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Navigating uncertainty through the integration of ecosystems, sustainability and effectuation: evidence from New Zealand's agritech SMEs

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ABSTRACT

This study examines how New Zealand agritech SMEs navigate uncertainty and build international traction by aligning entrepreneurial ecosystems (EEs), sustainable business models (SBMs), and effectual decision-making. In small, resource-constrained economies, entrepreneurs face a practical coordination problem: they must mobilise ecosystem resources, strategically configure sustainability, and adapt to uncertainty, yet existing research treats these domains largely in isolation. Drawing on an exploratory multiple-case study of three innovation-driven agritech SMEs, we show that international traction emerges not from any single domain, but from their dynamic configuration. Ecosystem mobilisation enables access to resources and legitimacy; sustainability configuration supports differentiation and partner attraction; and effectual adaptation operates as the cross-cutting mechanism that aligns these elements. The study extends EE, SBM and effectuation scholarship by offering a processual account of sustainable entrepreneurial strategy in a small-economy context and provides integrated implications for SMEs, policymakers, and ecosystem builders.

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Introduction

The agritech sector is increasingly recognised as a critical domain for addressing global challenges in food security, climate change, and sustainable resource management (N. Bocken et al., 2018; Technology Investment Network [TIN], 2022). In small, geographically isolated economies such as New Zealand, agritech firms face additional pressures to internationalise early while managing resource constraints and technological uncertainty (Autio et al., 2018; MBIE, 2022; TIN, 2022). These firms must navigate complex environments characterised by evolving market demands, regulatory pressures and sustainability expectations, making strategic coordination under uncertainty particularly difficult.

For entrepreneurs in such contexts, the challenge is not simply innovation, but coordination. Agritech SMEs must simultaneously engage ecosystem actors, configure sustainable business models, and make adaptive decisions under uncertainty. Yet existing research treats these domains largely in isolation. Entrepreneurial ecosystem studies focus on structural supports (Spigel, 2017; Stam, 2015), sustainable business model research emphasises value creation and sustainability integration (N. Bocken et al., 2018; Nosratabadi et al., 2019), and effectuation literature examines entrepreneurial decision logics under uncertainty (Arend et al., 2015; Sarasvathy, 2001). This fragmentation creates a practical problem: entrepreneurs, policymakers and ecosystem support actors lack coherent guidance on how to align resource mobilisation, sustainability strategy and adaptive experimentation in ways that support international traction. As a result, SMEs may struggle to coordinate ecosystem relationships, sustainability objectives and iterative scaling decisions effectively (Ferreira et al., 2023; Pankov et al., 2021).

To understand how SMEs navigate these challenges, this study draws on three complementary perspectives: entrepreneurial ecosystems (EEs), sustainable business models (SBMs) and effectuation theory. Entrepreneurial ecosystems highlight the role of interconnected actors and institutional supports in

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enabling venture development (Spigel, 2017; Stam, 2015). Sustainable business models focus on integrating environmental and social value into firm strategy alongside economic value (N. Bocken et al., 2018). Effectuation theory explains how entrepreneurs make decisions under uncertainty by leveraging available means and adapting through iterative learning (Sarasvathy, 2001). While each perspective offers valuable insights, each provides only a partial explanation when considered independently. EE research often emphasises structural features over entrepreneurial agency. SBM research frequently treats sustainability configuration as relatively stable, while effectuation research gives limited attention to ecosystem and sustainability contexts.

Consequently, the literature still lacks a coherent explanation of how these domains interact in practice when SMEs attempt to build international traction under uncertainty. This gap is particularly salient in small economies, where resource scarcity and international dependence intensify strategic complexity (Autio et al., 2018). Rather than developing a new standalone theory, this study adopts an exploratory, theory-extending approach to examine how entrepreneurial ecosystems, sustainable business models and effectuation operate as interdependent elements of SME strategy. Using a multiple-case study design (Yin, 2018), we examine how New Zealand agritech SMEs integrate ecosystem mobilisation, sustainability configuration and effectual adaptation in pursuit of international competitiveness.

For the purposes of this study, international competitiveness is conceptualised as **international traction**, including early market access, legitimacy abroad, niche positioning and stepwise scaling rather than sustained large-scale growth. This framing reflects the realities of SMEs in small economies, where incremental international expansion is often the dominant pathway. Accordingly, this study examines how SMEs navigate fragmented strategic demands by analysing the integrated roles of ecosystem engagement, sustainability configuration, and effectual decision-making in shaping international traction. The research is guided by the following questions:

- RQ1: How do New Zealand agritech SMEs leverage entrepreneurial ecosystems and sustainable business models to achieve international competitiveness?
- RQ2: How does effectuation shape entrepreneurial decision-making under uncertainty?

Literature review

The literature underpinning this study spans three core domains: entrepreneurial ecosystems, sustainable business models and effectuation theory. Each provides unique insights into how SMEs operate under uncertainty. Together, they offer a foundation for examining sustainable entrepreneurship in New Zealand's agritech sector. We review key contributions in each area, identify conceptual gaps and develop the basis for our integrative framework.

Entrepreneurial ecosystems (EEs)

Entrepreneurial ecosystems (EEs) refer to the interconnected institutional and resource environment that supports entrepreneurship (Spigel, 2017; Stam, 2015). These systems include investors, universities, government agencies, and support organisations whose interactions shape venture development. In small, geographically isolated economies, EEs are particularly significant due to limited domestic markets, restricted access to capital and pressure to internationalise early (Autio et al., 2018; United Nations, 2022). Recent empirical work further suggests that entrepreneurial ecosystems influence SME internationalisation trajectories through network connectivity and institutional coordination mechanisms (Ferreira et al., 2023).

Existing EE research has often emphasised structural features such as funding availability or network density (Spigel, 2017; Stam, 2015), while offering more limited insight into how founders actively mobilise ecosystem resources under uncertainty. In contexts such as New Zealand, where early internationalisation is often necessary, entrepreneurial agency within ecosystems becomes especially important (TIN, 2022). Although EEs can foster sustainable entrepreneurship by shaping pro-sustainability norms and providing institutional resources (Bischoff & Volkmann, 2018; Tiba et al., 2020), empirical evidence remains limited on how ecosystem engagement supports the development and scaling of sustainable business models in agritech (Ratten, 2020). This points to the need for closer examination of how SMEs strategically mobilise ecosystem relationships to pursue both sustainability and international reach.

Sustainable business models (SBMs)

Sustainable business models (SBMs) integrate environmental and social value into a firm's value-creation, delivery, and capture mechanisms alongside economic objectives (Schaltegger et al., 2016). While much SBM research has focused on large, established firms, there is more limited empirical insight into how SMEs experiment with and adapt sustainability-oriented models in dynamic contexts such as agritech (N. Bocken et al., 2018). This makes sustainable business model innovation (SBMI) particularly important, as sustainability transitions often require firms to reconfigure value propositions, partner relationships and revenue logic over time (N. M. P. Bocken et al., 2014).

SBMI is shaped by internal capabilities and external ecosystem conditions (N. M. P. Bocken & Geradts, 2020; Hermundsdottir & Aspelund, 2021). Prior studies show that sustainability configurations vary across contexts and evolve unevenly across firms (Ulvenblad et al., 2019). Ecosystem actors, including policy institutions and innovation intermediaries, can facilitate this evolution by reducing risk and supporting collaboration (Baiocco & Panicia, 2023; Pardo-del-Val et al., 2024). Nevertheless, sector-specific evidence remains limited on how agritech SBMs evolve over time and how this evolution supports international competitiveness (Barth et al., 2021).

For agritech ventures, sustainability-oriented innovation may also underpin international competitiveness, particularly where regulatory standards and customer expectations favour environmental performance (N. Bocken et al., 2018; Boons & Lüdeke-Freund, 2013). However, developing such models often involves iterative experimentation and stakeholder co-creation, suggesting that sustainability configuration is intertwined with entrepreneurial decision-making processes rather than simply representing a stable strategic choice. To examine that interaction more closely, we incorporate effectuation theory.

Effectuation under uncertainty

Effectuation theory explains entrepreneurial decision-making and strategy under uncertainty (Sarasvathy, 2001). Subsequent validation studies have further clarified the distinction between causation and effectuation, showing that both logics may co-exist within entrepreneurial strategy (Chandler et al., 2011). Rather than pursuing predefined goals through planned optimisation, effectual entrepreneurs begin with available means and allow objectives to emerge through iterative learning and stakeholder engagement (Sarasvathy, 2001). This logic is especially relevant in agritech, where technologies, markets and regulatory expectations evolve unpredictably.

Although widely applied in entrepreneurship research, effectuation has been criticised for insufficient engagement with broader institutional and strategic contexts (Kitching & Rouse, 2020; Perry et al., 2012). Much of the literature examines cognitive processes in isolation, overlooking how ecosystem structures and sustainability imperatives shape entrepreneurial action (Arend et al., 2015). Moreover, whether effectual logic inherently supports sustainability objectives or requires complementary frameworks remains unclear (Laveren et al., 2020), although recent research suggests that effectuation may provide an important decision-making logic for sustainable entrepreneurship (Dawa & Marks, 2024).

Situating effectuation within the ecosystem and sustainability context helps address these concerns. By examining how founders employ effectual experimentation while engaging ecosystem actors and configuring sustainable business models, this study responds to calls for more contextualised effectuation research (Kitching & Rouse, 2020) and contributes to understanding sustainable entrepreneurship under uncertainty. This study conceptualises effectuation not as a parallel perspective, but as the mechanism through which ecosystem resources and sustainability strategies are dynamically aligned.

Integration of theoretical frameworks

Although entrepreneurial ecosystems, sustainable business models and effectuation each offer valuable insights, their independent application reveals important conceptual limitations. Entrepreneurial ecosystem research advances understanding of institutional support structures but often underplays entrepreneurial agency in mobilising those resources (Roundy, 2019; Spigel, 2017). SBM scholarship highlights sustainability integration yet often treats business models as relatively stable architectures, paying limited attention

to their dynamic evolution in SMEs under constraints (N. Bocken et al., 2018; Boons & Lüdeke-Freund, 2013). Effectuation theory explains adaptive decision-making but may underemphasise how institutional and sustainability contexts condition entrepreneurial action (Kitching & Rouse, 2020).

Taken together, these limitations suggest that analysing each framework independently risks overlooking the interdependencies shaping SME strategy in small economies. Emerging scholarship on sustainable entrepreneurial ecosystems similarly highlights the importance of examining how contextual and sustainability-oriented dynamics intersect within ecosystem structures (Pankov et al., 2021). For agritech SMEs in New Zealand, ecosystem mobilisation, sustainability configuration and adaptive experimentation are therefore better understood as interdependent rather than parallel processes. Accordingly, this study adopts an integrative perspective to examine how these domains interact in practice to shape international traction under uncertainty.

Research design: methods and methodology

We aim to investigate entrepreneurial decision-making and sustainability practices under uncertainty, so we adopted a qualitative, exploratory research design using a multiple-case study approach. Qualitative case study research is well-suited for exploring complex, context-dependent phenomena that are not yet well understood (Creswell & Poth, 2018). A multiple-case design allows for the in-depth examination of real-world entrepreneurial processes in context, and its purpose is analytic rather than statistical generalisation (Yin, 2018). By examining multiple information-rich cases, we aim to refine and extend theoretical understanding of how EEs, SBMs and effectuation interact in SME strategy, rather than to claim representativeness across the broader agritech population.

Case selection

Three New Zealand agritech SMEs were purposefully selected as case studies (Patton, 2002). To ensure rich information, the firms met criteria including: (1) a strong sustainability orientation (environmental or social initiatives integral to their business model), (2) involvement in international markets (exporting or operations abroad), and (3) active participation in the local entrepreneurial ecosystem (e.g. incubators, industry networks or government programmes). These criteria captured ventures likely to exhibit the intersection of EEs, SBMs and effectuation in their strategies, aligning with our research questions. For confidentiality, the firms are anonymised as Firm A (FA), Firm B (FB) and Firm C (FC). Each is an innovation-driven SME (<50 employees) with growth ambitions (MBIE, 2022). All three provide agritech products or services that improve sustainability outcomes in agriculture, and all are embedded in New Zealand's agritech ecosystem. This selection enabled us to observe entrepreneurial behaviours in a context relevant to our theoretical framework.

The selection was theoretically driven rather than convenience-based (Patton, 2002). Firms were chosen because they exhibited characteristics at the intersection of ecosystem engagement, sustainability orientation and international activity, making them appropriate for examining the integrative research questions. This theoretical sampling enhances internal coherence between case selection and conceptual framing.

Data collection

We conducted five interviews (one to two per firm, including follow-ups) with founders and senior managers (e.g. CEOs, COOs, CTOs) who are directly involved in strategic decision-making and internationalisation. In SMEs, strategic authority is frequently concentrated among founders and a small number of senior managers, particularly in innovation-driven ventures (Knight & Cavusgil, 2004). Accordingly, interviewing these central decision-makers provides insight into the core strategic logic of each firm rather than peripheral operational perspectives. Data collection, therefore, prioritised depth of strategic insight over numerical breadth. For this study, we collected data through semi-structured interviews with key decision-makers at each firm, supplemented by secondary sources. Using semi-structured interviews ensured we covered core themes (strategy under uncertainty, sustainability integration, ecosystem engagement, adap-

tive experimentation) while allowing flexibility for participants to introduce related insights. Interviews (approximately 45–60 min each) were audio-recorded with consent and transcribed verbatim for accuracy. Participants were assured anonymity and are referenced by codes (PA for Firm A's participant, PB for Firm B, PC for Firm C) to encourage openness. The study's researchers obtained ethical approval prior to contacting potential firms at the university, and interviewees provided informed consent.

The interviews probed how entrepreneurs formulated their strategies, responded to uncertainties or setbacks, pursued sustainability goals, engaged with ecosystem actors (government agencies, research institutes, investors, etc.), and made decisions as they developed their business models. Questions were open-ended (e.g. 'Describe the main challenge in scaling your product and how you dealt with it') to elicit detailed narratives. In addition to interviews, we gathered secondary data for each case, including company websites, product documents, press releases, industry reports, and government programme materials. Secondary data were incorporated into the coding process rather than used solely for contextual description. For example, references to ecosystem partnerships, funding support or international expansion in interview transcripts were cross-checked against public documentation. Where discrepancies emerged, these were revisited during analysis. This strengthened interpretive credibility and reduced reliance on single-source narratives (Yin, 2018).

Data analysis

We employed thematic analysis (Braun & Clarke, 2006) and conducted both within-case and cross-case analysis (Miles et al., 2014). Our unit of analysis is the entrepreneurial process (e.g. the strategies and decision-making logics of entrepreneurs) rather than the firm itself, aligning with our focus on how entrepreneurs engage with ecosystems, shape business models, and make decisions under uncertainty.

Analysis commenced with an in-depth reading of each transcript. We manually performed open coding, allowing close immersion in the data (Braun & Clarke, 2006). Coding proceeded in three stages. First, first-order codes captured specific actions and events described by participants (e.g. 'leveraging R&D grants', 'co-developing with pilot customers', 'adjusting value proposition for export markets'). Second, these codes were grouped into broader second-order themes reflecting ecosystem mobilisation, sustainability configuration and effectual adaptation. The coding process followed a structured progression from first-order codes reflecting participant language to second-order themes and aggregate dimensions aligned with the study's theoretical framing (Miles et al., 2014). This staged analysis enhanced transparency and theoretical coherence. An illustrative summary of this coding development is provided in Table 1.

Third, we examined how these themes interacted within and across cases, identifying patterns of co-occurrence and recursive alignment. This staged coding approach enhances transparency in linking empirical data to theoretical interpretation (Braun & Clarke, 2006; Miles et al., 2014). Throughout this iterative process, we refined our coding scheme, merging related codes and distinguishing sub-themes as needed to accurately reflect the data.

Table 1. Coding structure: first-order codes, second-order themes and aggregate dimensions.

First-order codes (participant language)	Participant code	Second-order themes	Aggregate dimensions
'We've worked closely with Callaghan and Lincoln Agritech on a number of projects –they've helped us refine and validate the technology'	PA (Firm A)	Government support leverage	Strategic Ecosystem Mobilisation
'NZTE were really helpful in making introductions and helping us understand how to approach the US market'	PB (Firm B)	Export facilitation engagement	Strategic Ecosystem Mobilisation
'Being a spin-out from Plant & Food gave us immediate credibility...having that research backing made conversations with investors much easier'	PC (Firm C)	Institutional legitimacy building	Strategic Ecosystem Mobilisation
'Sustainability is built into what we do –it's not an add-on'	PB (Firm B)	Mission-driven positioning	Sustainability Configuration
'Our customers care about efficiency and reducing inputs –that's where sustainability meets performance'	PA (Firm A)	Sustainability-oriented value framing	Sustainability Configuration
'We're constantly looking at how to improve the sustainability of what we're doing'.	PC (Firm C)	Continuous sustainability refinement	Sustainability Configuration
'We pivoted three times before the tech stuck'	PC (Firm C)	Iterative market experimentation	Effectual Adaptation
'We take feedback from the field and build that straight back into the next version'	PA (Firm A)	Customer co-development	Effectual Adaptation
'We didn't want to overcommit before we knew there was real demand'.	PB (Firm B)	Affordable-loss scaling	Effectual Adaptation

Several procedures were employed to enhance the credibility and trustworthiness of the analysis. Firms were anonymised (FA, FB, FC) and participants coded (PA, PB, PC) to maintain confidentiality while enabling systematic cross-case comparison. Regular team debriefings were conducted to discuss emerging interpretations, challenge assumptions and refine theme definitions, thereby strengthening analytical consistency. Triangulation across interviews and secondary sources was used to corroborate key claims; for example, references to R&D support or export facilitation were cross-checked against publicly available documentation. Reflexive memos were maintained throughout the coding process to document analytic decisions and theoretical linkages. Together, these steps support the dependability and interpretive rigour of the study (Yin, 2018). Through this systematic and iterative process, the study developed grounded insights into how sustainability-oriented strategies and ecosystem interactions shape SME responses to uncertainty.

Findings

The data analysis identifies three themes that capture how New Zealand agritech SMEs navigate uncertainty and pursue international traction: (1) strategic use of entrepreneurial ecosystems, (2) sustainability as strategy and (3) effectual adaptation. Although presented separately for analytical clarity, these themes were deeply interconnected in practice. Ecosystem engagement, sustainability configuration and adaptive experimentation were recursively aligned as firms navigated uncertainty and should therefore be understood as mutually reinforcing elements of SME strategy rather than independent dimensions. Table 2 summarises these themes with illustrative interview data, followed by a detailed discussion of each.

Theme 1: strategic use of entrepreneurial ecosystems

All three case firms actively leveraged elements of New Zealand's entrepreneurial ecosystem to support their growth. They viewed the ecosystem as an extension of their resource base, acting as a catalyst for innovation and scaling. Participants emphasized that strategically collaborating with government agencies and research institutes reduced barriers to market entry and accelerated innovation. For example, both Firm A and Firm B obtained grants and expertise from government initiatives: 'Callaghan Innovation helped us develop our prototype and de-risk the R&D phase' (PA) and 'NZTE opened doors for us in the US, including introductions to our first distributor' (PB). These engagements provided critical funding, technical validation and market access that the firms could not have achieved alone. These supports also created the conditions for experimentation and strengthened the firms' ability to refine sustainability-oriented offerings before scaling internationally. Firm C similarly benefited from its origin as a spin-out in partnership with a Crown Research Institute. As PC explained, this 'gave us lab access and credibility that others did not have'.

Table 2. Emerging themes and representative evidence from case firms.

Theme	Description	Representative evidence from cases
Ecosystem Leverage	Strategic engagement with • government agencies, • research institutions • national networks to access funding, credibility and international pathways.	Firms accessed R&D grants and prototype development support through innovation agencies (Firm A) leveraged export facilitation programmes to enter US markets (Firm B) and benefited from institutional partnerships that provided laboratory access and credibility (Firm C)
Sustainability as Strategy	Sustainability embedded as a core value proposition guiding • product development, • differentiation and • market positioning.	Participants described sustainability as central to their mission rather than a peripheral feature (Firm B) framed offerings around plant health, food security and climate resilience to resonate with global buyers (Firm A) integrated environmental risk reduction into core technology development (Firm C)
Adaptive Experimentation	Iterative prototyping, stakeholder co-creation and affordable-loss scaling to manage uncertainty and refine business models.	Firms engaged in repeated market pivots through customer co-development (Firm C) derived key product features through direct interaction with growers (Firm A) and adopted small-scale, staged market entry strategies to limit risk before scaling (Firm B).

Collaborations within the ecosystem were also pivotal. Firm B went through an agritech accelerator, gaining mentorship and networking opportunities, while Firm A partnered with a university horticulture lab via an incubator programme. Such connections embedded the firms in knowledge-sharing networks and signalled legitimacy to external partners. The entrepreneurial ecosystem thus served as a foundation for international traction, enabling these SMEs to overcome the limitations of firm size and resource scarcity. For instance, when approaching overseas customers, Firm A deliberately leveraged New Zealand's reputation for high-quality, sustainable agriculture (an intangible ecosystem asset). As PA noted, being a New Zealand company with a clean-green image 'definitely got us a second look in Europe'. Meanwhile, Firm C navigated complex overseas regulations by tapping into ecosystem networks. PC described those introductions via an industry group 'helped us tackle EU compliance, because we met people who had done it before'.

In summary, **ecosystem leverage** manifests through securing funding and support (grants and accelerators), building credibility through institutional linkages, and utilising New Zealand's national brand and networks to enter global markets. The entrepreneurs did not passively receive help; they strategically engaged the ecosystem by identifying available programmes, cultivating relationships with key actors and aligning their ventures' needs with what the ecosystem could offer.

Importantly, ecosystem mobilisation did not occur in isolation. In the cases examined, engagement with investors, research institutions and policy actors was frequently intertwined with sustainability objectives and iterative experimentation. Access to ecosystem resources enabled firms to test and refine sustainability-oriented offerings, while sustainability commitments strengthened their legitimacy within the ecosystem. This interaction suggests that ecosystem engagement both shaped and was shaped by firms' evolving business models and adaptive decision-making.

Theme 2: sustainability as strategy

An apparent similarity across cases was that sustainability is not a peripheral concern or marketing angle, but a core strategic driver. Each venture had sustainability deeply embedded in its value proposition and product development, enhancing differentiation in international markets. As Firm B's participant said, 'It is not just a feature; sustainability is our reason to exist. Our whole pitch is lower emissions and better performance'. This indicates dual value creation: delivering economic value to customers while achieving environmental benefits. In this sense, sustainability functioned not only as a normative commitment but as a strategic configuration that shaped how firms positioned their offerings, attracted partners, and prioritised experimentation. Similarly, Firm A's founder framed their mission around grand challenges: 'We talk to customers in terms of plant health, food security, climate resilience – that is our language of value'. By doing so, the firm aligns its offerings with the sustainability priorities of global consumers and policy trends.

The agritech SMEs continuously adapted their business models to reinforce this sustainability orientation. They invested in innovation that furthered sustainable outcomes. For example, Firm C focuses its R&D on biosensor technology to detect agricultural pests, aiming to reduce chemical use. As PC noted, 'If we find a process in our ops that is not sustainable, we treat it like a bug to fix – it is iterative improvement'. This mindset shows how sustainable practices are integrated into operational decisions and product design choices (such as using recyclable materials or energy-efficient processes). In effect, sustainability acts as a guiding constraint that spurs creativity – the firms are driven to find solutions that meet customer needs and environmental standards simultaneously.

Importantly, a committed sustainability mission also unlocked certain ecosystem benefits and market advantages. All firms mentioned that being purpose-driven opened doors to partnerships and funding earmarked for sustainability initiatives (e.g. a government sustainability grant or an impact investor fund). Internationally, their strong sustainability stance resonated with regulators and buyers in markets with stringent environmental requirements. PB recounted how a European distributor chose their product because 'our lifecycle footprint was much better than the competitors', and their government buyers care about that now'. This use of sustainability as a strategy contributes to the firm's international competitiveness, serving as both a market differentiator and a gateway to resources. Although the firm must balance

sustainability with cost and functionality, participants reported that investing in sustainability strengthened brand and innovation capacity.

Sustainability orientation was therefore not only a value-driven positioning but also a mechanism that structured ecosystem relationships and guided experimentation. Firms frequently leveraged sustainability narratives to attract partners, funding and international interest, while simultaneously adjusting their business models through iterative testing. This indicates that sustainability configuration functioned in close interaction with ecosystem mobilisation and effectual adaptation rather than as a static strategic choice.

Theme 3: adaptive experimentation

The third theme reflects how these entrepreneurs approach uncertainty through continuous adaptation and experimentation, essentially, effectuation in practice. Instead of executing rigid long-term plans, the firms use iterative learning to refine their products and business models. Each venture underwent multiple strategic changes informed by stakeholder feedback. For example, Firm C initially pursued one application of its sensing technology but refined its market focus through early pilot collaborations. As PC reflected, 'Each pilot gave us new data that reshaped how we positioned the technology'. This iterative co-development with lead customers allowed the firm to test assumptions incrementally and redirect its application strategy before committing substantial resources. This quote highlights an effectual tactic: partnering with customers and other stakeholders early to test assumptions, thereby reducing market uncertainty. Importantly, these experiments were not confined to product development alone; they also reshaped how firms engaged ecosystem actors and adjusted sustainability-oriented value propositions in response to emerging feedback.

All interviewees described a 'trial, feedback and revise' philosophy. PA illustrated how key product features emerged: 'Most of our key features came out of talking to growers directly, not from boardroom planning'. Rather than relying on extensive upfront market research, they built basic prototypes and showed them to users, then adjusted their course based on what they learned. This approach aligns with the effectual principle of affordable loss: firms invest small amounts and manage risk at each step, preferring quick, frugal experiments over big bets. As PB noted, they deliberately used a limited initial scale to control risk: 'We don't hire a huge team or build a giant factory first. We start small, prove it, then scale stepwise. It is about not overextending until you have evidence'. Such thinking ensured that no single failure was catastrophic, helping them survive early setbacks.

Networking and partnership were also key to their adaptive strategy. Entrepreneurs frequently leverage partnerships to fill capability gaps and share risks – a means-driven approach. For instance, Firm B formed a joint project with a local farm to pilot its irrigation technology, splitting costs and learning together. Firm A entered the Australian market by partnering with an established agricultural supplier for distribution rather than immediately setting up its own channels. These partnerships functioned as real-world experiments that provided market insight and credibility.

In sum, the cases demonstrated a pattern of adaptive experimentation: entrepreneurs started with the means at hand (technical know-how and initial contacts), quickly launched test offerings, gathered feedback from customers and partners and refined their strategy accordingly. This iterative process allowed them to gradually discover viable business models and scaling paths, effectively navigating uncertainty. The effectual behaviours observed, for example, in embracing flexibility, leveraging contingencies, and collaborating closely with stakeholders, proved instrumental to their innovation and internationalisation journey. Notably, this adaptiveness did not occur in isolation; it was often enabled by ecosystem supports and aligned with their sustainability mission. For example, experiments in the sustainability domain sometimes attracted interest in the ecosystem (one firm received help from a university lab for a sustainable farming trial). Thus, the three themes were interlinked rather than sequential: ecosystem mobilisation and sustainability configuration both shaped and were reshaped by firms' adaptive entrepreneurial responses. Effectual adaptation operated as the mechanism through which ecosystem resources and sustainability commitments were aligned under uncertainty. Entrepreneurs recalibrated partnerships, refined value propositions and adjusted resource commitments in response to feedback from ecosystem actors and international markets. Rather than acting independently, effectuation enabled the dynamic configuration of ecosystem engagement and sustainable business model development observed across the cases.

Discussion

These findings illuminate the practical challenge identified earlier: how SMEs align ecosystem engagement, sustainability strategy and adaptive decision-making under conditions of uncertainty.

Integration as the central mechanism in SME strategy

The findings suggest that the international traction achieved by the agritech SMEs cannot be fully explained by entrepreneurial ecosystems (EEs), sustainable business models (SBMs) or effectuation in isolation. Rather, competitiveness emerged through the dynamic configuration of these elements under uncertainty.

EE research has emphasised structural components such as funding availability and network density (Spigel, 2017; Stam, 2015), yet our findings reinforce critiques that ecosystem value depends significantly on entrepreneurial agency and strategic mobilisation (Roundy, 2019). In the cases examined, ecosystem resources did not automatically generate advantage; rather, founders selectively mobilised partners and institutional supports in ways aligned with evolving sustainability objectives. This extends ecosystem scholarship by showing how SMEs in small economies actively configure ecosystem engagement to support adaptive business development.

Similarly, SBM scholarship highlights the integration of environmental and social values into firm strategy (N. Bocken et al., 2018; Boons & Lüdeke-Freund, 2013), yet often conceptualises business models as relatively stable architectures. Our findings align more closely with emerging views of sustainable business model innovation as iterative and context-dependent (N. M. P. Bocken et al., 2014; Hermundsdottir & Aspelund, 2021). In the agritech cases, sustainability was not a fixed blueprint, but a continuously refined configuration shaped through ecosystem interactions and international market feedback. This supports arguments that SBMs in SMEs evolve through experimentation and stakeholder engagement rather than linear transformation (Baiocco & Panicia, 2023).

Effectuation theory explains entrepreneurs' actions under uncertainty (Sarasvathy, 2001; Fisher, 2012), yet critics note limited engagement with institutional context (Kitching & Rouse, 2020). Recent scholarship has also begun to explore the relationship between effectuation and sustainable entrepreneurship (Dawa & Marks, 2024). Our findings extend this discussion by demonstrating that effectual reasoning functioned as an adaptive mechanism linking ecosystem mobilisation and the configuration of sustainability. Affordable-loss experimentation, partnership co-creation and iterative learning enabled firms to recalibrate both their ecosystem relationships and their business models as new information emerged. Effectuation was therefore embedded within structural and sustainability contexts rather than operating independently. In this sense, effectuation is conceptualised not as a parallel theoretical pillar, but as the mechanism through which ecosystem mobilisation and sustainability configuration are brought into alignment.

Taken together, these insights indicate that integration is not additive but configurational. Ecosystem mobilisation enabled sustainability experimentation; sustainability commitments enhanced ecosystem legitimacy; and effectual adaptation aligned both domains under uncertainty. This recursive interaction underpinned the firms' international traction.

Processual model of integrated strategy under uncertainty

The integrative configuration is illustrated in Figure 1.

The model in Figure 1 depicts SMEs operating under resource constraints, sustainability pressures and international market challenges characteristic of small economies (Autio et al., 2018). Within this context, entrepreneurs mobilise ecosystem resources (Spigel, 2017; Stam, 2015) while configuring sustainability-oriented value propositions (Boons & Lüdeke-Freund, 2013). Effectual adaptation (Sarasvathy, 2001) operates as a cross-cutting adaptive mechanism that links ecosystem mobilisation and sustainability configuration through iterative alignment under uncertainty.

The model reflects recursive feedback loops rather than linear causality. Ecosystem engagement shapes sustainability experimentation, which in turn influences subsequent ecosystem relationships. Effectual adaptation enables ongoing recalibration in response to technological, regulatory and market change. This process orientation responds directly to calls to contextualise effectuation (Arend et al., 2015; Kitching &

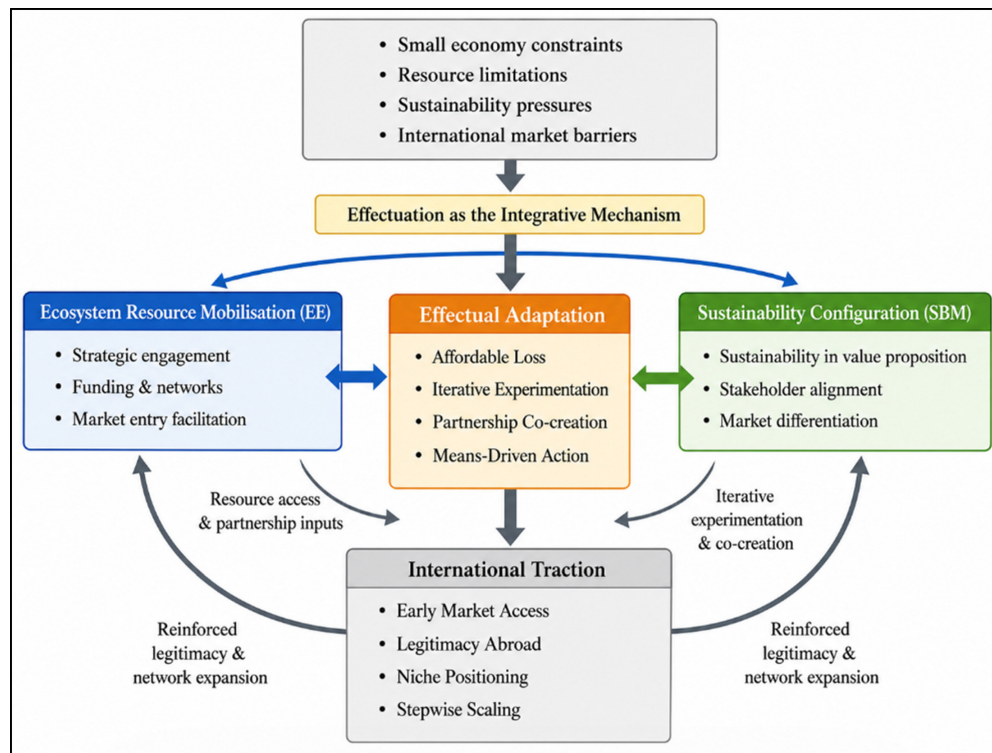


Figure 1. Process model of integrated ecosystem-sustainability strategy under uncertainty: effectuation as the adaptive mechanism linking ecosystem resource mobilisation and sustainability configuration to international traction.

Rouse, 2020) and to examine SBMs as dynamic and evolving (N. Bocken et al., 2018). By visualising these interactions, the model addresses the tendency to analyze EEs, SBMs and effectuation independently and shows how international traction emerges from their co-evolution.

Addressing the research questions

Our integrative framework helps address the research questions by clarifying how SMEs leverage ecosystems and sustainability strategies, and how effectuation shapes their decision-making under uncertainty.

RQ1 (ecosystems and SBMs for international competitiveness)

The findings indicate that SMEs leveraged ecosystems not merely as structural backdrops but as platforms for collaboration and legitimacy-building (Roundy, 2019). Sustainability commitments enhanced credibility and alignment with international regulatory and market expectations (N. Bocken et al., 2018; Boons & Lüdeke-Freund, 2013), supporting differentiation and entry into higher-value markets. Ecosystem mobilisation and sustainability configuration were mutually reinforcing: access to resources enabled sustainability experimentation, while mission-driven positioning attracted partners and funding.

RQ2 (effectuation under uncertainty)

Effectuation operated as an adaptive mechanism through affordable-loss commitments and partnership-based experimentation, supporting incremental international expansion consistent with small-economy dynamics (Autio et al., 2018). By embedding effectuation within ecosystem and sustainability contexts, this study responds to critiques that the theory insufficiently engages with structural conditions (Kitching & Rouse, 2020). Effectual reasoning enabled SMEs to recalibrate both ecosystem relationships and sustainability configurations as new information emerged.

Theoretical contributions

By addressing inherent limitations in the EE, SBM and effectuation literature, this study contributes to all three streams. First, it extends entrepreneurial ecosystem research by showing that ecosystem value depends not only on structural attributes but also on how entrepreneurs strategically configure available supports (Roundy, 2019; Spigel, 2017). Second, it reframes sustainable business models in SMEs as adaptive configurations shaped through ecosystem interaction and iterative experimentation, extending more static SBM conceptions (N. Bocken et al., 2018). Third, it contextualises effectuation by embedding it within ecosystem and sustainability dynamics, thereby responding to calls for greater institutional integration in effectuation research (Arend et al., 2015; Kitching & Rouse, 2020).

Rather than proposing a new, standalone theory, the study integrates and refines these perspectives within a small-economy agritech context, offering a processual understanding of SME strategy under uncertainty.

Practical implications (for SMEs and ecosystem builders)

The findings address the practical coordination problem faced by SMEs in uncertain environments by showing how ecosystem engagement, sustainability strategy and adaptive decision-making can be aligned rather than treated as separate strategic concerns. In doing so, they provide integrated guidance for entrepreneurs, policymakers and ecosystem support actors.

For SMEs, the evidence suggests that competitiveness does not stem from treating entrepreneurial ecosystems, sustainable business models and effectual decision-making as separate tools, but from integrating them strategically. Ecosystem resources such as funding, expertise and networks can enable sustainability experimentation; in turn, a clearly articulated sustainability mission can deepen ecosystem engagement and enhance legitimacy. Effectual logic, particularly incremental scaling and iterative learning, allows these elements to operate cohesively under uncertainty. Across the cases, staged market entry, pilot-based validation and constrained resource commitments supported international expansion without excessive risk exposure. Sustainability therefore functioned not merely as compliance or branding, but as a strategic anchor shaping value propositions, partner relationships and market positioning.

For policymakers and ecosystem builders, the findings suggest that support mechanisms should move beyond generic provision of funding or networking opportunities. Targeted institutional support, including R&D grants, export facilitation services and research partnerships, can play a critical role in enabling sustainability-driven internationalisation. In small economies, ecosystem investments are likely to be most effective when they combine innovation support with sustainability objectives and create opportunities for SMEs to experiment, validate and scale through collaboration. Funding schemes linked to environmental outcomes and platforms connecting SMEs to global partners may therefore enhance both competitiveness and long-term impact.

From an industry perspective, agritech SMEs can benefit from combining iterative product-market alignment with stakeholder co-creation. The cases demonstrate that sustainability can function as a strategic anchor rather than a constraint, while affordable-loss experimentation reduces risk during scaling. Entrepreneurship support programmes should therefore promote integrated capability-building in ecosystem navigation, sustainable business model development and adaptive decision-making. Such an approach would better prepare SMEs to translate uncertainty into learning, partnership formation and international traction.

Limitations and future research

This study focuses on sustainability-oriented agritech SMEs that are actively engaged in ecosystem networks and international markets. As such, the cases were theoretically selected to examine the intersection of ecosystem mobilisation, sustainable business model configuration and adaptive experimentation. Firms without an explicit sustainability orientation or those less embedded in ecosystem structures may exhibit different strategic configurations. Future research could examine whether similar patterns of integration emerge in non-sustainability-driven SMEs or in firms operating in less supportive ecosystem environments.

Such comparative analysis would further refine the understanding of how contextual and strategic variations influence entrepreneurial responses to uncertainty.

Additionally, while the study draws on multiple data sources and cross-case comparison, the findings are based on a limited number of cases within a specific national and sectoral context. The purpose is analytic generalisation rather than statistical representativeness (Yin, 2018). Our findings are based on three cases in the agritech sector of one small economy; thus, patterns observed may not hold in other sectors or cultural contexts. Future research could expand the sample to agritech SMEs in other small economies or conduct comparative studies with firms in larger markets to examine how context influences the EE-SBM-effectuation interplay. Longitudinal studies would be valuable in tracking the evolution of sustainable strategies beyond initial scaling phases.

Furthermore, quantitative research could test relationships proposed by our framework – for instance, examining the impact of ecosystem engagement on export performance, or the role of effectuation in innovation outcomes. Further inquiry might also explore potential tensions: for example, conflicts between effectual experimentation and long-term sustainability commitments, or constraints imposed by ecosystem structures on effectual flexibility. Exploring these nuances would deepen understanding of sustainable entrepreneurship.

Conclusion

This study responds to the practical and theoretical fragmentation in existing research by examining how New Zealand agritech SMEs achieve international traction by integrating entrepreneurial ecosystems (EEs), sustainable business models (SBMs) and effectuation within a unified strategic framework. Through three case studies, we found that entrepreneurs strategically mobilised ecosystem supports (grants, partnerships, networks) to overcome resource constraints, embedded sustainability as a core logic to build resilience and differentiation and navigated uncertainty through effectual principles – including affordable-loss experimentation, stakeholder co-creation and iterative adaptation.

Our research contributes an integrated, mechanism-based model linking external resource orchestration, sustainability-driven value creation and adaptive decision-making. This framework clarifies how these elements interact to support international traction and positioning for SMEs in small economies and provides a foundation for future empirical testing. The findings underline the importance of targeted, mission-aligned ecosystem investments (such as R&D grants, export platforms and research collaborations) in amplifying competitiveness and sustainability outcomes. Policymakers should recognize the compounded benefits of strengthening ecosystem structures that support sustainable and iterative innovation. For practitioners, the study highlights the value of treating sustainability as a strategic anchor, engaging in stakeholder co-creation and adopting an experiment-driven, partnership-led approach to de-risk internationalisation.

Despite the limitations noted, this study makes a timely contribution at the intersection of entrepreneurship, sustainability and small enterprise development. As industries worldwide seek sustainable solutions, the experiences of New Zealand's agritech SMEs offer valuable lessons on building competitive, resilient ventures that align profit with purpose – even under conditions of uncertainty and constraint. This work contributes to a growing body of literature advocating integrative, context-sensitive approaches to entrepreneurial strategy and informs practical strategies for entrepreneurs, policymakers, and ecosystem builders.

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Data availability statement

The interview data supporting this study's findings are not publicly available due to confidentiality agreements with the participating firms. De-identified excerpts are available from the corresponding author upon reasonable request. Secondary data sources (company reports, public documents) are cited in the References where appropriate.

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