Private capital investments in agrifood-tech startups in South America, 2007-2022

Juan M. Vergara[*, ^] **and Christopher B. Barrett**[*, #]

[*] Charles H. Dyson School of Applied Economics and Management, Cornell University, Ithaca, NY USA

[^] Agribusiness and Forestry, International Finance Corporation, Washington D.C., USA

[#] Jeb E. Brooks School of Public Policy, Cornell University, Ithaca, NY USA

December 2023

Abstract: This paper documents rapid growth in private investment in agrifood-tech startups in South America. Over the 15 period 2007-22, nearly US$10 billion flowed into 547 startups via more than 1100 business deals. The real annualized growth rate of 52% in such investment has gone largely unnoticed. The South American agrifood-tech ecosystem is heavily concentrated in Brazil and Argentina, which together account for 75% of the population of startups. Likewise, the ten largest deals over this period account for 48 percent of all investments; the median investment in South American agrifood tech is modest, roughly US$100,000. Pre-farm gate technologies captured over 42% of the deal flow but only 15% of the total capital invested. By contrast, investments at the consumer-facing end of the agrifood value chain, into on-demand delivery startups, represent 51% of all investments in the region but only 8% of the deal flow. Just 46% of firms raised two or more funding rounds over the 15-year period. Multivariate regression models find that country-year-level macroeconomic, financial and agricultural indicators fail to explain much variation in private capital investments in South American agrifood tech. Drawing on key informant interviews, we identify some of the main barriers to and accelerators of adoption and uptake at scale of agrifood technologies in South America.

Keywords: Argentina, Brazil, Chile, Colombia, financing, innovation, technology, venture capital
Running title: Agrifood-tech Investments in South America
JEL codes: Q16, M13, O13, O54, Q16

Acknowledgements: We thank the Fulbright Commission for financial support, Louisa Burwood-Taylor, Cody Kugler, Mario Herrero, Matt Marx, Sudha Narayanan, Ernesto Stein, José Gobbée, Trevor Sieck, Martin Burló, Ana Castillo Leska, Matias Peire, Roberto Vitón, Juan Ortega, Jeremías Latchman, Pablo Mac Clay, Pablo Villalobos, and Laurens Klerkx for helpful discussions, and Louisa Burwood-Taylor, Matt Marx and AgFunder for access to data. Any remaining errors are our sole responsibility.

Private capital investments in agrifood-tech startups in South America, 2007-2022

1. Introduction

The agricultural and food technology (agrifood-tech) sector is an entrepreneurial ecosystem focused on creating new solutions and services with the goal of improving global food production, processing, distribution, delivery, and consumption. The aim of the agrifood-tech sector is to meet looming global food demand growth profitably while simultaneously addressing major societal challenges, such as climate change, population growth, limited land, labor scarcity, and food waste, and the unintended spillover effects inherent to all innovations (Parfitt et al., 2010; Rockström et al., 2017; Herrero et al., 2021; Barrett et al., 2022a).

Promising new agrifood technologies have captured the attention of venture capital (VC) and private equity (PE) funds in recent years. Over the past decade, global private capital investments in agrifood-tech startups have skyrocketed, increasing from US$3.1 billion in 2012 to US$29.6 billion in 2022 (AgFunder, 2023). South America, as a major exporting region, has not been an exception to this phenomenon. As we report below, private capital investments in South American agrifood-tech startups increased from US$ 79 million to US$ 1.87 billion, 2012-22, representing a massive 2200% increase over a decade.

Surprisingly, little is known about these investments in the South American agrifood-tech ecosystem (SAAE). No prior studies have measured the direction and magnitude of agrifood-tech investments in South America. Most data available are fragmented and limited to primary production, although more than 70 percent of the value addition reflected in consumer food expenditures globally occurs post-farmgate (Yi et al., 2021). Prior studies of the SAAE have focused on how startups add value to the agrifood supply chain and help small and medium farmers to incorporate new technologies, and on how the innovative business model of agrifood-tech startups drives internationalization (Silveira et al., 2022;

Vargas, 2020; Cavallo et al., 2020). They have also documented high rates of digitalization, especially in Brazil, whose 46% rate of farmer use surpasses American and European producers' use rates of 31% and 22%, respectively (Lachman et al., 2021; Dias et al. 2022). But to date there has been no comprehensive enumeration of private capital investments in the SAAE broadly. This paper begins to fill that gap.

We assemble a large data set on private financing deals in the agrifood-tech sector across South American countries. We then provide descriptive quantitative analysis of the patterns evident in those data. We document considerable heterogeneity across industry segments and countries in the growth of agrifood-tech investment in South America, little of which can be explained by macroeconomic or agricultural phenomena. We supplement the quantitative work with qualitative evidence gleaned from interviews conducted with agrifood-tech startups and investors in the region. These interviews emphasize that government intervention, institutional bureaucracy, and high technology costs negatively impact technology uptake in the region.

2. Tracking private capital investments in agrifood-tech startups: Data and methods

Agrifood systems (AFS) encompass the entire range of firms/actors, and their interlinked value-adding activities, engaged in the primary production of food and nonfood agricultural products, as well as in storage, aggregation, post-harvest handling, transportation, processing, distribution, marketing, disposal, and consumption of all food products including those of non-agricultural origin. The AFS thereby encompasses the whole value chain, from input suppliers to primary producers upstream to food consumer-facing companies downstream (Barrett et al. 2022a,b; FAO, 2022).

There is no formal definition of an agrifood-tech startup. Nonetheless, the literature implicitly defines an agrifood-tech startup as a young company that is intense in the use of technology, highly innovative, has a scalable business model, and its mission is to improve and transform the agrifood industry by increasing efficiency, sustainability, and/or productivity in the food supply chain, from farm to fork (Connolly et al., 2018; Cockayne, 2019). Agrifood-tech startups can operate in various sectors of the

industry, also called industry groups, including primary production, storage, transport, distribution, finance, and food service.

This research follows a mixed-methods approach to explore private capital investment in agrifood-tech startups in South America. First, we constructed a data set on private investments in order to understand its distribution across countries, industry segments, and technology groups from 2007 to 2022. This descriptive analysis includes a multivariate regression analysis of the association between private agrifood-tech investments and a range of country-and-year-specific factors. Finally, we supplement the quantitative analysis with qualitative analysis of key accelerators and barriers to the development of the SAAE based on interviews with key informants in the sector.

The extent of agrifood-tech investment remains unclear, globally or within the South America region on which this paper focuses. No public or governmental institution actively tracks these investments and provides accurate, structured information on agrifood-tech companies. Nor have studies tested the associations between agrifood-tech investments and country-level socio-economic indicators that one might naturally hypothesize to influence such investments, such as the size of the agricultural economy, agricultural total factor productivity, macro-financial conditions (e.g., bond ratings), or innovation patterns in the broader economy.

In this paper, we assemble data on private agrifood-tech investments in South America. There are two potential methods one can follow. One option is an expenditures-based approach, based on recorded flows of companies' research and development (R&D) investments. This has the advantage of assigning R&D investments to the years in which they occur. But structured data on R+D expenditures are scarce, largely limited to publicly traded companies and government entities, and accounting practices on what qualifies as an R+D expenditure varies across jurisdictions, limiting international comparability. We therefore opted for a revenue-based approach using the timing of financing flows, which are more broadly and consistently reported. The drawback of this approach is that one cannot establish what share of the financing actually goes into R&D, as opposed to general operations, nor when. Further, while private

financing is better covered than R&D expenditures, it too is incomplete. PE firms, in particular, often keep their deals private for various reasons. As a result, we expect that PE financing deals are likely disproportionally underreported in our data. We nonetheless believe this new data set to be the most comprehensive yet available on this topic; but there remains considerable room for improvement.

Private capital funding events are often labeled 'funding rounds', which describe the process of raising money from investors, typically in exchange for equity. Pre-seed, Seed, and Series A rounds are considered early-stage VC, whereas Series B and beyond are late-stage VC rounds. Depending on the funding stage, different investors and financial entities participate in the funding event. The terms and conditions of each funding round, including the amount of equity that investors receive in exchange for their investment, are negotiated between the startup and the investors.

We compiled, merged, and de-duplicated data on private capital investments in agrifood-tech startups headquartered in South America from 2007 to 2022 from AgFunder (AF) and Pitchbook's (PB) databases, and complemented those merged data with entries derived from our independent research on government and media websites. AF and PB data sets are framed differently and include different variables. Both sources reported a similar number of US dollars invested in South American agrifood-tech firms for the time series; but they only shared 47% of reported deals. We worked closely with AF and PB representatives to understand their data generation process and data entry methodology. The resulting, merged and supplemented data set consists of 1,106 deals conducted by individual investors, private institutions, accelerators/incubators, PE and VC firms into 586 agrifood-tech startups from South America. Mergers and acquisitions were excluded from the analysis, given lack of availability and reliability of data on such business deals.

The series begins in 2007 because prior volumes are trivial in magnitude. Deals were indexed to a company and deal ID in order to identify them unequivocally. All entries were recorded in US dollars and

converted to real 2022 US dollars base year;[1] all figures reported hereafter are real 2022 US dollars unless otherwise noted.

Table 1 shows the distribution of deals based on investor type classification. The overwhelming majority (87%) of deals in the data set were financed by VC firms. Partly this reflects the secrecy of PE firms that we suspect generates relatively greater underreporting of PE-financed deals. But key informants uniformly confirm that VC finance dominates the sector. Almost all (roughly 95%) of that finance is equity; debt and grant financing is only 2-3 percent each.

Deal Type	No. Of Deals	(%)
Venture Capital	**962**	**86.98**
1. Angel (Individual)	41	3.71
2. Accelerator/Incubator	204	18.44
3. Early-Stage VC	585	52.89
4. Late-Stage VC	132	11.93
Private Equity	**95**	**8.59**
Grant	**29**	**2.62**
Debt	**20**	**1.81**
Total	**1,106**	**100**

Table 1: Distribution of investments by investor type classification.

We then manually classified firms into one of nine industry groups defined by the Food Systems Dashboard (Food System Dashboard, 2020). The Industry Group Series classification allows us to identify the segment of the value chain where the startup adds value. Classifications were assigned based on three parameters: i) company description (provided to data providers by the company itself), ii) data providers' (i.e., AgFunder or Pitchbook) own classification system, iii) professional interpretation based on our team's expertise. Additionally, we assigned startups to 1 of 14 technology groups defined based on the technology domains first proposed by Herrero et al. (2020) and expanded by Barrett et al. (2022a), supplemented by

[1] Specifically, we used the adjust_for_inflation function available on R Studio package *priceR*, which retrieves historic Consumer Price Index data from World Bank's database.

AgFunder's technology classification, which seems fairly standard within the industry. The purpose of classifying investment flows by technology and industry groups is to spot historical and current trends in agrifood-tech investments in SAAE. We seek to show how and where investments into agrifood-tech startups in South America have increased over time and what, if any, shifts have occurred in their geography or sub-sector foci.

We also seek to establish whether there exist any clear correspondence between private capital inflow patterns and national-level socioeconomic, macroeconomic, and/or agricultural indicators using multivariate regression analysis, in which we include multiple levels of fixed effects to control for a range of unobservable factors. The explanatory variables included in the regression model measure intra-country investment performance in three dimensions: macrofinance, macroeconomics, and agriculture production. Table 2 shows the variables we include.

	Variable Name	Description
1	DealID	The primary key for the deal.
2	DealYear	Year in which the financing event was completed. DealYear range: 2007-2022.
3	CompanyID	Unique identifier for the company involved in the deal.
4	CompanyName	Name of the company receiving the financing.
5	HQSubRegion	The region in the world where the startup is headquartered, i.e., South America.
6	HQCountry	Country where the startup is headquartered (e.g., Argentina, Brazil, Chile, etc).
7	Vertical	Venture Capital startup vertical. Categories: Agtech, Biotech, Foodtech, Fintech, Insurtech
8	Industry Group	USDA Industry Group Series adapted and expanded by the Food System Dashboard. Categories: (i) Agriculture Inputs, (ii) Primary Production, (iii) Storage, Transport, and Distribution (STD), (iv), Processing and Packaging, (v) Marketing and Retail, (vi) Consumption, (vii) Finance, and (viii) Cross-cutting Innovation).
9	Technology Group	Technology groups proposed by Agfunder's agrifood-tech reports and adopted and expanded by our research group. (i) Ag Biotech, (ii) Bioproducts, (iii) Circular Economy, (iv) Cloud Infrastructure, (v) Digital Agribusiness, (vi) Food Safety and Traceability, (vii) Food Services, (viii) Home & Cookingtech, (ix) Innovative Food, (x) Insurtech & Fintech, (xi) Intensification, (xii) Robotics and Automation, (xiii) Smart Farming, (xiv) On-demand Delivery.
10	DealSize	Total amount of capital invested into a company by an investor or group of investors for a specific transaction (current year USD millions)
11	DealSize_Adj	Millions of 2022 USD reported in the financing event.

12	DealType	Identifies and categorizes distinct types of transaction or financing rounds between an investor and company. Categories: (i) Angel Investor, (ii) Accelerator/Incubator, (iii) Early-stage VC, (iv) Late-stage VC, (v) Private Equity (PE), (vi) Debt, and (vii) Grant.
13	FinancingStatus	Represents the type of investors that are financially backing the company at the time of the deal. Categories: (i) VC-backed, (ii) PE-backed.
14	VCRound	Venture Capital financing round. Categories: (i) Seed, (ii) Series A, (iii) Series B, (iv) Series C, (v) Series D, (vi) Series E, and (vii) Series F.
15	TotalInvestedCapital	Amount of capital (equity and net new debt) put in by the investor. Amount in current USD millions.
16	AgGDP	Contribution of Agriculture to GDP of country stated in HQCountry during year = DealYear (% of total GDP). (Source: World Bank).
17	AgLand	Agricultural land area of HQCountry, in millions of hectares. (Source: FAOSTAT)
18	AgTFP	Agriculture Total Factor Productivity for country and year stated in HQCountry and DealYear (Source: USDA ERS)
19	Net_Capital_Stock	Net capital stock per capita in millions of US dollars in country and year stated in HQCountry and DealYear (Source: FAOSTAT)
20	EMBI	The average annual score of the Emerging Market Bond Index for country and year stated in HQCountry and DealYear. (Source: J. P. Morgan - BCRD).
21	GE	Government expenditure in agriculture in country and year stated in HQCountry and DealYear (current USD millions). (Source: FAOSTAT)
22	GII	WIPO - Global Innovation Index for country and year stated in HQCountry and DealYear. (Source: World Intellectual Property Organization)

Table 2: Description of variables

3. The South American Agrifood-tech Ecosystem

The SAAE has shown steady growth over the past 15 years, with increasing investments and growing deal volume. Figure 1 shows the historical evolution of private capital investment in agrifood-tech startups in South America from 2007 to 2022. Total investments in agrifood-tech startups from 2007 until 2022 add up to $9.85 billion in constant 2022 US dollars. A significant increase occurred from $1.9 million in 2007 to a peak of $2.371 billion in 2021. The 2021 peak reflects two factors. First, several deals that were expected to close in 2020 were delayed to the next year as VC funds waited for reduced uncertainty about global markets during the early stage of the Covid-19 pandemic. Second, Covid-19 dramatically boosted the use of food service and grocery delivery apps, accelerating digital transformation that drew large sums of private capital into agrifood-tech startups. The fall in investment flows in 2022, relative to 2021, is primarily explained by an increase in interest rates globally, which reduced cheap money flows to startups, and increased uncertainty in global agricultural commodity markets following Russia's invasion of Ukraine. We also expect that the difference between 2021 and 2022 will gradually shrink as more deals 2022 get reported with a delay. Over the last decade, investments in South American agrifood-tech increased at an annual compound rate of 51% in nominal terms.

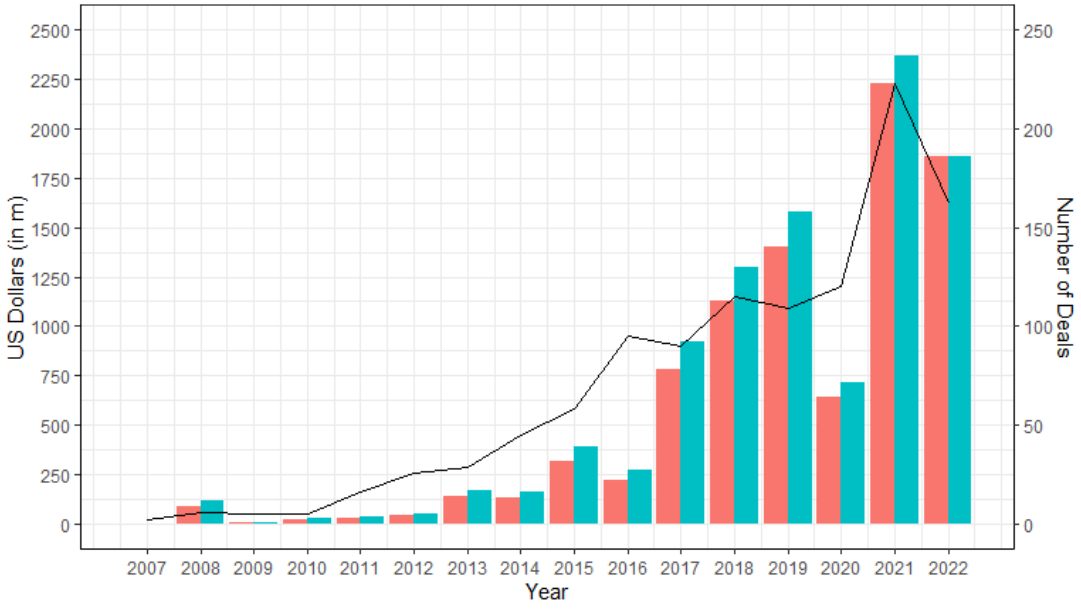

Figure 1: Historic evolution of capital investments in South America from 2007 through 2022. The bars represent the amount of nominal US dollars (red) and constant 2022 US dollars (green) invested in South America in the corresponding year, the line represents the evolution in deal volume.

The number of deals conducted in the region follows that same pattern, with a peak of 224 reported deals in 2021. The number of transactions per year grew gradually from 5 in the first decade of the 2000s to over 120 in 2019, before skyrocketing to over 200 deals in 2021.[2] The SAAE is primarily characterized by a large number of early-stage funding rounds (rounds prior to series B). The median deal size for South America is roughly US$100,000. Seed rounds (36%) and funding rounds led by accelerators and incubators (20%) together represent a majority of all deals conducted in South America. As reflected by the median deal size, the deal size distribution is heavily skewed. The top ten largest deals account for almost 48 percent of all investments in the time series.

When compared to South American governments' expenditures on agriculture, private capital investment flows are relatively small. In 2021, governments in South America spent over $5.5 billion on agriculture. Brazil holds the largest expenditure on agriculture with $3.7 billion dollars, which is reasonable considering its population and agricultural land (FAOSTAT, 2022). Over one-quarter of Brazil's public agricultural expenditures support R&D activities. By contrast, Argentina's budget for agriculture is small

[2] Nearly $61 million dollars were excluded from the analysis because of missing deal date data.

when compared to the country's size. In 2020, Argentina's government spent $267 million on agriculture while its neighboring country, Chile, which has 40% of Argentina's population and just 15% of its agricultural land, allocated over $743 million to agriculture.

Figure 2 shows the evolution of agrifood-tech investment among the region's major agricultural countries. There is a clear upward trend in reported investment and deal volume. Argentina, Brazil, and Colombia are regional leaders, attracting larger inflows of capital and closing more deals than other countries. Startups are heavily concentrated in Brazil and Argentina, home to 70% of the agrifood-tech startups in the region, consistent with the estimates in Viton et al. (2019).

Colombia and Chile hold a similar population of startups, but they significantly differ in the amount of capital that their startups raised. Chile is a significant player in the SAAE despite its small agricultural land. One of the main reasons for this phenomenon is that Chile ranks first in the region in the World Bank's 'Ease of doing business' table, closely followed by Colombia. Since 2005, Chile and Colombia conducted over 40 structural reforms to facilitate the opening of new businesses and to attract foreign direct investment into the country. Argentina and Brazil rank last for those same indicators within the countries included in this study. Uruguay has a small population of agrifood-tech startups, but it has attracted considerable capital. Adjusting by population size, the number of agrifood-tech startups in Uruguay is similar to the number reported for Argentina with approximately 0.3 startups for every 100,000 inhabitants.

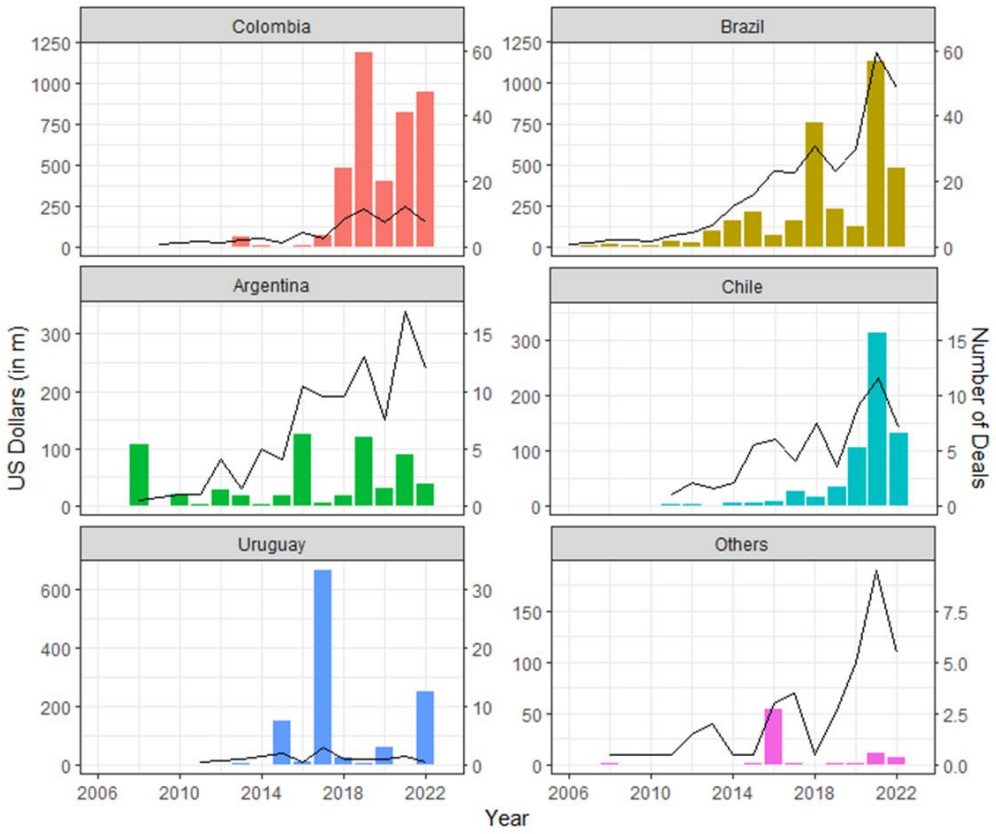

Figure 2: Historic evolution of private capital investment in agrifood-tech startups by country. The bars represent the aggregated investments in constant 2022 US dollars. The solid line is the number of deals reported.

Capital investments by value chain segment

Figures 3 and 4 show the evolution of private capital investment in constant 2022 US dollars in South America by agrifood value chain segment. Storage, Transport, and Distribution (STD) is the most significant industry segment with $5.43 billion of startup investments, representing 54.4% of total investments in the region. STD requires intensive capital for infrastructure. Roads, railroads, and inland ports play a significant role in the long-distance transportation of agricultural goods and fertilizers in Brazil, Argentina, and Chile. STD ranks fourth in deal volume with 10.8% of market share, indicating that deal sizes are especially large in STD.

Primary production ranks first in deal volume among all industry segments with 301 deals (27.2%) completed in the past 15 years, and fifth in capital invested with $713 million (7.14% of total invested). Investments in this segment have increased over time as well as the number of deals conducted. But they are relatively small in average size per deal.

Figure 3: Evolution of private capital investments in South America in constant 2022 US dollars by value chain segment from 2007 through 2022. STD = Storage, Transport, and Distribution.

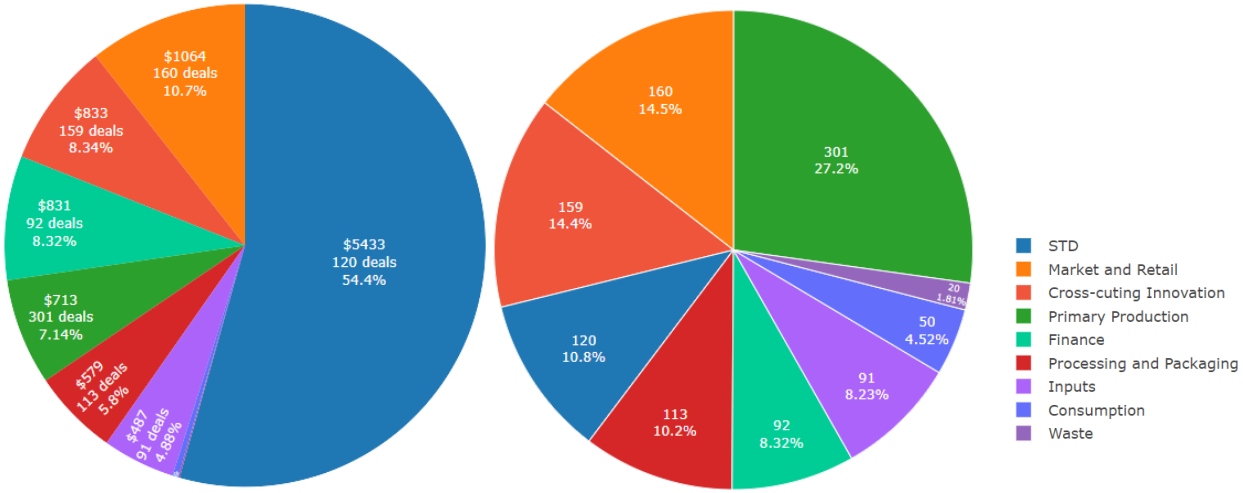

Figure 4: Total invested capital (left) and deal volume (right) in agrifood-tech startups in South America from 2007 through 2022, by technology group. STD = Storage, Transport, and Distribution.

The marketing and retail segment has increased exponentially after Covid-19, as digital marketplaces overcame farmers' initial resistance to trying new online tools. This segment ranks second in deal volume and capital invested with 160 deals and $1.06 billion in investments, respectively. It accounts

for 10.7% of investments and the region is a global market leader in this segment. In the next five years, e-commerce is predicted to rise by 19%, outpacing the global average of 14% (Mordor Intelligence, 2022).

Processing and packaging of agricultural products follow the same trend as the demand for processed food, which has increased steadily globally. It ranks sixth in terms of deal volume, close to the STD segment, with 113 deals and 10.3% share of deal volume. Nevertheless, with just $579 million invested, it represents only 5.8% of total investments in the region as these deals are relatively small.

Cross-cutting innovation refers to all technological solutions that support the enabling environment along different stages of the supply chain. Similar to marketing and retail, digitalization has sparked exponential growth in this segment over the last decade. It ranks third in both deal volume and capital with 159 deals and $980 million dollars in investments. Almost 10% of capital inflows in the region are directed into this segment ,which accounts for 9.2% of deal volume.

Finance remained constant during the study period. It ranks fourth in terms of capital invested with $831 million and sixth in volume with 92 deals. It represents 8.32% of deal flow and capital invested. Fintech has a huge penetration in South America where levels of financial inclusion are low; only 50% of the population has a bank account and less than 21% own a credit card (Demirguc-Kunt et al., 2019). The literature often attributes insufficient financial inclusion to institutional weaknesses, low levels of bank competition resulting in high financial service cost, insufficient infrastructure, and an overly restrictive regulatory environment (Dabla-Norris et al. 2015b, Fishbane 2014, Rojas-Suárez 2016).

Agricultural inputs refer to all resources and materials used in the production of crops, livestock, and other primary agricultural products. This segment is highly concentrated in a few corporations that produce the inputs. Startups in this sector are often acquired in early stages by corporations through corporate venturing programs. Inputs rank seventh in terms of volume and capital with 104 deals (8.23%) and $487 million in capital (4.9 %).

Finally, consumption and waste management rank last in South America, representing roughly 0.9% of total investments. Consumption refers to end consumer technologies, from kitchen appliances to nutrition apps. This segment reported only 70 deals and $48 million in funding since 2007. The waste

management segment has nonetheless attracted increasing funding as the environmental and social awareness of food waste increases.

Capital investments by technology group

Private capital investments across all technology groups have shown significant growth over the last 15 years, with increasing deal sizes and numbers of deals completed. Figures 5 and 6 show the evolution of private capital investments by technology group in terms of capital and deal volume, respectively.

On-demand delivery technologies alone explain 50.9% of total capital investment in the region although they only represent 8.4% of deal volume (103 deals since 2007). This group includes eight out of the ten largest agrifood-tech deals in the region, adding up to $3.6 billion, representing 39.3% of the total capital invested in South American agrifood-tech during the past 15 years.

Cloud infrastructure accounts for another 9.1% of capital inflows with $974 million in raised capital and for 12.1% of deal volume with 48 deals reported. This group was catapulted by the growth of on-demand delivery apps as cloud infrastructure provides back-end solutions for most consumer- or farmer-facing digital applications. These technologies help restaurants, retailers and wholesalers manage orders and facilitate payments tools to digitalize various segments of the supply chain.

Insurtech and fintech take the third place with $831 million dollars in investments and 7.8% of deal volume. Fintech is a very attractive vertical for venture capitalists who are interested in investing in South America. Agriculture is a risky activity by nature; a startup able to mitigate climate and financial risk will usually find fertile soil to expand its business. This group ranks seventh in terms of deal volume with 98 deals completed and 8% of deal flow.

The digital agribusiness category experienced massive growth during the last five years, accumulating over $575 million dollars in private capital (6% of total capital invested) and 142 deals completed (11.6%). As we discussed previously, market and retail industry segments are growing at an accelerated pace. The digital agribusiness technology group is predominantly made of digital marketplaces focused on the acquisition of agricultural inputs and services.

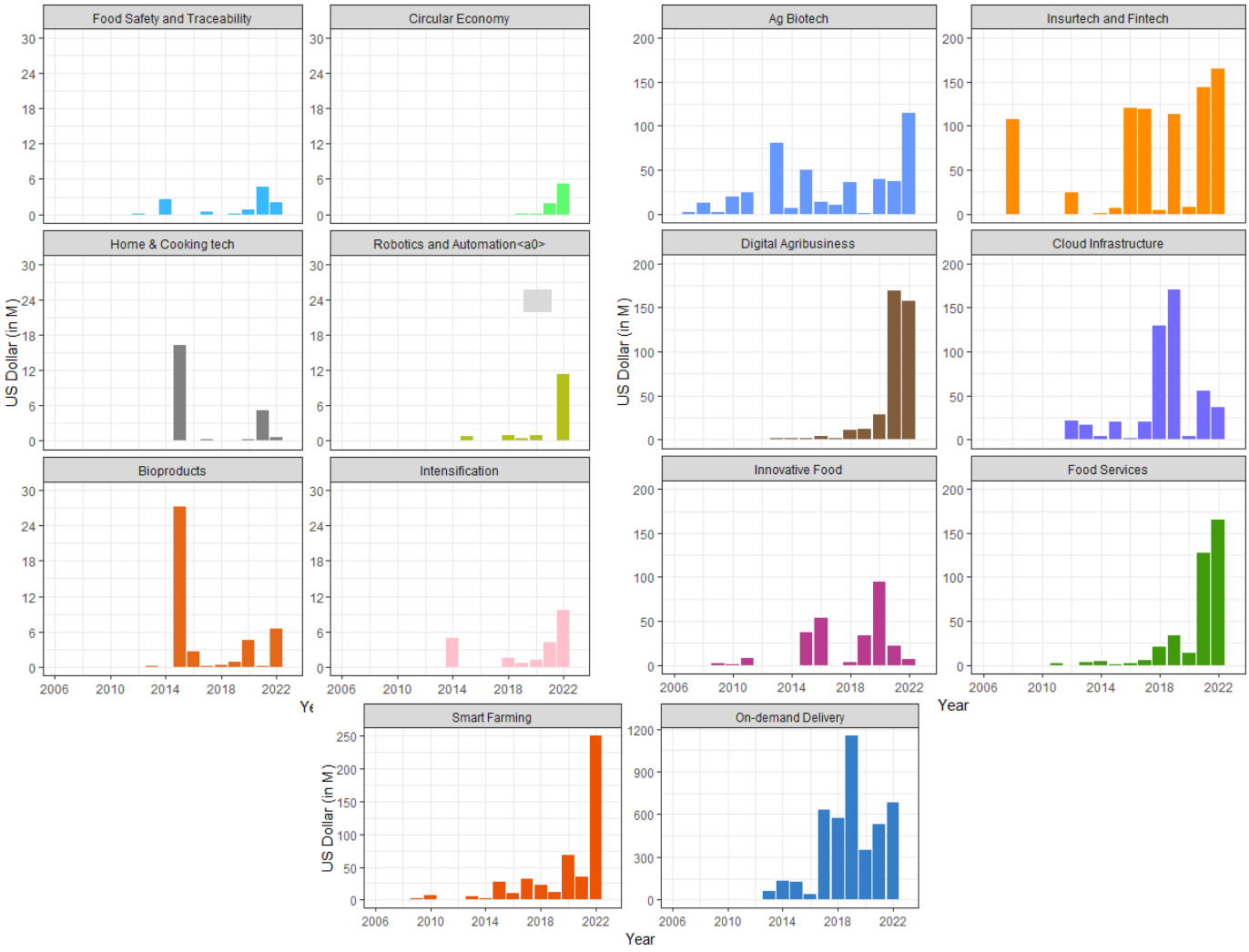

Figure 5: Historical evolution of private capital investments in millions of 2022 constant US dollars by technology group and year in South America from 2007 through 2022.

Food services is the fourth largest technology in terms of raised capital and deal volume with $742 million dollars (7.0%) and 126 deals completed (10.3% of deal volume), respectively. It involves various tools and systems to manage and streamline different aspects of the food service industry, including food preparation, order processing, purchasing, and delivery. Note that we analyze food delivery as a separate group (on-demand delivery) in order to illustrate the magnitude of each segment. Growth in the food service and associated restaurant delivery segments have been widely overlooked in research on agrifood value chains (Barrett et al. 2022b).

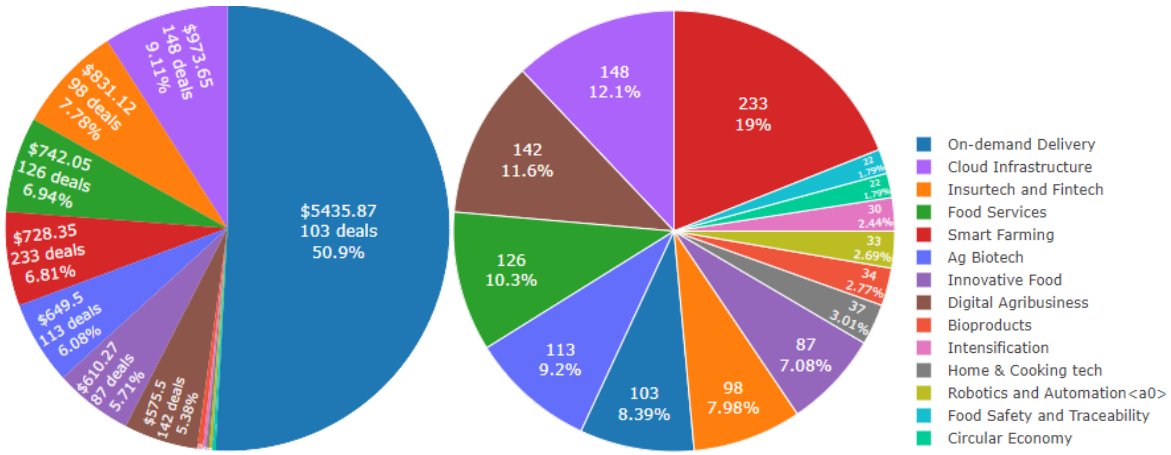

Figure 6: Total invested capital (left) and deal volume (right) in agrifood-tech startups in South America from 2007 through 2022, by technology group.

Smart farming refers to any technology that enables the deliberate management of information to boost productivity at the farm level. Ag-biotech, on the other hand, includes all agribusinesses that produce all inputs employed in the production of agricultural goods. Smart Farming and Ag-Biotech raised $728 million and $650 million in funding, respectively. These technologies account for about 13% of capital inflows into South America and 28.2% of deal volume. Smart farming has seen the largest deal volume, accounting for 19% of all deals completed in the region.

Innovative food is primarily represented by highly processed foods and novel food ingredients. These technologies are frequently used as intermediates for the elaboration of elaborated food whereas others can be sold directly as ready-to-eat items. Innovative food has raised over $610 million in capital in 87 transactions, accounting for 5.7% of all investments. Consumers in South America, particularly in metropolitan areas, are increasingly interested in healthy and sustainable food diets, creating market potential for firms that provide alternatives to traditional food products (Wee et al., 2014).

Bioproducts are technological products that contain some biological or renewable material component. Biomaterials, bioenergy, and biofuels are the most prominent examples in the sector. Given that most of the biofuel industry is extremely concentrated in a few huge corporations and highly regulated, it is a very nascent area for entrepreneurs in South America. Since 2007, it has only reported $44 million in capital investments and 34 deals.

Intensification and Robotics are immature sectors in South America when compared to developed countries (AgFunder, 2023). Vertical farming, indoor farming, irrigation systems, and other hardware technologies that boost productivity are examples of intensification. These technologies are intensive in capital and require considerable disbursement of funds, which sets barriers to broad adoption among farmers. These groups accumulated $48 million in capital and account for about 5% of deal activity.

Lastly, we have two technologies that have recently joined the ecosystem: food safety and traceability and circular economy. Together they explain 3.6% of deal volume and have raised $26.7 million in venture capital since 2007. Circular economy technology follows the same pattern as the waste management industry segment, given that the two are closely related. Food safety and traceability are strongly linked to the STD segment.

Repeated funding series

Another important metric to understand the performance of local economies and industry segments to the agrifood-tech ecosystem is to see how many companies were able to raise subsequent funding rounds. 252 out of 547 firms reported two or more funding rounds from 2007 to 2022. Despite accounting for only 46.1% of firms recorded in the dataset, these startups captured 73.3% of investment flows with 811 deals conducted over the study period.

Companies based in Brazil or Argentina lead in repeated funding rounds with 131 and 41 firms, respectively. On average, every firm was able to raise up to three funding rounds, with accelerator/incubator, seed, and series A the most frequent rounds. Brazil alone accounts for 52% of the startups that have reported repeated funding series. Colombia and Chile follow behind with 29 and 28 firms reporting repeated funding rounds, respectively. Both Chile and Colombia average 3.2 funding rounds per agrifood-tech startup. Lastly, Peru and Uruguay had 13 and 6 firms, respectively, receiving multiple funding rounds.

Among industry groups, primary production is the industry segment with the most firms raising repeated funding series: 63 firms with 228 funding rounds, accounting for 25% of the startups that reported

repeated deal series. In addition, primary production shows the best-repeated investment ratio among all industries with 3.6 deals per startup. Market retail and cross-cutting innovation follow behind and, individually, each industry segment explains 15% of repeated funding series in South America. Processing and packaging and STD report 30 (11.9%) and 27 (10.7%) firms with subsequent funding series, respectively. In terms of relevance, the remaining industry segments rank as follows: finance (9.5%), inputs (7.14%), consumption (3.5%), and waste (2.4%).

4. Multivariate Regression Analysis

Given rapid growth in in the region, one naturally wants to identify those factors associated with observed patterns of private agrifood-tech investments in South America from 2007 until 2022. We therefore conducted a multivariate regression analysis using a linear model with multiple levels of fixed effects employing the *reghefe* package available in Stata. The linear model is defined as follows:

$$INV_{cts} = \alpha + \beta X_{ct} + \delta_c + \eta_s + \mu_t + \varepsilon_{cst}$$

where INV_{cts} is the aggregated amount in millions of constant 2022 US dollars invested in agrifood-tech startups in country *c*, year *t*, and value chain stage *s*. X_i are country-and-year-specific explanatory variables, the socio-economic, macroeconomic, and agricultural indicators shown in Table 2, with descriptive statistics presented in Table 3: (i) share of agriculture on GDP in percentage (**AgGDP**), (ii) agriculture total-factor-productivity (**AgTFP**), (iii) country's net capital stock in billion of USD (**NCS**), (iv) Doing Business Index score (**DB**), (v) J. P. Morgan emerging markets bond index (**EMBI**), (vi) annualized government expenditure in agriculture per capita in constant 2022 US dollars (**GE**), and (vii) Global Innovation Index score (**GII**) (Sources: FAOSTAT, World Bank, J.P. Morgan, USDA, WIPO).[3] δ_c is a country fixed effect, η_s is a value chain segment fixed effect, μ_t is a year fixed effect, and ε_{cst} is the error term. Year fixed effects control for the sample average changes over the full-time series, 2007-2022. Industry stage fixed effects correspond to the nine categories defined in Section 3 and control for time-invariant, industry-specific

[3] Unfortunately, full time series are unavailable for the whole set of explanatory variables. We therefore estimate multiple models to explore the tradeoff between omitted variables bias and loss of explanatory power due to reduced degrees of freedom.

factors not included in the set of explanatory variables. Country fixed effects control for time-invariant, country-specific features common to all industry groups for the countries that reported private capital investments over the study period.

	INVcts	Ag_Land	AgTFP	AgGDP	NCS	EMBI	GE	GII
N	333	333	259	333	298	333	298	287
Mean	3.31	105.1	98.2	5.63	52.7	7.18	2.44	33.3
Median	2	49.6	98	5.82	34.8	2.62	2.45	3.34
SD	4.005	90.7	7.72	1.56	40.3	30.77	7.84	3.1
Time Series	[2007,2022]	[2007,2022]	[2007,2020]	[2007, 2022]	[2007,2021]	[2007,2022]	[2007,2021]	[2013,2022]

Table 3: Descriptive statistics of explanatory variables included in the regression analysis.

We hypothesize that AgGDP, AgTFP, and AgLand are positively associated with agrifood-tech investment flows, for the simple reason that larger, more technically efficient regions with expanding agricultural land area hold more appeal to private investors. Similarly, we expect that regions with larger GII, DB, and NCS will enjoy greater investment flows, while EMBI and GE will be negatively associated with investment flows.

Table 4 shows the regression estimates. Private investment flows are positively and at least weakly significantly associated with the amount of land in agricultural production but not with agriculture's share of national output (AgGDP), and positively but insignificantly associated with overall agricultural productivity (AgTFP). Given that the country fixed effects control for inter-country differences already, such that these partial correlations are identified off of intertemporal variation within each country, we find that agricultural land expansion is associated with more capital inflows into the total agrifood value chain. Given adverse environmental effects associated with deforestation and loss of wetlands and wildlife habitat, this association raises questions about the sustainability impacts of agrifood tech investment in the region.

	INVcts_1		INVcts_2		INVcts_3		INVcts_4		INVcts_5		INVcts_6	
Adj. R^2	0.186		0.168		0.113		0.124		0.150		0.147	
Prob > F	0.0000		0.0000		0.0006		0.0011		0.0003		0.0007	
Degrees of freedom	333		298		257		257		215		215	
	Coeff	**p-val**	**Coeff**	**p-val**	**Coeff.**	**p-val**	**Coeff.**	**p-val**	**Coeff.**	**p-val**	**Coeff**	**p-val**
Constant	-513.1	0.02	-479.6	0.04	-423.0	0.06	-452.0	0.07	-350.1	0.40	-425.4	0.38
AgLand	4.26	0.03	4.11	0.04	3.86	0.08	3.94	0.07	6.02	0.10	7.02	0.08
AgGDP	3.07	0.73	1.10	0.93	-22.8	0.16	-24.9	0.15	-20.2	0.39	-30.9	0.19
AgTFP					1.77	0.20	2.04	0.15	1.43	0.44	1.70	0.37
EMBI	0.09	0.77			0.71	0.90					1.22	0.67
GE			-2.85	0.85			-15.7	0.40			-34.4	0.27
CSN			0.09	0.91			0.52	0.58			1.11	0.47
GII									-10.3	0.39	-10.2	0.43
Industry												
Consumption	-1.72	0.94	5.07	0.83	6.54	0.79	6.72	0.79	2.16	0.94	2.70	0.93
Cross-cutting Inno.	4.46	0.81	8.50	0.66	3.96	0.84	3.96	0.85	4.70	0.84	4.80	0.84
Finance	17.7	0.44	15.4	0.52	15.1	0.55	15.5	0.54	14.7	0.62	15.7	0.59
Inputs	13.9	0.50	13.36	0.53	14.4	0.51	14.9	0.49	13.2	0.63	13.5	0.62
Market and retail	14.7	0.47	8.83	0.68	-3.14	0.88	-2.41	0.91	-2.87	0.91	-0.89	0.97
Process. & packag.	12.1	0.54	14.5	0.47	13.9	0.51	12.9	0.54	12.3	0.63	10.42	0.68
STD	137.9	0.00	141.1	0.00	125.4	0.00	125.8	0.00	138.6	0.00	139.2	0.00
Waste	-25.7	0.41	-24.1	0.47	5.24	0.91	6.30	0.89	8.81	0.86	9.50	0.85
Country												
Bolivia	277.7	0.19	299.5	0.18			381.2	0.11				
Brazil	-493.4	0.04	-477.7	0.06	-506.9	0.07	-518.3	0.06	-748.8	0.10	-867.8	0.07
Chile	422.4	0.02	410.3	0.05	296.1	0.16	337.8	0.13	577.1	0.15	751.2	0.09
Colombia	339.3	0.01	319.8	0.02	282.2	0.08	289.0	0.08	448.9	0.09	531.7	0.08
Ecuador	437.2	0.06	429.3	0.09	482.7	0.08	515.8	0.06	661.5	0.11	834.5	0.06
Paraguay	429.3	0.07	426.2	0.10	529.1	0.07	555.8	0.06	684.9	0.11	875.1	0.07
Peru	368.8	0.04	353.8	0.06	337.6	0.11	339.5	0.12	534.6	0.12	634.2	0.10
Uruguay	481.2	0.02	464.2	0.05	446.9	0.05	516.1	0.03	684.6	0.08	935.5	0.04
Venezuela	263.4	0.18	261.7	0.19	190.1	0.41	211.9	0.34				
Year												
2008	17.1	0.87	20.2	0.85	8.91	0.93	9.2	0.93				
2009	-36.0	0.73	-33.9	0.74	-42.9	0.67	-39.0	0.70				
2010	-17.7	0.86	-16.8	0.87	-36.2	0.72	-27.3	0.80				
2011	-31.5	0.75	-16.2	080	-49.1	0.62	-37.3	0.72				
2012	-19.0	0.85	-16.6	0.87	-51.2	0.60	-39.4	0.70				
2013	-26.8	0.79	-20.9	0.84	-54.5	0.58	-40.4	0.69				
2014	-26.6	0.79	-21.7	0.83	-54.9	0.57	-42.3	0.68	-9.5	0.78	-12.4	0.72
2015	-26.7	0.79	-22.0	0.82	-67.8	0.50	-57.2	0.57	-26.8	0.46	-34.5	0.40
2016	-25.1	0.80	-18.9	0.85	-45.4	0.64	-32.3	0.74	-28.4	0.59	-27.3	0.65
2017	-0.23	0.99	5.06	0.96	-36.1	0.71	-21.2	0.83	-13.3	0.78	-10.1	0.85
2018	19.2	0.84	25.1	0.80	-17.5	0.86	-4.2	0.96	1.0	0.98	0.94	0.98
2019	17.3	0.86	23.5	0.81	-25.0	0.80	-14.6	0.88	-6.8	0.90	-12.0	0.85
2020	-9.1	0.92	-2.09	0.98	-31.3	0.76	-20.7	0.84	-41.5	0.63	-42.4	0.66
2021	38.8	0.69	47.9	0.63								
2022	31.8	0.74										

Table 4: Multivariate regression analysis results. Dependent variable is total private capital investments in 2022 constant US dollar. Prob> F indicates the p-value on the F-test of the full regression. STD = storage, transport, and distribution.

The omitted industry segment is primary production, which represents the largest deal volume. Except for STD deals, which are significantly larger than in other sectors, no meaningful differences exist among industry segments. Much of the variation is at the country level, with Brazil getting less investment than one would predict, given its vast land in agriculture and relatively high agricultural productivity, and all the other countries getting more private agrifood-tech investment than one would predict relative to the Argentina base case. The macroeconomic and financial indicators – CSN, EMBI, GE and GII – have effectively no explanatory power. Likewise, the year fixed effects have essentially no explanatory power. Together, these results signal that the dramatic rise in private agrifood-tech investment over the study period has likely been driven by company-level fundamentals, not by time trends independent of the explanatory variables nor by macroeconomic conditions. Together, all of these explanatory variables account for just 11-19 of observed variation in private investment flows.

OLS regression results with decomposition of R^2 (in %)		
Model	**Group Variables**	***R^2* decomposition (%)**
INVcts_1	Agriculture	5.25
	Macro	0.61
	Fixed Effects	94.13
INVcts_2	Agriculture	5.77
	Macro	4.19
	Fixed Effects	90.03
INVcts_3	Agriculture	12.05
	Macro	2.22
	Fixed Effects	85.72
INVcts _4	Agriculture	13.18
	Macro	1.52
	Fixed Effects	85.29
INVcts_5	Agriculture	8.98
	Macro	0.50
	Fixed Effects	90.51
INVcts_6	Agriculture	7.15
	Macro	4.98
	Fixed Effects	87.85

Table 5: Shapley R^2 decomposition of the ag variables (AgLand, AgGDP, AgTFP), macro variables (GE, GII, CSN, EMBI), and fixed effect control variables dummies employed in the multiple regression models.

This conclusion is only reinforced by Table 5, which reports the Shapley decomposition of the explained variation in private investment flows among agricultural variables (AgLand, AgGDP, AgTFP), macroeconomic factors (GE, GII, CSN, EMBI), and the various fixed effects. These clearly show that the fixed effects – mainly country fixed effects – explain 85-95 percent of the variation that can be explained. Since fixed effects reflect unobservables, this basically signals that private investment flows are driven overwhelmingly by micro- (likely firm-)level factors, not macro-scale ones nor simple trends.

5. Accelerators and barriers to technology adoption and uptake to scale

Because the multivariate regression analysis underscores that the explosive growth observed in private agrifood-tech investment flows into South America are associated mainly with sub-national factors specific to particular sub-sectors, firms, or technologies, we complement the quantitative analysis with qualitative findings from structured interviews with industry experts.[4] The main purpose of those discussions was to identify the main barriers to and accelerators of agrifood technologies and innovations in South America and how the resulting scaling of innovations might influence private investment flows. This section summarizes the views consistently advanced by these experts.

A consistent theme of the key informant interviews was the multiplicity of hurdles within the SAAE to the adoption and scaling of agrifood technologies and innovations and thus of private investment to support firms' agrifood tech initiatives. Investing in agrifood-tech startups differs from investing in publicly traded companies, sovereign bonds, or other, more conventional financial assets. Agrifood-tech startups are often pre-revenue or very early stage with limited revenue, and thus with limited financial data available, making it challenging to assess their prospects accurately using traditional financial models. Our regression analysis suggests that most macroeconomic and financial indicators cannot easily explain observed variation in investment flows, strongly suggesting the central importance of firm fundamentals. Investors

[4] We thank our key informants for their valuable insights: José Gobbé (The Context Network), Martin Burló (Red Surcos SRL), Trevor Sieck (FoodBytes by Rabobank), Tomás Peña (The Yield Lab), Ernesto Stein (IDB Lab), Ana Castillo Leska (IDB Lab), Matias Peire (GRIDX), Roberto Vitón (Valoral Advisors), Juan Ortega (Rappi), Pablo Villalobos (UTALCA, Chile), Laurens Klerkx (UTALCA, Chile), Jeremías Latchman (University of Buenos Aires), and Pablo Mac Clay (Universidad Austral, Argentina).

commonly value startups based on (i) the innovativeness of their technology, (ii) their business model, (iii) the size and potential growth of the market target, (iv) the entrepreneurial team, and (v) market validation.

Agrifood technologies such as smart farming, digital agribusiness, and on-demand delivery directly benefit from digitalization in all of its dimensions. SAAE is well-positioned to take advantage of digital transformation, primarily because of wide access to the internet and high rate of penetration of ICT devices (OECD, 2022). Of course, this raises the risk that digitalization may exacerbate social inequality if governments do not act to ensure that small enterprises and disadvantaged groups can share in the benefits of digitalization. But digitization comes up frequently as a big driver of agrifood tech investment in South America.

Higher education also plays a key role in driving innovation. A positive correlation exists between the number of people holding graduate degrees and a country's level of innovation, as measured by the number of patents and the contribution of skilled human capital to total factor productivity (Chellaraj, 2005; Marotta, 2007). Despite an abundance of degree and postgraduate programs, South America lacks high-level training programs (primarily Ph.D.s), which impedes R&D in this space. In South America, 50 new doctorates are awarded per million inhabitants each year, whereas in the USA, the figure is three times higher, at 150 per million inhabitants (CONACyT, 2010). Geographic pockets with agglomerations of highly educated scientists and engineers attract more private agrifood tech investments, just as in North America.

Despite promising investment trends, limited access to funding and underdeveloped capital markets in most South American countries hinder the growth of startups and limit their impact. Historically, emerging market funds have underperformed global market averages (MSCI Emerging Market Index, 2012-2022). This empirical regularity is partially explained by low standards of corporate governance in terms of the quality of information required to make investment decisions and monitor performance once investments have been made; the weakness of legal systems in enforcing contracts and protecting all classes

of investors; and the inability of domestic equity markets to offer a reasonable prospect of exit through the IPO market (Leeds & Sunderland, 2003)

A strong domestic capital market encourages investment in innovation, provides governments and businesses with long-term funding in local currency, and promotes long-term growth with more job prospects. This is both a barrier and an opportunity for South America's agrifood-tech ecosystem to grow. South America's market capitalization as a proportion of GDP is just 21.1%, which is low when compared to developed domestic markets, where capitalization rates frequently exceed total domestic GDP (CEIC, 2022). Brazil is the most developed and active capital market in the region, with a market capitalization of $770 billion, accounting for 75% of South America's total equity valuation. Brazil accounted for all but one of the 46 IPOs completed in South America in 2021 (Guzman et al., 2022). Meanwhile, there is a general process of delisting going on in Chile, Colombia, and Argentina. In Colombia and Argentina, the last IPOs recorded date from 2012 and 2010, respectively.

The agrifood tech sector requires sophisticated investors who understand agrifood systems at a deeper level than the average investor, for multiple reasons. First, agrifood tech has a long investing horizon, primarily due to the nature of biological processes and crop cycles. Unlike sectors with rapid product development or technology adoption and diffusion, developing and scaling agrifood-tech projects often require patient capital and can be capital-intensive. The rapid influx of investments into downstream delivery apps after the COVID pandemic began underscores the difference between patient investment in biological innovations and short-run investment in purely digital ones. Sophisticated investors understand the extended timelines involved in primary production, in novel foods development, and in a good deal of storage, transportation and distribution investments, and have the financial capacity to sustain investments over extended periods.

Second, the agrifood-tech sector is subject to a complex web of food safety and environmental regulations. Knowing how to navigate these regulatory waters is crucial to success in this space. Sophisticated investors are well-versed in the legal and environmental aspects of agrifood systems.

Finally, investing in agrifood-tech demands technical expertise and industry knowledge. Sophisticated investors need to have a wide understanding of the various scientific fields involved in the primary production, post-harvest processing and marketing, and final consumer use patterns of agrifood products. They must be able to evaluate and assess market demand, distribution networks, and regulatory environments. Such expertise is relatively scarce in the investing community. especially in emerging markets.

South American governments could expand efforts to facilitate interactions between the private sector, governments, and research institutions to boost domestic R&D and innovation. This includes creating the financial vehicles necessary to co-finance R&D projects that focus on the delivery of new products and services into domestic and regional markets. These partnerships and financial vehicles ultimately fill gaps that enable research institutions and businesses to pursue innovative projects. For example, the Brazilian Agricultural Research Corporation (EMBRAPA) has successfully collaborated with private companies to develop and commercialize genetically modified crops (Parente et al., 2021). Further, international organizations like FONTAGRO have actively funded research projects in South America, leading to private sector successes with significant social benefit.

Governmental interventions through infrastructure investments, financing, and public policies may help to mitigate risk and create an enabling environment to attract private investment. Risk exposure and risk preferences influence the timing and extent of technology adoption (Marra et al. 2003; Liu 2013). At the farm level, there are three variables that have to be taken into account to foster technology uptake: (i) opportunity cost, (ii) risk, and (iii) the possibility of postponing adoption (Spiegel et al., 2021). Governments and technological institutions can intervene in this area by providing safety mechanisms for technology testing. For example, the government of Israel deployed a technology uptake program that finances up to 50% of the cost of running a pilot test at the farm level, with the other 50% incurred by the farmer (Israel Innovation Authority, 2023). Israel expects this initiative to boost economic welfare and increase agricultural output.

Overall, the adoption and uptake of agricultural technology at scale in South America is influenced by a complex set of factors, including government policies, the presence of well-educated scientists and engineers as well as sophisticated investors, public-private partnerships, access to financing, infrastructure, and knowledge and skills. Investment trends suggest that the ecosystem has the potential to continue growing and transforming the agrifood industry in the region. But challenges related to funding, education, technology cost, and regulation will need to be addressed to fully realize this potential. Addressing these challenges will be crucial to unlocking the full potential of the agrifood-tech sector in South America. Investors can play a crucial role in this game, but they must also be aware of the challenges and barriers that may limit their impact.

6. Conclusions

Calls for agrifood systems transformation are widespread today. But data on rates of investment, especially private investment, and most especially into the Global South, remain scarce, as do studies that begin to identify the accelerators of and barriers to such investment. In this paper we report on a newly assembled database we constructed on private investment flows into the agrifood tech sector in South America over the 15 years period, 2007-22. We show that investments have increased dramatically in real terms, but quite unevenly across countries, sectors and technologies. Little of that variation can be explained by macroeconomic or agricultural indicators at country-year level. So much of the ongoing work to help stimulate private investment to help accelerate agrifood systems transformation in South America will require far more careful attention to highly local, and often firm- or technology-specific factors.

References

AgFunder. (2023). AgFunder AgrifoodTech Investing Report, 2022. Available at https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2023/

Barrett, C. B., Benton, T., Fanzo, J., Herrero, M., Nelson, R.J., Bageant, E., Buckler, E. Cooper, K.A., Cullota, I., Fan, S., and Ghandi, R. (2022a). *Socio-technical innovation bundles for agri-food systems transformation*. Springer Nature, 2022.

Barrett, C. B., Reardon, T., Swinnen, J., & Zilberman, D. (2022b). Agri-food value chain revolutions in low-and middle-income countries. *Journal of Economic Literature*, *60*(4), 1316-1377.

Cavallo, A., Ghezzi, A., & Ruales Guzman, B. V. (2020). Driving internationalization through business model innovation: Evidences from an AgTech company. *Multinational Business Review*, 28(2), 201-220.

Chellaraj, G., Maskus, K. E., & Mattoo, A. (2005). The contribution of skilled immigration and international graduate students to US innovation (Vol. 3588). World Bank Publications.

Charlton, D., & Kostandini, G. (2021). Can technology compensate for a labor shortage? Effects of 287 (g) immigration policies on the US dairy industry. *American Journal of Agricultural Economics*, 103(1), 70-89.

CONACyT (2010), Informe general del estado de la ciencia y tecnología, México, CONACyT.

Cockayne, D. (2019). What is a startup firm? A methodological and epistemological investigation into research objects in economic geography. *Geoforum*, 107, 77-87.

Connolly, A. J., Turner, J., & Potocki, A. D. (2018). IGNITE your corporate innovation: Insights from setting up an ag-tech start-up accelerator. *International Food and Agribusiness Management Review*, 21(6), 833-846.

Dabla-Norris, E., Y. Deng, A. Ivanova, I. Karpowicz, F. Unsal, E. VanLeemput, and J. Wong. 2015a. "Financial Inclusion: Zooming in on Latin America." IMF Working Paper, 15/206.

Demirguc-Kunt, A., Klapper, L., Singer, D., & Ansar, S. (2022). The Global Findex Database 2021.

Dias, C., Gonçales, M., Sakuda, L., de Souza, S. S., Jardim, F., Cleidson Nogueira Dias, S. I. N., & Francisco, I. J. (2022). Radar Agtech Brasil 2020/2021: map of the Brazilian startups of the agricultural sector.

Food and Agricultural Organization of the United Nations (FAO). (2023). FAOSTAT. Available at https://www.fao.org/faostat/en/#data.

Frewer, L. J., van der Lans, I. A., Fischer, A. R., Reinders, M. J., Menozzi, D., Zhang, X., & Zimmermann, K. L. (2013). Public perceptions of agri-food applications of genetic modification–a systematic review and meta-analysis. *Trends in Food Science & Technology*, 30(2), 142-152.

Herrero, M., Thornton, P.K., Mason-D'Croz, D., Palmer, J., Benton, T.G., Bodirsky, B.L., Bogard, J.R., Hall, A., Lee, B., Nyborg, K. and Pradhan, P. (2020) "Innovation can accelerate the transition towards a sustainable food system." *Nature Food* 1, 5: 266-272.

Herrero, M., Thornton, P.K., Mason-D'Croz, D., Palmer, J., Bodirsky, B.L., Pradhan, P., Barrett, C.B., Benton, T.G., Hall, A., Pikaar, I. and Bogard, J.R. (2021) "Articulating the effect of food systems innovation on the Sustainable Development Goals." *The Lancet Planetary Health* 5, 1: e50-e62.

Israel Innovation Authority. (2023). Pilot Programs with Multinational Corporations (MNCs). Available at https://innovationisrael.org.il/en/page/programs.

J. P. Morgan - Emerging Markets Strategic Bond Fund. (2023). Emergin Markets Bond Index. Available at https://www.invenomica.com.ar/riesgo-pais-embi-america-latina-serie-historica/

Guzman, J., Katri, K., Abraham, P., Vetterli, J. (2022). "Latin America IPOs surged on the back of tech listings". White & Case. https://www.whitecase.com/insight-our-thinking/latin-american-ipos-surged-back-tech-listings

Kennedy, Eileen, Patrick Webb, Steven Block, Timothy Griffin, Dariush Mozaffarian, and Rachel Kyte. "Transforming food systems: the missing pieces needed to make them work." *Current Developments in Nutrition* 5, 1 (2021): nzaa177.

Lachman, J., López, A., Tinghitella, G., & Gómez-Roca, S. (2021). Agtech in Argentina. Documentos de trabajo del Instituto Interdisciplinario de Economía Política, (57), 1-51.

Leeds, R., & Sunderland, J. (2003). Private equity investing in emerging markets. *Journal of Applied Corporate Finance*, 15(4), 111-119.

Liu, E. M. (2013). Time to change what to sow: Risk preferences and technology adoption decisions of cotton farmers in China. *Review of Economics and Statistics*, 95(4), 1386-1403.

Marra, M., Pannell, D. J., & Ghadim, A. A. (2003). The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: where are we on the learning curve?. *Agricultural Systems*, 75(2-3), 215-234.

Mordor Intelligence. (2022). Latin America E-commerce logistics market size & share analysis – growth trends & forecast (2023 – 2028).

Owusu-Nantwi, V., & Erickson, C. (2019). Foreign direct investment and economic growth in South America. *Journal of Economic Studies*.

Parente, R., Melo, M., Andrews, D., Kumaraswamy, A., & Vasconcelos, F. (2021). Public sector organizations and agricultural catch-up dilemma in emerging markets: The orchestrating role of Embrapa in Brazil. *Journal of International Business Studies*, 52, 646-670.

Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050. *Philosophical transactions of the royal society B: biological sciences*, 365(1554), 3065-3081.

Ramirez, M. D. (2000). The impact of public investment on private investment spending in Latin America: 1980–95. *Atlantic Economic Journal*, 28(2), 210-225.

Regmi, A., & Dyck, J. (2001). Effects of urbanization on global food demand. Changing structure of global food consumption and trade, 23-30.

Retterath, Andre, and Reiner Braun (2020).. "Benchmarking venture capital databases." Available at SSRN 3706108.

Rockström, J., Williams, J., Daily, G., Noble, A., Matthews, N., Gordon, & Smith, J. (2017). Sustainable intensification of agriculture for human prosperity and global sustainability. *Ambio*, 46, 4-17.

Rojas-Suárez, L. (2016). "Financial Inclusion in Latin America: Facts, Obstacles and Central Banks' Policy Issues", IDB Discussion Paper, 464.

Sarker, M. A. R., Alam, K., & Gow, J. (2021). Agricultural technology adoption and its implication for sustainable development in developing countries: A systematic literature review. *Journal of Cleaner Production*, 280, 124193.

Searchinger, T., Hanson, C., Ranganathan, J., Lipinski, B., Waite, R., Winterbottom, R., & Ari, T. B. (2014). Creating a sustainable food future. A menu of solutions to sustainably feed more than 9 billion people by 2050. World resources report 2013-14.

Siegrist, M., & Hartmann, C. 2020. Consumer acceptance of novel food technologies. *Nature Food*, 1(6), 343-350.

Silveira, G. B., Farina, M. C., & Santos, I. C. D. (2022). High-technology based startup in agribusiness sector: mapping linkages, products and services. *Revista de Economia e Sociologia Rural*, 61un. "Benchmarking venture capital databases." Available at SSRN 3706108 (2020).

Spiegel, A., Britz, W., & Finger, R. (2021). Risk, risk aversion, and agricultural technology adoption─ A novel valuation method based on real options and inverse stochastic dominance. *Q Open*, 1(2), qoab016.

The World Bank. (2020). Doing Business 2020 archive. Available at https://archive.doingbusiness.org/en/doingbusiness

The Food Systems Dashboard. Global Alliance for Improved Nutrition (GAIN) and Johns Hopkins University. (2020). Geneva, Switzerland. https://www.foodsystemsdashboard.org. DOI: https://doi.org/10.36072/db.

United States Department of Agriculture (USDA). (2022). "International Agriculture Productivity". Available at https://www.ers.usda.gov/data-products/international-agricultural-productivity/

Van Loo, E. J., Caputo, V., & Lusk, J. L. (2020). Consumer preferences for farm-raised meat, lab-grown meat, and plant-based meat alternatives: Does information or brand matter? *Food Policy*, 95, 101931.

Vargas, V. L. (2020). Implementation of a participatory methodology based on STEAM for the transfer of ICT knowledge and creation of Agtech spaces for the co-design of solutions that contribute to the development of small and medium agricultural producers in Colombia, Panama and China. In 2020 IEEE World Conference on Engineering Education (EDUNINE) (pp. 1-6). IEEE.

Vitón, R., Castillo, A., & Lopes Tixeira, T. (2019). AGTECH: Agtech Innovation Map in Latin America and the Caribbean. http://dx.doi.org/10.18235/0001788.

Wee, C. S., Ariff, M. S. B. M., Zakuan, N., Tajudin, M. N. M., Ismail, K., & Ishak, N. (2014). Consumers perception, purchase intention and actual purchase behavior of organic food products. *Review of Integrative Business and Economics Research*, 3(2), 378.

World Intellectual Property Organization (WIPO). (2022). Global Innovation Index. Available at https://www.wipo.int/global_innovation_index/en/

Yi, Jing, Eva-Marie Meemken, Veronica Mazariegos-Anastassiou, Jiali Liu, Ejin Kim, Miguel I. Gómez, Patrick Canning, and Christopher B. Barrett. (2021). "Post-farmgate food value chains make up most of consumer food expenditures globally." *Nature Food* 2, 6: 417-425.