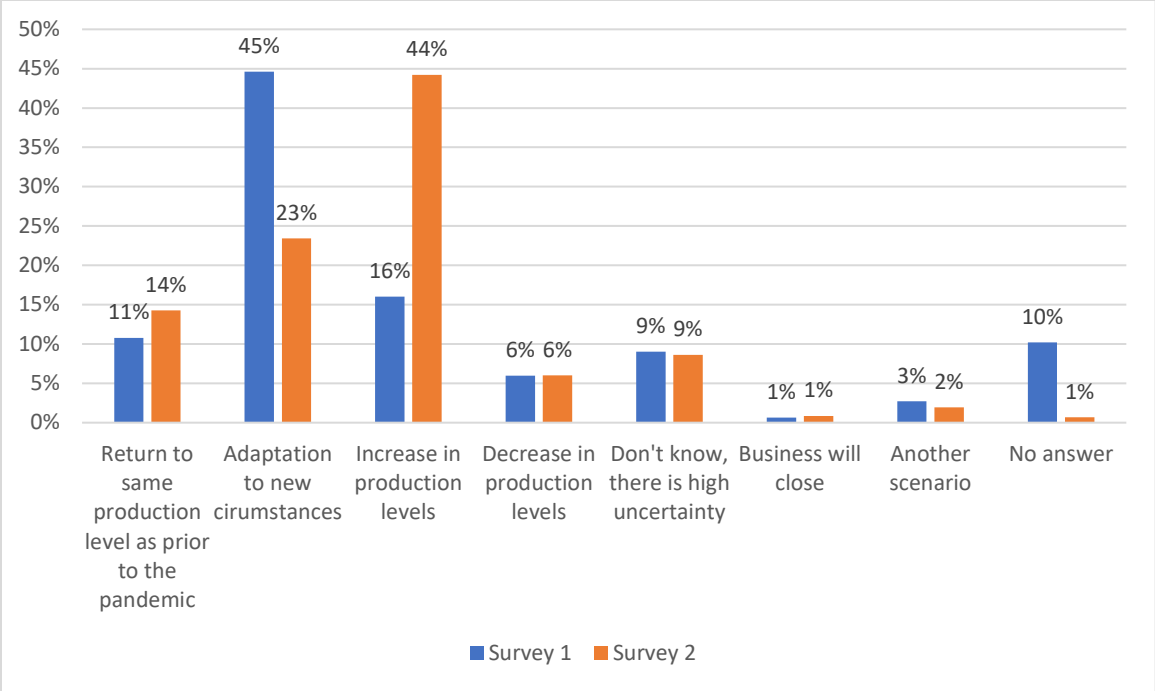**Figure 4. Types of continuous innovations by agrifood supply chain stage in 2021**

Figure 5. Future scenario perspective (one to two years from the time of the survey)