Sustainability and economic performance of startups in the AgTech sector: empirical evidence from Argentina

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Abstract

In this paper, we build a sustainability score to measure the performance of Argentine companies in the AgTech sector in its social and environmental dimensions, by using data from the companies themselves that we collected through own surveys in 2022 and 2023. Then, we use regression models to estimate the effect of the social and environmental performance of companies on two economic performance indicators (revenues and insertion in foreign markets) that adequately signal the scaling potential of startups. Our main results suggest that, beyond the potential of the firms, there is still a long way to go to expand the scope of their social and environmental sustainability. While companies believe they contribute to the achievement of the SDGs and produce carbon-smart results, they could improve web-based communication, which highlights a lack of public commitment to sustainability and inconsistencies with respect to what they declare in our survey. In addition, most of the firms do not have sustainability certificates, nor do they measure the social and environmental impact of the technology they offer. Econometric estimates suggest that social and environmental performance tends to correlate negatively with companies' revenues, although this effect is likely to be reversed for high levels of sustainability, suggesting that consumers "asymmetrically value" different degrees of sustainability. However, we find that better social and environmental performance increases the likelihood of go beyond the boundaries of the local market by accessing foreign markets.

JEL classification: Q01, Q10, Q55

Keywords: Sustainable AgTech, Startups, Sustainable Development Goals

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1. Introduction

Agrifood systems have been undergoing radical transformations since the last century, driven both by social demands and by the need to increase global production while reducing its costs. In the 20th century, the so-called "Green Revolution" expanded the production of calories for a growing population that demanded them at low prices for their subsistence. Once a very high productivity was achieved, technologies were aimed at achieving food production in accordance with the new demands of consumers who required more information about them, their origin, the methods with which they were produced and the consequences for their health and nutrition. In the 21st century, claims about the environmental and social consequences of food production emerged with force being placed on the Sustainable Development Goals (SDGs) approved in the United Nations 2030 Agenda. "Zero Hunger", "Responsible Consumption and Production", "Climate Change", "Life on Earth", among other SDGs - are directly related to the new challenges facing the global agri-food system.

In Latin America and the Caribbean (LAC) and other regions of the world, agrifood systems contribute to the economic development of their countries feeding their growing population, while generating valuable ecosystem services for the rest of the world. However, millions of people in those regions still suffer from regular hunger or malnutrition and related diseases. Therefore, the current challenges faced by their agrifood systems include providing healthy diets accessible to the entire population, safeguarding the planet's environmental conditions, while transforming low-productivity rural agricultural systems to contribute to the fight against poverty and global inequality (Barrett et al., 2022; Herrero et al., 2021; Navarro et al., 2022).

Since the adoption of the 2030 Agenda by the UN in 2015, there has been a growing interest in assessing the adoption of sustainable practices by companies. Initially, this focus was on companies in developed countries. In recent years, there has been a growing focus on developing countries. For example, Echeverri-Pimienta et al. (2022) conducted a study on a group of Latin American countries, while Manrique et al. (2017) examined a combination of developed and developing countries.

However, the aforementioned studies analyze the effect of the commitment to sustainability of large firms that are mostly listed on the stock exchange. However, in agrifood ecosystems, innovation is strongly associated with hundreds of AgTech startups. This phenomenon is especially relevant in LAC, particularly in Brazil and Argentina, but also in Colombia, Chile, Costa Rica, among others. There are few empirical studies linking startups' commitment to sustainability to their economic performance. Among them, Navarro et al. (2022) find evidence that AgTech entrepreneurs in LAC, although they are aware of the SDGs and globally understand how their business contributes to them, lack instruments to monitor the social and environmental impact of their innovations.

This paper pursues two general objectives. At first, we build a sustainability score to measure the performance of Argentine companies in the AgTech sector in its social and environmental dimensions. For this, we use data from the companies and complementary information exogenous to them. In this sense, in the absence of an international sustainability score for young and innovative companies that are not listed on the stock exchange, it is expected to contribute with a first methodological approach that could be replicated in other countries in the region. Second, we use regression models to estimate the effect of the social and environmental performance of companies on two economic performance indicators (revenues and insertion in foreign markets) that adequately signal the scaling potential of startups. These estimates provide empirical evidence on the profitability of improving their social and environmental performance.

Our main results suggest that, beyond the potential of the firms, there is still a long way to go to expand the scope of their social and environmental sustainability. While companies believe they contribute to the achievement of the SDGs and produce carbon-smart results, they could improve web-based communication as well as the measurement of their social and environmental impact. Indeed, econometric estimates suggest that social and environmental performance tends to correlate negatively with companies' revenues, although this effect is likely to be reversed for high levels of sustainability. In addition, we find that better social and environmental performance increases the likelihood of accessing to foreign markets.

This paper contributes to the literature by analyzing the sustainability of a key innovative actor in Argentina's agri-food ecosystem. Also, given the absence of an international sustainability index for young innovative companies -startups- this study contributes to highlight the need for such an index and presents an opportunity to discuss a methodology for its construction. Furthermore, measuring the economic effect of adopting sustainable practices provides empirical evidence to answer the question of whether it is profitable for companies to improve their social and environmental performance. Our study is a valuable contribution not only for academic purposes, but also as a practical tool for decision making by all stakeholders: companies, consumers, investors, policy makers, international organizations, green funds and other interested parties. Equally important is the possibility of scaling up the approach used in this research so that it can be replicated in other countries with potential in the AgTech startup sector.

2. Literature review

Since there is no single optimal socio-technological package to address the social and environmental challenges of different agrifood systems, technological innovations are diverse and, in general, are characterized by a complex and long-term trajectory for their solutions to be effective. These innovations also have the potential to introduce deep and disruptive changes in the links of the global food chain, particularly those that are at the forefront in fields such as biotechnology, artificial intelligence, robotics, blockchain, advanced materials science, photonics, electronics, and quantum computing (Peña & Jenik, 2023). However, the introduction of these new technologies could have very different impacts, with favorable consequences for some SDGs and undesired adverse effects for others (Fundación Endeavor Argentina & Bain & Company, 2022; Herrero et al., 2020; Herrero et al., 2021). The growing importance of AgTech innovation is evidenced by the growth of venture capital investment in the sector, which globally went from US$3.1 billion in 2012 to US$29.6 billion in 2022, with a large share from South America, where it expanded from US$79 million to US$1.87 billion (Vergara, 2023).

On the other hand, it cannot be ignored that cultural changes are also a relevant factor in the transformation trajectory of agrifood systems, aligning traditional economic interests (profits) with broader social objectives. Some profit-maximizing companies make decisions aimed at social and environmental well-being without moving away from traditional economic objectives, even when they do not face legal requirements, adopting what is known as Corporate Social Responsibility (CSR).

Companies have incentives to adopt CSR if it contributes to reducing costs, including future regulatory costs. It could also be adopted as a communication and marketing tool to attract consumers and investors. If consumers face search costs, companies may turn to CRS and advertising to capture their attention. In the presence of asymmetric information, invest in CSR spending could be a signal to convey additional information to investors about their financial strength beyond the traditional one. Traditional economic benefits could also be increased by addressing the social motivations of stakeholders. Consumers may be willing to pay higher prices for products that meet certain social requirements, or they may not buy certain products because of their consequences on the environment. The adoption of CSR could allow companies to expand faster or perhaps also pay lower costs if investors and employees have social preferences (Glazer et al., 2010; Lassala et al., 2021; Khaled et al., 2021; Manrique et al., 2017; Schmitz & Schrader, 2013). The ability of companies to respond to stakeholder pressure is partly conditioned by the presence of asymmetric information and signaling problems. Stakeholders' difficulty in correctly identifying the degree of companies' commitment to sustainability, negatively influences market reputation. For example, consumers may perceive that the entire chain has a low commitment to sustainability when they buy from some companies without such commitment. Due to the incentives of companies to act as free riders of sectoral reputation, it is likely that the unilateral commitment of some of them is insufficient to eliminate the problems caused by asymmetric information. In this sense, some authors (Fischer et al., 2008; Hobbs, 2004) show the importance of b2b cooperation in the adoption of traceability systems to provide transparency to the whole value chain. Ex ante, quality or safety certification of a product reduces consumer uncertainty with respect to these attributes, while ex post traceability protects producers with good practices from the negative externalities that may be caused by producers with bad practices.

Finally, some companies – called social or hybrid enterprises – prioritize social outcomes over economic ones. These companies define their business model with the aim of contributing to solving a certain social or environmental problem (e.g., B Corps) (Diez-Busto et al., 2021; Romi et al., 2018; Schmitz & Schrader, 2013; Stubbs, 2017).

Although there is no consensus in the literature that analyzes the relationship between CSR and financial performance, empirical studies generally show a positive association between both, or at least that their incorporation would not harm financial performance. In part, the mixed results found by the empirical literature are related to the data sources, the temporal extension of the relationship analyzed, and the empirical methodology used (Lassala et al., 2021; Manrique et al., 2017). In a paper for Latin American countries, Echeverri-Pimienta et al. (2022) find a positive correlation between the contribution to the SDGs (measured by ESG index) and financial performance (ROA and ROE) of listed companies for Colombia, Chile, Mexico and Peru, of which 24% belong to the food industry. For their part, Manrique et al. (2017) show that prioritizing environmental performance (measured by the first dimension of an ESG Index) is positively correlated with accounting and financial performance measures, and that this influence is stronger in developing countries.

The empirical literature on B corporations is still evolving and has not yet reached a definitive conclusion on the relationship between certification and financial performance. Some authors find that it has a positive and statistically significant effect on the sales growth rate compared to their private counterparts without such certification (Gazzola et al., 2019; Paelman et al., 2020; Romi et al., 2018), while others suggest similar (Chen & Kelly, 2015) or negative performance (Gamble et al., 2020).

3. Data and methodology

Currently, there are no harmonized databases that systematically collect information from startups in the AgTech sector in Argentina and LAC. This lack is partly due to the dynamic – and still emerging – nature of the sector in the region. However, we had access to socioeconomic and business model data for startups in the AgTech sector compiled by Fundación Endeavor Argentina in 2022 for a set of companies in the country. This information was obtained from a survey conducted between May and July 2022 to startup founders, mostly CEOs. The survey consisted of 40 questions organized in 5 thematic sections: general characteristics of the company, commercial and financial profile, human capital, projections and entrepreneur's profile. Of these questions, 18 were open-ended and 22 closed-ended, distributed in 5 binary, 2 rating scales, 12 single-choice, and 3 multiple-choice. It includes data on the revenues of the firms (in ranges), year of foundation, number of workers, financing, markets and products, obstacles that prevent their growth, among other variables. Thus, the data collected was subjected to an initial analysis to verify the consistency of the responses. If inconsistencies were detected, the corresponding entrepreneur was contacted to request clarification and correct possible errors. For example, an entrepreneur who initially indicated that he/she had not received external investment, but then mentioned financing from family and friends, was sent an email to rectify the information.

To expand the number of observations and identify firms that may not have been in Endeavor's report, we conducted ad hoc searches through the Internet and consulted industry experts. Then, we sent them a survey between July and October 2023 to collect socioeconomic and business model data. At the same time, we obtained access to the Crunchbase[1] platform to validate the companies from our database.

Although there are international scores to measure the social and environmental performance of companies (for example, the ESG scores of Refinitiv - London Stock Exchange Group), this type of database does not include the universe of companies under study. The startups are not listed on the stock exchange and there is no publicly accessible information about them to estimate such performance. Given these limitations, we sent to all the companies of our database a module of questions that aim to measure their degree of commitment and contribution to the SDGs linked to social and environmental dimensions[2], based on the previous work of Navarro et al. (2022). After combining the data from both question modules and performing a final cleanup of the information collected, our database includes approximately 200 companies in the AgTech sector (about 85% corresponds to Endeavor's report and 15% are new companies identified).

Based on the information in the second module of questions, we build a sustainability score for each company in our database, normalizing and aggregating a set of variables that measure different dimensions of the firms' social and environmental performance. In a first version of the score, seven indicators were used, which can be divided into two groups.

The first group includes ordinal categorical variables and numerical variables. On the one hand, we have the contribution to the SDGs as perceived by the company, based on an index that varies between 0 (does not contribute) and 5 (very high or significant contribution). Since we have this index for each SDG of our interest, we summarize the subjective contribution by computing a simple average. On the other hand, we have information about the number of carbon-smart outcomes that companies' technology contributes to achieving. These results include: increased production with the same or less amount of agricultural inputs; reduction of greenhouse gas emissions (biological methane, nitrous oxide, carbon dioxide, etc.); adaptation to the expected impacts of climate change (floods, warmer/colder temperatures, changing weather patterns, etc.) and other carbon-smart outcomes. In addition, based on an analysis of the firms' websites, two variables were constructed to approximate their degree of public commitment to sustainability and consistency respect to what was declared in our survey. Thus, we consider the degree of public commitment to be Null (if the firm does not mention its commitment to sustainability on its website), Medium (if the mention is vague) or High (if it explicitly mentions its commitment to sustainability, usually in a specific section of its website). Similarly, the

[1] Crunchbase is a platform that groups business information about innovative private and public companies from around the world.
[2] "SDG 2 - Zero Hunger", "SDG 5 - Gender Equality", "SDG 6 - Clean Water and Sanitation", "SDG 7 - Affordable and Clean Energy", "SDG 9 – Industry, Innovation and Infrastructure", "SDG 12 – Responsible Consumption and Production", "SDG 13 – Climate Action", and "SDG 15 – Life on Land".

consistency with respect to what is declared in our survey can be Null (if the company does not mention on its website the SDG to which it claims to contribute mainly), Medium (if the mention is vague) or High (if the SDG is explicitly mentioned).

The second group comprises three binary variables, whose possible values are "yes" or "no" in response to the following questions: (1) *Does your company conduct systematic measurements or assessments to determine its social and/or environmental impact?* (2) *Does your company have any sustainability certifications?* (3) *Is your company's technology or innovation aimed at MSMEs, family producers, indigenous peoples or other vulnerable social groups?* Naturally, when the company answers yes to these questions, it is beneficial for sustainability.

Once the ordinal and binary categorical variables were converted into numeric, the seven variables were normalized using the min-max method so that they vary in the range [0, 1]. To calculate the score, a simple average of the values of the normalized variables was computed[3] and the result was multiplied by ten, so that the score varies in the range [0,10], where a higher value indicates a better social and environmental performance of the firm.

On the other hand, we constructed a second version of the score by feeding the first one from the measurements of Herrero et al. (2021), which allows to incorporate exogenous information about the sustainability of the firm. This study computes a score that measures the direct and indirect effect of different technologies on each of the SDGs, based on the opinion of experts. In order to combine this information with our database, the websites of the firms were analyzed and classified by technological group, according to the categories of the aforementioned work: Cellular agriculture; Digital agriculture; Food processing and safety; Gene technology; Health; Inputs; Intensification; Replacement food and feed; Resource use efficiency. [4] Then, for each technology group, the scores of Herrero et al. (2021) for the SDGs of interest were summed, and the result was normalized using the min-max method. Finally, the second version of the score was calculated from a simple average between the seven normalized variables that make up the first version and the normalized score of the aforementioned study.[5]

Regarding the analysis of the data, we used traditional methods of descriptive statistics for a first inspection of the information, and then we estimated regression models to quantify the relationships between the level of sustainability of the firms and economic performance variables (revenues and insertion in foreign markets). Regarding the first economic performance variable, since startups' revenues are measured in ranges, we are dealing with interval-coded data. Let y be the (unobserved) log-revenue and $r_1 < r_2 < \cdots < r_J$ the known interval limits. Then we have:

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[3] In the case that, due to lack of response from the firms, there are missing values for one or more variables, these variables are considered to have a value of zero, in order to avoid the loss of observations. However, if all the variables that make up the score have missing values, no value is assigned to the score.

[4] Cellular agriculture includes: Artificial meat/fish, Artificial products, Molecular printing. Digital agriculture includes: Robotics, Nanotechnology, Internet of Things, Traceability technologies, Farm-to-fork virtual marketplace, Big data, Drones, Artificial intelligence, Intelligent food packaging, Advanced sensors, Improved climate forecasts, Data integration, Tracking / confinement tech for livestock, among others. Food processing and safety includes: Biodegradable coatings, Sustainable processing technologies, Drying/stabilisation, Whole genome sequencing, Food safety tech, among others. Gene technology includes: Synthetic biology, Novel nitrogen - fixing crops, Biofortified crops, Plant phenomics, Disease/pest resistance, Weed - competitive crops, Genome wide selection, Reconfiguring photosynthesis, Genome editing, GM assisted domestication, RNAi gene silencing, Genomic selection, among others. Health includes: Personalised food. Inputs includes: Soil additives, Nanofertilise, Enhanced efficiency fertilisers, Nanopesticides, Nanoenhancers, among others. Intensification includes: Irrigation expansion, Electro - culture, Vertical agriculture. Replacement food and feed includes: Microalgae & cyanobacteria for food, Insects for food, Microbial protein, Livestock/sea food substitutes, Dietary additives for livestock, among others. Resource use efficiency includes: Circular economy.

[5] If the first version of the score had a missing value, the second version of the score is also assigned a missing value.

$$w = 0 \text{ if } y < r_1, w = 1 \text{ if } r_1 \leq y < r_2, \ldots, w = J \text{ if } y \geq r_J$$

Although we do not observe y, we are still interested in modelling $\mathrm{E}(y|\mathbf{x}) = \mathbf{x}\boldsymbol{\beta}$, where $\mathbf{x}$ is a vector of explanatory variables and $\boldsymbol{\beta}$ is a vector of parameters to be estimated. Under the normality assumption of the error term in the equation $y = \mathbf{x}\boldsymbol{\beta} + u$, the vector $\boldsymbol{\beta}$ can be estimated through maximum likelihood (Wooldridge, 2010). The log likelihood for a random draw i is:

$$l_i(\boldsymbol{\beta}, \sigma) = 1[w_i = 0]\log\{\Phi[(r_1 - \mathbf{x}_i\boldsymbol{\beta})/\sigma]\} + 1[w_i = 1]\log\{\Phi[(r_2 - \mathbf{x}_i\boldsymbol{\beta})/\sigma]$$
$$-\Phi[(r_1 - \mathbf{x}_i\boldsymbol{\beta})/\sigma]\} + \cdots + 1[w_i = J]\log\left\{\Phi[(r_J - \mathbf{x}_i\boldsymbol{\beta})/\sigma]\right\}$$

where Φ is the cumulative standard normal distribution and σ is the standard deviation of the error term.

We apply this type of interval regression model to estimate the marginal effect of sustainability on firms' revenues[6], controlling for employment (in logarithms), year of foundation, technology group (binary variables) and year to which the socioeconomic information corresponds (binary variable). To test the robustness of the results, the models were estimated using both versions of the sustainability score (separately) and using two functional forms: the first incorporates the score in a linear way, while the second does so in a quadratic way to allow the marginal effect of sustainability to vary for different levels of this variable.

Finally, we use probit models to estimate the marginal effect of sustainability on the probability that the firm's sales are concentrated in foreign markets, conditional on the vector $\mathbf{x}$. The specification is as follows:

$$\mathrm{P}(y = 1|\mathbf{x}) = \Phi(\mathbf{x}\boldsymbol{\beta})$$

where $y = 1$ if the firm's sales are concentrated in foreign markets, $\mathbf{x}$ is the same vector as before, $\boldsymbol{\beta}$ is a vector of parameters to be estimated, and Φ is the standard normal cumulative distribution function. Then, the marginal effect of sustainability is calculated as follows[7]:

$$\frac{\partial \widehat{\mathrm{P}}(y = 1|\mathbf{x})}{\partial x_j} = \varphi(\mathbf{x}\widehat{\boldsymbol{\beta}})\widehat{\beta_J}, \quad \varphi(\mathrm{z}) \equiv \frac{\mathrm{d}\Phi}{\mathrm{d}z}(z)$$

where x_j is the sustainability score. Since this marginal effect depends on the values of the vector $\mathbf{x}$, we compute the average effect across all the observations of the sample.

4. Results

In the first place, it is illustrative to describe the socioeconomic profile of surveyed AgTech companies and their leaders, for which Table 1 shows descriptive statistics for selected socioeconomic variables. Our data show that most companies are of recent creation, with three-quarters of them starting operations in 2016 or later. The youth of companies is also evident when examining their size (measured by employment) and revenues. Indeed, while the number of workers at AgTech firms ranges from 1 to 540 people, 75% of companies employ 21 people or less. At the same time, almost two-thirds of companies have a revenue of less than USD 240,000 per year, and only 27% of firms concentrate their sales in foreign markets. Respect to firms' technology solutions, the predominant category is "Digital agriculture", accounting for almost two-thirds of the companies surveyed. The second most important category is "Inputs" (13%), followed by "Food processing and

[6] Since the natural logarithm was applied to the revenues ranges, the marginal effect of sustainability can be interpreted as a semi-elasticity.

[7] This formula corresponds to the case where the sustainability score enters only linearly in the argument of the Φ function. In the case where the score also enters in a quadratic way, the marginal effect of sustainability is $\varphi(\mathbf{x}\widehat{\boldsymbol{\beta}})(\widehat{\beta_1} + 2\widehat{\beta_2}x_2)$, where $\widehat{\beta_1}$ is the estimated coefficient for the linear term of the score, x_2 is the quadratic term of the score and $\widehat{\beta_2}$ is the estimated coefficient of the latter term.

safety", "Gene technology" and "Replacement food and feed" (with shares between 5% and 6%). Finally, the technology groups "Cellular agriculture", "Health", "Intensification" and "Resource use efficiency" represent 3% or less of the companies.

The entrepreneurs who lead AgTech companies also exhibit distinctive characteristics. They are in their "prime age": 90% of entrepreneurs are between 22 and 54 years old, with an average and median age of approximately 41 years. Furthermore, these leaders are highly educated, since 85% of them have a university education or higher, and almost 30% of the total respondents have a master's degree or equivalent.

Table 1. Socioeconomic profile of AgTech startups

Numeric variables	Obs.	Mean	Std. Dev.	Min.	25th pct.	Median	75th pct.	Max.
Year of foundation	142	2016.6	6.5	1979.0	2016.0	2019.0	2020.0	2024.0
Number of workers	193	25.1	51.5	1.0	6.0	12.0	21.0	540.0
Age of the entrepreneur	194	41.5	9.7	0.0	35.0	41.0	47.0	76.0
Categoric variables	**Obs.**	**% of companies**						
Revenue range (USD)								
[$0; $45,000)	75	43.9%						
[$45,000; $240,000)	33	19.3%						
[$240,000; $1,500,000)	29	17.0%						
[$1,500,000; $12,000,000)	25	14.6%						
[$12,000,000; $17,000,000)	2	1.2%						
[$17,000,000; +∞)	7	4.1%						
Target market								
National	143	73.3%						
Foreign	52	26.7%						
Technology solutions								
Cellular agriculture	2	1.0%						
Digital agriculture	127	64.5%						
Food processing and safety	12	6.1%						
Gene technology	12	6.1%						
Health	1	0.5%						
Inputs	25	12.7%						
Intensification	3	1.5%						
Replacement food / feed	9	4.6%						
Resource use efficiency	6	3.0%						
Educational level of the entrepreneur								
Primary education	2	1.0%						
Secondary education	13	6.7%						
Tertiary education	16	8.2%						
Bachelor's or equivalent	86	44.3%						
Master's or equivalent	57	29.4%						
Doctorate or equivalent	9	4.6%						
Postdoctorate or equivalent	11	5.7%						

Source: calculations based on data from own surveys.

On the other hand, Panel A of Table 2 shows a descriptive picture of the different dimensions of social and environmental sustainability of AgTech companies that we surveyed. At this point, we observe that almost all the companies (98%) consider that they contribute, directly or indirectly, to the achievement of the SDGs. Regarding to the goals declared as the main ones by the firms, two of them stand out: "Responsible Consumption and Production" (33% of the responses) and "Zero Hunger" (28%). This result is not surprising, since most of the companies use technologies linked to Digital Agriculture and are located at the beginning stage of the value chain, offering goods and services that improve the efficiency of farmers and increase their productivity, which contributes to reducing environmental degradation and the risks of hunger. When we quantify the subjective contribution of AgTech firms to the SDGs through an index that varies between 0 (does not contribute) and 5 (very high or significant contribution), we find that, on average, companies report having an "intermediate" contribution (2.5 points), with a seemly normal distribution. If we focus on more specific dimensions of environmental and social sustainability, our data show that almost 85% of companies consider that their technology contributes to achieving at least one carbon-smart outcome, while 55% declare that such technology is aimed at vulnerable social groups.

Although these data suggest that AgTech companies are aware of their social and environmental impact, we also find that their degree of visibility into the sustainability could be significantly improved. For example, our analysis of company websites indicates that 43% of firms do not show a public commitment to sustainability, while in 60% of cases the statements on the website are inconsistent with the information they provide in our survey. At the same time, the measurement of social and environmental impact is still relatively scarce, with almost 75% of firms declaring that they do not carry out this type of measurement. Likewise, only 4% of the companies surveyed have sustainability certificates.

In Panel B of Table 2 we summarize the different dimensions of social and environmental sustainability through two scores that vary between 0 and 10. In both versions of the score we detect, on average, a relatively low level of sustainability in AgTech companies (3.5 points). In fact, the median score is even lower (3.1 points), reflecting a right-skewed distribution, i.e., a concentration of firms at low levels of sustainability.

Table 2. Social and environmental sustainability of AgTech startups

PANEL A: DIFFERENT DIMENSIONS OF SOCIAL AND ENVIRONMENTAL SUSTAINABILITY OF AGTECH COMPANIES								
Numeric variables	**Obs.**	**Mean**	**Std. Dev.**	**Min.**	**25th pct.**	**Median**	**75th pct.**	**Max.**
Average subjective contribution to SDGs	140	2.5	1.2	0.0	1.7	2.5	3.1	5.0
Categoric variables	**Obs.**	**% of companies**						
Does the company contribute, directly or indirectly, to the achievement of the SDGs?								
No	3	2.1%						
Yes	142	97.9%						
SDGs declared as main ones								
SDG 02 - Zero hunger	39	27.5%						
SDG 05 - Gender equality	4	2.8%						
SDG 06 - Clean water and sanitation	2	1.4%						
SDG 07 - Affordable and clean energy	3	2.1%						
SDG 09 - Industry, innovation and infraestructure	20	14.1%						
SDG 12 - Responsible consumption and production	47	33.1%						
SDG 13 - Climate action	14	9.9%						
SDG 15 - Life on land	10	7.0%						
Another SDG	3	2.1%						

(Table continues on next page)

Does the company's technology/innovation target vulnerable social groups?		
No	64	45.1%
Yes	78	54.9%
Number of carbon-smart outcomes achieved		
None	23	16.2%
One carbon-smart outcome	46	32.4%
Two carbon-smart outcomes	44	31.0%
Three carbon-smart outcomes	24	16.9%
Four or more carbon-smart outcomes	5	3.5%
Degree of public commitment to sustainability		
Null	60	43.5%
Medium	40	29.0%
High	38	27.5%
Consistency with respect to what is declared in the survey		
Null	83	60.1%
Medium	23	16.7%
High	32	23.2%
Measurement of social and environmental impact		
No	105	73.9%
Yes	37	26.1%
Does the company have any sustainability certification?		
No	137	96.5%
Yes	5	3.5%

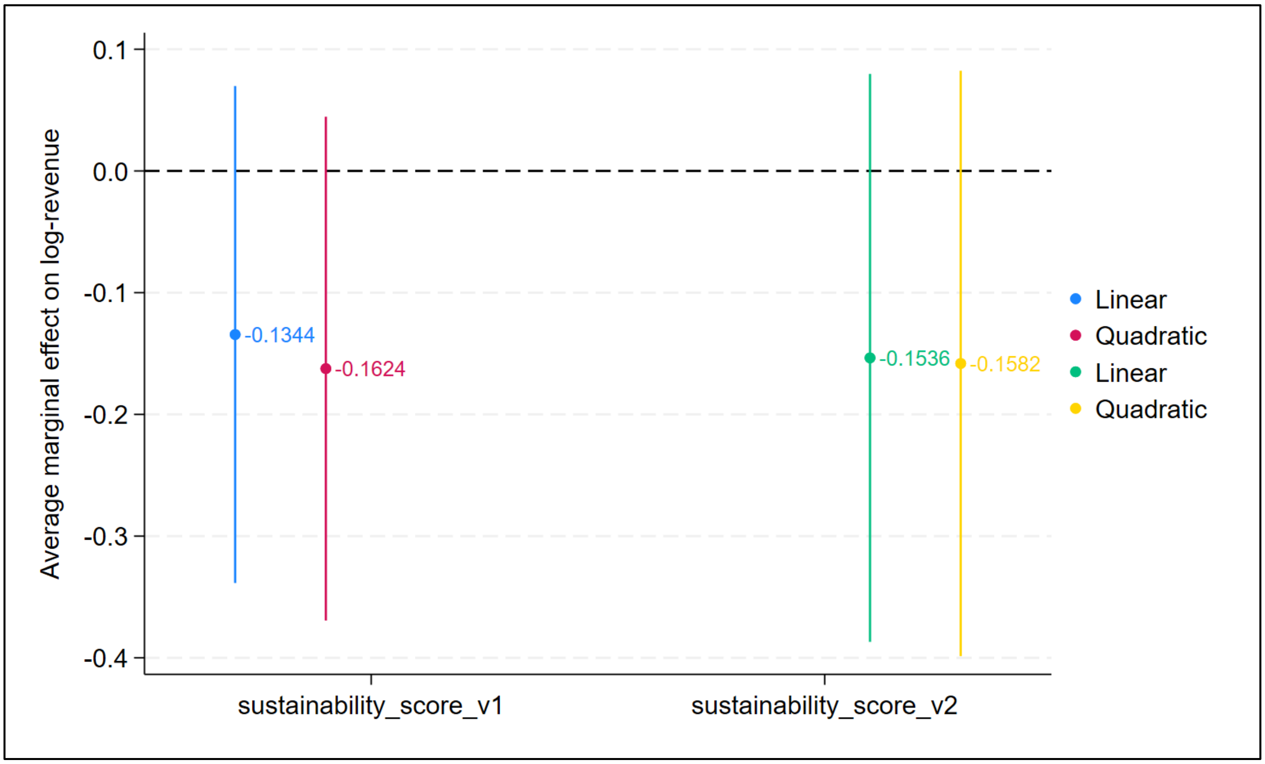
PANEL B: SUSTAINABILITY SCORES OF AGTECH COMPANIES

Score	Obs.	Mean	Std. Dev.	Min.	25th pct.	Median	75th pct.	Max.
Version 1	142	3.5	2.1	0.0	2.0	3.1	5.1	9.6
Version 2	142	3.5	2.0	0.3	2.1	3.1	4.8	8.9

Source: calculations based on data from own surveys.

Does the sustainability of AgTech companies affect their economic performance? As shown in Figure 1, the different estimated econometric models suggest that the level of social and environmental sustainability of firms has a negative effect on their revenues, a result that is in line with some of the empirical literature that analyzes large firms (Gamble et al., 2020; Lassala et al., 2021). More specifically, we found that, on average, a 1-point increase in the sustainability score is associated with a 13% to 16% drop in revenues, depending on the version of the sustainability score used and the functional form of the model (linear or quadratic). Although, these results are not statistically significant at the conventional 5% level (as can be seen in the 95% confidence intervals in the Figure 1), they become statistically significant if, given the small sample size, we allow a level of significance slightly higher than 10%.

Figure 1. Average effect of sustainability on AgTech companies' revenues



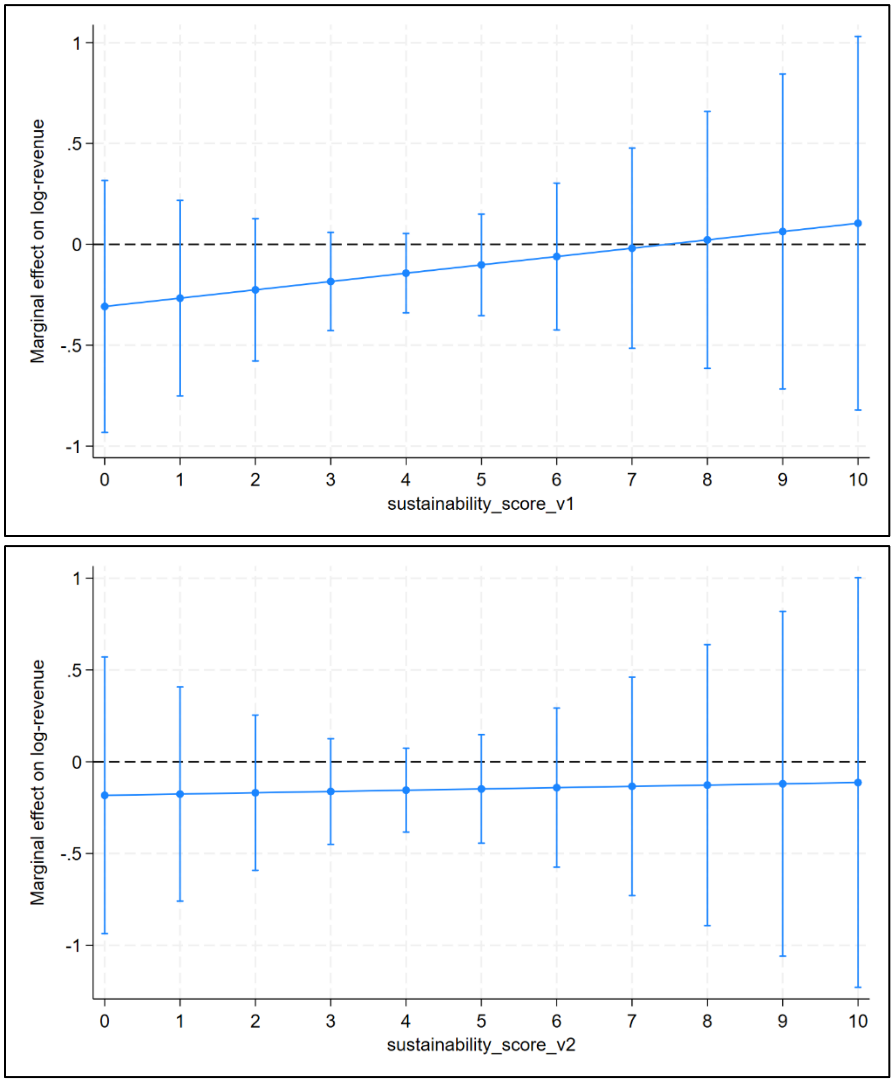
Source: calculations based on data from own surveys.

Note: circles represent point estimates, while vertical lines show 95% confidence intervals with robust standard errors.

The quadratic specification allows the marginal effect of sustainability to vary for different levels of this variable. Figure 2 shows that, when the score is introduced in this way, the effect of sustainability on revenues grows the more sustainable the company is, and even becomes positive at high levels of sustainability for the first version of the score. It is possible that, in the first stage, sustainability reduces companies' revenues due to penalties from their customers for not having enough information about the sustainability of the firm. Indeed, when the firm's level of sustainability is too low, clients may not value the technological innovation offered to them enough. However, as the commitment of AgTech companies becomes more visible, sustainability is likely to be economically profitable, because signaling mechanisms arise for customers and investors who have social preferences and who reward "green" companies. We believe that this result is valuable for ecosystems in general and for startups in particular, as improvements in the sustainability score could, in part, be low-cost for firms, as they are essentially about communicating their environmental and social contribution more explicitly. However, certifications can be a cumbersome process for companies, so the involvement of the ecosystem through the public sector and large companies should make it easier for startups to value and achieve these certifications.

Figure 2. Effect of sustainability on AgTech companies' revenues

Quadratic models

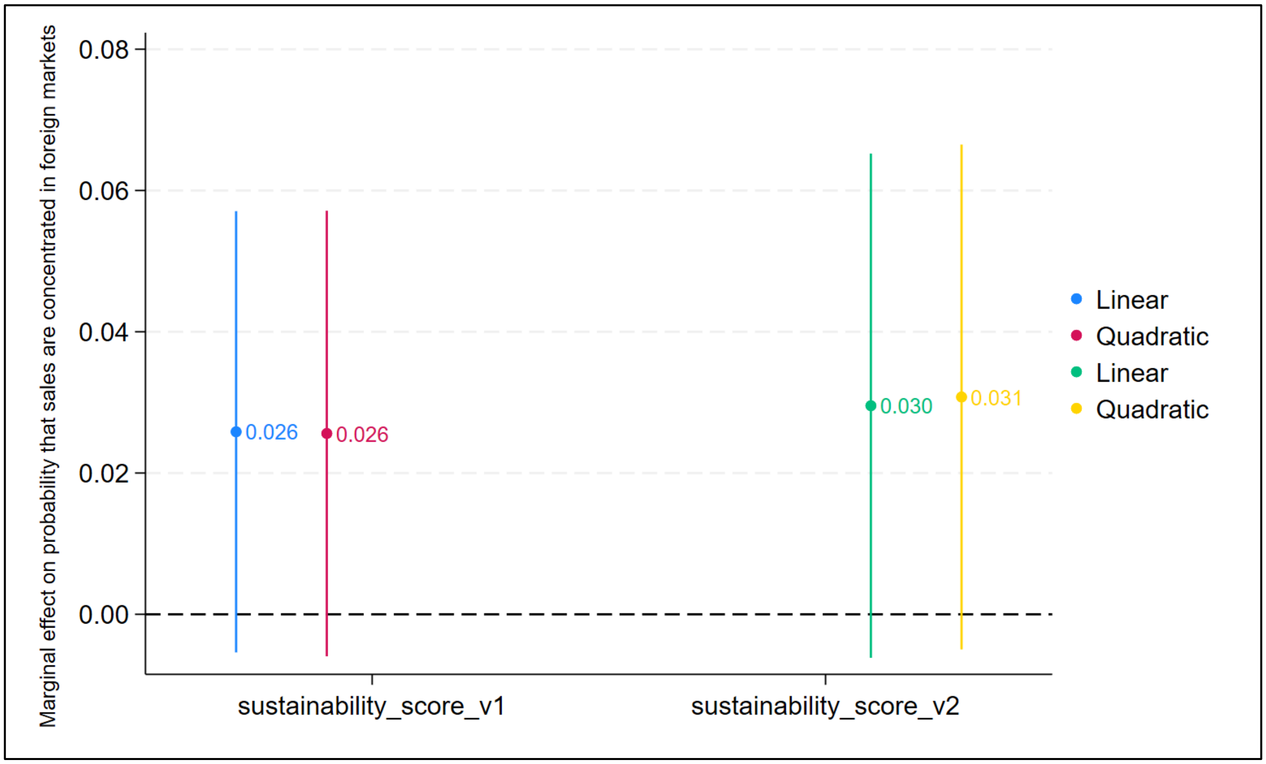


Source: calculations based on data from own surveys.

Note: circles represent point estimates, while vertical lines show 95% confidence intervals with robust standard errors.

Regarding the effect of sustainability on insertion of AgTech firms into foreign markets, our estimates suggest a positive relationship (Figure 3). On average, depending on the estimated model, a 1-point increase in the sustainability score is associated with an increase of between 2.6 p.p. and 3.1 p.p. in the probability that sales are concentrated in foreign markets. These results are mostly statistically significant at the 10% level. Our hypothesis is that the improvement in the export capacity of AgtTech firms is probably explained by the need to adapt to a greater demand from foreign consumers, as well as stricter regulations regarding the social and environmental effects of AgTech companies.

Figure 3. Average effect of sustainability on insertion of AgTech firms into foreign markets



Source: calculations based on data from own surveys.

Note: circles represent point estimates, while vertical lines show 95% confidence intervals with robust standard errors.

5. Concluding remarks

Throughout this study, we seek to measure the performance of Argentine companies in the AgTech sector in their social and environmental dimensions, for which we built a score with information from the companies themselves that we collected through surveys in 2022 and 2023. We also complement our score with data from Herrero et al. (2021), which quantify expert opinions on the effects of different technologies on the SDGs. Then, we use econometric models with different specifications to estimate the effect of the social and environmental performance of companies on their revenues and insertion in foreign markets.

The data we collected shows that Argentine AgTech companies are of recent creation and are led by young entrepreneurs with a high level of education. The technological solutions they provide are focused on Digital Agriculture and Inputs. Beyond the potential shown by the firms, our score suggests that there is still a long way to go to expand the scope of their social and environmental sustainability. While companies believe they contribute to the achievement of the SDGs and produce carbon-smart results, they show certain flaws in web-based communication, which highlights a lack of public commitment to sustainability and inconsistencies with respect to what they declare in our survey. In addition, a high percentage of firms do not have sustainability certificates, nor do they measure the social and environmental impact of the technology they offer. Econometric estimates suggest that social and environmental performance tends to correlate negatively with companies' revenues, although this effect is likely to be reversed for high levels of sustainability, suggesting that consumers “asymmetrically value" different degrees of sustainability. However, we find that better social and environmental performance increases the likelihood of concentrating sales in foreign markets.

The results obtained highlights the importance of raising awareness among startups regarding their reliable communication of commitment and monitoring of their objectives, and the ecosystems that shelter them to reinforce the convenience of this improvement, as well as to support them in the process of obtaining international certifications that validate the environmental and social commitment of startups. Besides that, the difficult to identify the startups, is a challenging task due to the dispersion of information that could be improved by compiling data from sparse players of the ecosystem. In fact, such a compilation becomes even more important when it is observed that only the companies that achieve singular importance are visible in global databases, while the potential of those in the early stages remains completely off the global radar.

In future lines of research, we will work on methodological modifications that allow for a more in-depth approach to the measurement of the sustainability of AgTech firms and its effects on economic performance. In this sense, we will seek to deepen the analysis of technologies and their impacts on the SDGs, in order to achieve a more balanced composition of the score between the opinions of companies and objective components of their social and environmental commitment. We also hope to be able to extend the construction of the scores to other countries in the region.

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