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From critique to catalyst: How academic entrepreneurs transform negative feedback into pivots and performance

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Abstract

Research Summary: This study examines how academic entrepreneurs refine business ideas in response to external critique and how these responses relate to performance. We develop a framework that links feedback (critique), business-idea changes (pivots), and performance, and test it using detailed data on external stakeholder feedback, changes to the business idea's core and periphery, and commercialization outcomes in 316 academic-led teams. We find that academic entrepreneurs frequently modify their business idea's core in response to negative feedback, and that core changes—rather than peripheral ones—are positively associated with commercialization. Challenging the idea that all entrepreneurs are inertial, we find that academic entrepreneurs both actively embrace and benefit from changes to the business idea's core. By tracing the feedback-response dynamics of business idea components, our study adds granularity to research on pivoting.

Managerial Summary: Entrepreneurs often face a choice between reworking the core of a business idea and making changes to its periphery. Analyzing 316 academic-led teams seeking to commercialize technologies using the Lean

Startup Method, we find that academic-led teams frequently change their idea's core in response to negative feedback—and that only core changes, rather than peripheral changes, are linked to improved commercialization outcomes. Overall, the results show the effectiveness of the Lean Startup Method and demonstrate that focusing feedback on the core of the business idea is an effective way to provide feedback to academic entrepreneurs.

KEYWORDS
academic entrepreneurship, business idea development, entrepreneurial resilience, entrepreneurial strategy, failure, lean startup method, organizational learning, venture performance

1 | INTRODUCTION

At universities and national laboratories, faculty and students are increasingly pursuing entrepreneurship (Katila & Shane, 2005; Mathisen & Rasmussen, 2019; Motley et al., 2023; Phan & Siegel, 2006; Siegel et al., 2023). The success of academic entrepreneurs and their ventures contributes new resources to their institutions and enhances the economic well-being of their regions (Bercovitz & Feldman, 2006; Fini et al., 2018; Miranda et al., 2018). Therefore, understanding how academic-led teams[1] successfully develop their business ideas[2] to commercialize technology—particularly in response to feedback on their commercialization potential—is an important research direction.

The entrepreneurial strategy literature offers insights into business idea development, that is, how entrepreneurs refine their ideas (also known as pivoting)[3] to create and capture value (Bocken & Snihur, 2020; Corbo et al., 2020, 2025; Zott & Amit, 2008). Previous studies in this stream have provided evidence that the effective validation of an entrepreneur's business idea is crucial for performance (Ott et al., 2017) and that novel technology alone is insufficient to drive venture success (Dushnitsky & Matusik, 2019).

Academic entrepreneurs are highly capable in research and in generating lab results. However, strong evidence shows that they face significant challenges in the commercialization process, with business idea development posing a particular obstacle. Academic entrepreneurs particularly lack experience in validating market opportunities, which is crucial for business idea development (Chattopadhyay et al., 2025; Katila & Shane, 2005; Mathisen & Rasmussen, 2019; Zahra et al., 2007). Additionally, reducing market uncertainty can be especially challenging for academics, as they frequently seek to commercialize new technologies that have yet to be validated in the market (Vohora et al., 2004). Finally, academic entrepreneurs may experience unique difficulty with implementing the necessary changes to their ideas. For example, in studying the licensing of patented inventions from MIT, Katila and Shane (2005) found that commercialization efforts led by academics who had developed the original science often had difficulty "letting go" of the original frame. Altogether, prior work suggests that academic-led teams encounter distinct challenges in developing their business ideas.

While critically important to commercialization, business idea development remains relatively unexplored in the academic entrepreneurship literature. Instead, prior research on academic entrepreneurship has primarily focused on the effects of individual founder attributes, team composition, and the surrounding context (Ensley & Hmieleski, 2005; Markman et al., 2005; Rasmussen et al., 2014; Siegel & Wessner, 2012), highlighting, for example, the importance of non-academic team members, whose connections enable academic entrepreneurs to overcome challenges associated with commercialization (Knockaert et al., 2011; Mosey & Wright, 2007; Visintin &

Pittino, 2014). Yet, we still know little about how academic-led teams effectively develop their business ideas, with a recent review calling for more research on this topic (Miranda et al., 2018: 1021). It is essential that our theories of academic entrepreneurship address how academic-led teams can successfully develop their business ideas to commercialize technology, especially given the significant economic impact these entrepreneurs can have on their communities. Furthermore, a better understanding of this process will improve how practitioners train academic-led teams (henceforth referred to as academic teams).

Building on prior research, this paper asks: *How do academic teams shape business ideas in response to external stakeholder feedback?* We specifically examine the relationship between the critiques (i.e., negative feedback) from external stakeholders that academic teams receive, the business idea changes they implement, and the commercialization outcomes they achieve. To differentiate between the various components of the business idea, we categorize it into a core and a periphery (Thompson, 1967). As detailed below, we propose that the part of the business idea subject to critique will influence whether and what business idea changes are implemented. Furthermore, we hypothesize that making business idea changes to the core has a distinct link to commercialization outcomes compared to changes to the periphery.

We utilize a unique longitudinal dataset of weekly changes in business ideas from 316 academic teams. Funded by the U.S. National Science Foundation (NSF), the academic teams participate in the NSF's Innovation Corps (I-Corps) technology commercialization program across 20 cohorts. NSF's I-Corps program is an ideal setting for examining our research question, for several reasons. Academic teams enter the program at the commercialization stage of development and work to validate their business ideas with the goal of bringing their technologies to market. To develop the business idea, all participating teams follow the standardized Lean Startup Method. Participants form teams with academic, business, and entrepreneurial leads and undergo standard training in articulating hypotheses and testing them through interviews. In particular, during each week of the 8-week program, the teams are required to document their hypotheses about the business idea, interview external stakeholders to test each hypothesis, and document the feedback and changes to each component of the business idea in a consistent format on a platform after each interview (Leatherbee & Katila, 2020). Platform thus provides us with standardized access to the evolution of the business idea and the feedback the teams receive each week.

There are several key findings. First, we demonstrate the relevance of distinguishing between the "core" and the "periphery" of business models for academic entrepreneurship, extending prior work (Burnell et al., 2023; Leatherbee & Katila, 2020). Second, we find that critiques of the core motivate more changes than critiques of the periphery—a finding unique to academic entrepreneurs—possibly pointing to the iterative nature of science and to academics' greater capacity to harness feedback. Third, changes to the core are positively linked to academic teams' commercialization outcomes. Overall, our findings suggest that the Lean Startup Method—particularly the I-Corps program—accelerates improvements to the core of academic teams' business models, potentially contributing to better commercialization outcomes and economic growth.

Our paper provides several contributions. First, building on prior work (Burnell et al., 2023; Leatherbee & Katila, 2020), this study demonstrates the relevance of the core-periphery framework for business models. Our findings indicate that entrepreneurs' decisions to modify their business ideas depend on which part of the idea is criticized, shifting focus from whether entrepreneurs resist change (Grimes, 2017; Zuzul & Tripsas, 2020) to what they change. Second, while prior work offers deep insights into the attributes of academic entrepreneurs, including their human and social capital, we do not adequately understand how academic teams develop business ideas (Mathisen & Rasmussen, 2019; Miranda et al., 2018). Focusing on academic teams, this study reveals that these types of entrepreneurs tend to make more changes when the core of their idea (rather than the periphery) is criticized. Third, our findings underscore that early, strategic adjustments (Hallen et al., 2014; Katila et al., 2008) can accelerate learning and improve venture outcomes. We show the significance of granular, small-scale changes in the development process, which can accumulate to produce pivots (i.e., large-scale changes), highlighting the need to consider these nuanced modifications in entrepreneurship theories.

2 | RESEARCH FRAMEWORK

Three streams of literature are relevant to understanding business idea change: the importance of business ideas for academic teams; the dynamics of how teams develop business ideas; and the relationship between such changes and commercialization outcomes.

2.1 | Prior literature

The first stream of academic entrepreneurship literature emphasizes the importance of identifying and selecting the right business idea. These studies do not examine the process or steps of business idea change directly but rather compare different business ideas cross-sectionally, focusing on the challenge of choosing the best one among many possibilities (Druilhe & Garnsey, 2004; Lehoux et al., 2014; Lubik & Garnsey, 2016; Shane, 2000). Academic teams, in particular, often commit prematurely to a commercialization approach, leaving their business model underdeveloped (Ensley & Hmieleski, 2005; Katila & Shane, 2005; Lubik & Garnsey, 2016; Visintin & Pittino, 2014). One example is the study on university spinouts, which found that academic entrepreneurs frequently struggle to identify a business idea after exiting the research phase of development (Vohora et al., 2004). Another recent study found that academics often prioritize general knowledge creation over market applicability when attempting to commercialize a technology (Chattopadhyay et al., 2025).

Although academic teams may begin with underdeveloped or sub-optimal business ideas, their business ideas are adjustable. Prior work (e.g., Lubik & Garnsey, 2016) suggests that academic entrepreneurs often change their business ideas; however, many studies are high-level and rarely offer details or directly examine *how* academic entrepreneurs make these changes. Although the stream of academic entrepreneurship research alludes to the importance of choosing an effective business idea (Druilhe & Garnsey, 2004; Lubik & Garnsey, 2016; Vohora et al., 2004), we currently lack an adequate understanding of how academic teams develop business ideas.

A second stream of research that has recently emerged investigates the dynamics of business idea change, providing evidence that entrepreneurs in general may not be as flexible as often assumed. Despite the lack of traditional sources of organizational inertia, such as established routines and complex decision-making structures (Gerasymenko et al., 2015; Zuzul & Tripsas, 2020), many entrepreneurial teams are argued to be rigid due to a set of distinct inertial forces relevant to entrepreneurs (Berends et al., 2021; Kirtley & O'Mahony, 2020; Snihur & Clarysse, 2022). In particular, prior work highlights that individual cognitive factors, such as identity and psychological attachment, can limit an entrepreneur's willingness to implement change (Grimes, 2017; Zuzul & Tripsas, 2020). Consequently, a consensus has been emerging that entrepreneurial teams are surprisingly resistant to feedback. We challenge this dominant view and ask how academic teams differ in how they harness feedback, and the types of business idea changes they decide to implement.

A third stream of research relevant to understanding business idea change analyzes the consequences of changes.[4] This research emphasizes that even though teams can make business idea changes to improve performance, implementing those changes can be risky—and detrimental—when executed poorly. On the one hand, effective business idea changes can help teams capture high-value opportunities, with positive implications for venture survival, revenue, and growth (Camuffo et al., 2020; Gerasymenko et al., 2015). On the other hand, business idea change can upset external stakeholders, risking a venture's fledgling legitimacy and ability to secure future resources (Fisher et al., 2016; Hampel et al., 2019; McDonald & Gao, 2019). For example, Garud et al. (2014) find that some business idea changes make ventures less comprehensible to their early stakeholders, who often withdraw their support. Despite evidence that entrepreneurial teams make different types of business idea changes (Burnell et al., 2023; Kirtley & O'Mahony, 2020; Leatherbee & Katila, 2020), prior research on the performance implications of business idea changes in academic teams has yet to grapple with the heterogeneity of such changes.

Altogether, the three streams of research provide useful background for understanding how academic teams develop business ideas. However, current theory offers an incomplete view of the dynamics and performance implications of implementing different kinds of business idea changes.

2.2 | Categorizing the business idea

To understand when academic teams choose to modify their business ideas, it is essential to identify the specific components of the business idea that are likely to require change, as the effort required may vary depending on the component. Building on research on firms' technical core and periphery (Amburgey et al., 1993; Thompson, 1967), we categorize the components of the business idea as core or peripheral. The core of the business idea is defined as those business idea components that exhibit the most interdependencies with other business idea components; more specifically, the core components directly influence the configuration of other components. The periphery is defined as those components that are less interdependent and, therefore, often less complex to change. Put simply, the business idea's core comprises the components that are most central and most closely connected to the rest of the idea.

Research also suggests that the process and outcomes of changing the core differ significantly from those of changing the periphery (Thompson, 1967). For example, studies of established newspapers have found that changes in newspaper content, which is the core value proposition for a paper's subscribers, led to an increased likelihood of firm failure (Amburgey et al., 1993; Dobrev, 1999). In contrast, peripheral changes, such as changes to a newspaper's name or physical size, appeared unrelated to firm failure and sometimes increased the organization's likelihood of survival. Although this prior work focused on established firms, the distinction between the core and the periphery is likely also important for business ideas under development by academic teams. In the following hypotheses, we theorize about the implications of this distinction in the context of academic teams in the commercialization stages of development.

3 | HYPOTHESES

Hypotheses 1–3 distinguish between the core and the periphery of the business idea and propose a framework linking external stakeholder feedback, business idea changes, and their impact on academic teams' commercialization outcomes.

Research on organizational learning that connects feedback, organizational change, and performance across various organizational contexts suggests that senior managers and those with business experience frequently resist feedback (Dahlin et al., 2017; Grimes, 2017; Zuzul & Tripsas, 2020), especially if it is negative—and prefer to follow experience and gut feel instead. In contrast, we propose that academic teams, steeped in technical and scientific expertise and the scientific culture of innovation, may be more open to feedback about their business idea and better at implementing it. In the hypotheses that follow, we argue that the quantity and breadth of business idea changes that academic teams implement will vary depending on whether the negative feedback they receive targets the business idea's core or its periphery. Moreover, we theorize that the changes and their implementation fundamentally differ from what we know, as noted above, about core versus periphery changes in established firms.

3.1 | Which business idea changes are executed?

In H1, we argue that negative feedback about the core components of the business idea is associated with academic teams making a greater number of business idea changes compared to negative feedback about peripheral components of the business idea.

First, the organizational learning literature suggests that psychological attachment to prior practices can be a key barrier to individual change. Similarly, organizational search and learning literature has long demonstrated stickiness and inertia in search patterns in organizational settings (Katila & Ahuja, 2002; Katila & Shane, 2005; Thatchenkery & Katila, 2021). Extending learning theory, we propose that it is easier for academic teams to make changes to their business idea's core (relative to non-academic teams) because academic teams often lack business experience. That is, these teams lack cognitive inertia and assumptions about the types of business ideas that are most effective (Agarwal & Shah, 2014; Chattopadhyay et al., 2025; Ensley & Hmieleski, 2005; Park et al., 2024). Without clearly established priors (Katila & Shane, 2005), academic teams are likely to be especially attentive to feedback about their business idea and will likely approach the business idea with an openness to iteration.

Second, prior research on learning highlights that the salience of feedback affects responsiveness. Decision-makers' attention is limited, and thus, attention is usually focused on the more visible and salient areas (Li et al., 2013; Ocasio, 1997). Given the scientific background of academics and their ability to engage in scientific thinking about a business idea as an interrelated system, the significance of changing the core before the periphery is likely more salient to academics. Because the core is most salient, and because the lack of business expertise may make the overall commercialization task seem overwhelming for boundedly rational decision-makers—requiring some areas to receive more limited attention than others—teams are likely to prioritize feedback on the core rather than on the periphery. Due to these differences, we hypothesize that academic teams will make more changes to the business idea when negative feedback targets its core rather than its periphery.

> **Hypothesis 1.** (H1). Academic teams make more business idea changes when they receive negative feedback about the core of their business idea, relative to when they receive negative feedback about the periphery.

While H1 focused on whether the business idea changes at all, it is also interesting to ask whether changes will be made to the core of the business idea or to the periphery. Building on organizational learning research, we argue in H2a and H2b that the context of the feedback that academics receive, viewed through the lens of their prior experience, will result in academic teams making business idea changes across both the core and the periphery when negative feedback targets core components of the business idea. However, they will only make changes to the periphery when negative feedback targets the business idea's periphery.

We expect academic teams, steeped in technical and scientific expertise, to be more used to a scientific type of experimentation that requires the team to iteratively solve a problem with interconnected elements. The core components of the business idea are highly interdependent, exhibiting dependencies with the periphery of the business idea (Martignoni et al., 2020; Siggelkow, 2002). Therefore, changing the core of the business idea also likely necessitates complementary changes to multiple business idea components, including those on the periphery. Academic teams are likely to have expertise with this type of problem-solving and thus likely to realize the extent of the changes that will be needed. For example, when changing their value proposition, teams may also need to make peripheral changes to their strategy for interacting with their stakeholders, such as customers, investors, and the media (Leatherbee & Katila, 2020).

In contrast, we argue that changes to peripheral components of the business idea will be more isolated. While the core exhibits interdependencies with the periphery, a change that originates on the periphery is likely to remain confined to the business idea's periphery, if not to a single peripheral business idea component. Based on their prior experience of solving interconnected problems, we hypothesize that academic teams make changes to both the core and the periphery of their business ideas when they receive negative feedback about the core. In contrast, we hypothesize that when they receive negative feedback about peripheral components of the business idea, teams make changes only to the business idea's periphery.

> **Hypothesis 2a.** (H2a). When academic teams receive negative feedback about the core of their business idea, they make changes to both the core and the periphery of the business idea.

Hypothesis 2b. (H2b). When academic teams receive negative feedback about the periphery of their business idea, they make changes only to the periphery of the business idea.

3.2 | What are the implications for commercialization?

Thus far, our hypotheses have outlined academic teams' responses to different types of negative feedback, with options to change both the core and the periphery of their business idea. However, organizational learning research also suggests that not all efforts to respond to negative feedback lead to improved performance (e.g., Zollo, 2009). Therefore, the fact that an academic team responds to feedback does not necessarily mean that the resulting changes are performance-enhancing. H3 focuses on the implications of different types of changes on the commercialization outcomes of academic teams.

While prior research suggests a need to protect the organization's core and demonstrates the risks of changing it, this work has focused on established firms (Amburgey et al., 1993; Thompson, 1967). In established firms, prior work argues that enacting relatively simple changes on the periphery is more performance-enhancing than changes to the core. However, academic teams in the commercialization stage are unique in several important ways that make changing the core more feasible and, consequently, potentially more performance-enhancing.

Not unlike most technology-based startups, academic teams have fewer decision-makers than teams in established firms and thus are less affected by the bureaucracy, hierarchy, and politics, which each derail the implementation of change in established firms (Gerasymenko et al., 2015; Hampel et al., 2019). Additionally, in the commercialization stage, academic teams often lack or have fewer established processes and complex decision-making procedures, allowing them to be more flexible and open to implementing change. Lastly, academic teams are not constrained by existing irreversible investments in fixed assets that create resistance to change in established firms (Gerasymenko et al., 2015; Nicholls-Nixon et al., 2000; Pahnke et al., 2015). As a result, academic teams in the commercialization stage are particularly well equipped to implement core changes. Their inexperience in business, combined with the careful implementation of core changes and the ability to thoroughly consider interdependencies (as noted above), are assets. This is particularly true because they lack the prior knowledge or inertia that may derail implementation by business-oriented teams with prior experience (Leatherbee & Katila, 2020).

Additionally, core changes often necessitate complementary changes in the periphery; changing the business idea's periphery in isolation is inefficient if additional peripheral changes will be necessary in the wake of each subsequent core change. Thus, teams that make changes to the periphery of their business idea to optimize it for each configuration of the core *before* validating the core will create potentially redundant work. Take, for example, an academic team that makes an initial core change. In parallel, they dedicate time to make complementary changes to their business idea's periphery, only to repeat the process for each subsequent change they make to the core. This team will spend a lot of time and attention on needless peripheral changes that are likely to be rendered obsolete (and abandoned) upon the next change to the core. To avoid wasting limited time and attention, a more effective team would focus on changing the core of their business idea until establishing its validity. Only after validating the business idea's core would the higher-performing academic team focus on making the required changes to align the periphery of their business idea with its core.

Overall, we hypothesize that making changes to the core of the business idea is associated with more significant commercialization outcomes for academic teams (Figure 1).

Hypothesis 3. (H3). Business idea changes to the core of the business idea are more positively associated with an academic team's commercialization outcomes than business idea changes to the periphery of the business idea.

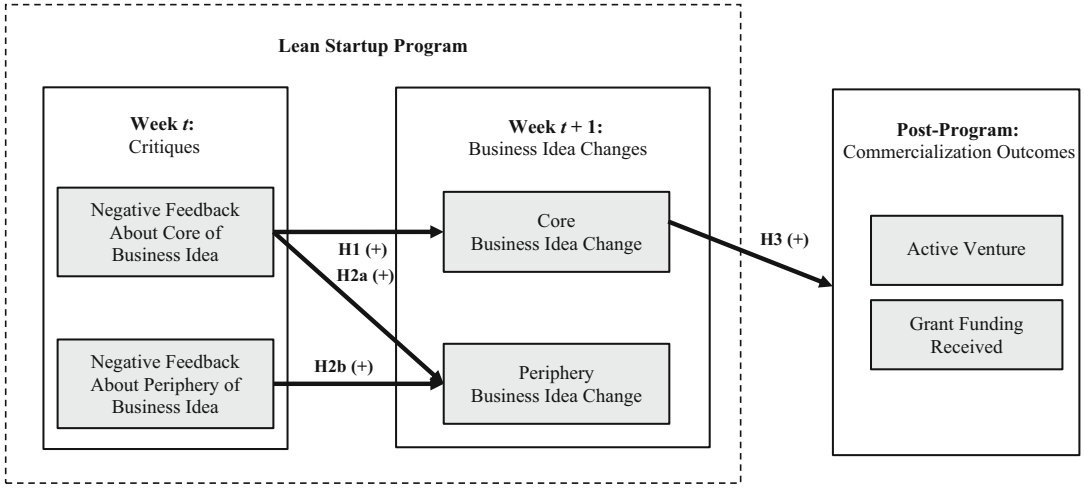

FIGURE 1 Conceptual model of critiques, business idea changes, and commercialization outcomes. The negative feedback (t) and academic team responses ($t + 1$) occur during the 8 weeks of the I-Corps program. Commercialization outcomes are observed after the I-Corps program concluded.

4 | DATA AND METHODS

4.1 | Data and sample

To analyze how academic teams develop and refine their business ideas in response to feedback, we used data on academic scientists funded by the U.S. National Science Foundation (NSF) pursuing new-technology-based business ideas. Teams led by these academics participated in the NSF's 8-week science commercialization program, called I-Corps, over two years.[5] We chose government-funded academic teams because government investors' hands-off approach to advising entrepreneurs (Pahnke et al., 2015) typically leaves more agency to ventures and their inventor-founders to craft their business ideas. We focused on academic teams pursuing new-technology business ideas in the commercialization stage because academics' business ideas are often initially vague, due to academic teams' primary focus on developing science and technology. Thus, we can directly observe the development of the business idea from its conception. Finally, we chose the NSF science commercialization program (I-Corps) because it has standardized requirements for team structure, team size, teaching materials, business idea descriptions, supervision and feedback methods, and evaluation protocols across all cohorts (Leatherbee & Katila, 2020). The program's standardized features enable us to unpack the role of negative feedback, absent the potential confounding influence of a program's features on commercialization outcomes. NSF program's requirements also restrict the business ideas to the early commercialization stage, helping us focus on a standardized set of academic teams at a standardized stage of development.[6] We analyzed data on business ideas and their evolution on a weekly basis.

The primary unit of analysis is the team-week.[7] During the I-Corps program, academic entrepreneurs work with their team members to develop their business ideas using the Lean Startup Method (Blank, 2003; Leatherbee & Katila, 2020; Ries, 2011). At the beginning of each week of the program, teams are required to seek feedback from potential stakeholders regarding the commercialization of an NSF-funded technology created by an academic scientist (one of the team members). At the end of each week, the team must use this feedback to iterate on their business idea. Data were collected for each academic team's business idea over the 8-week duration of the I-Corps program from 2013 to 2015. After the program concludes, teams decide whether to continue commercializing their business idea. Data on commercialization outcomes were collected after the program's conclusion.

Our primary data source on feedback and business idea changes is the online platform that all academic teams participating in I-Corps are required to use to track their progress through the program.[8] Using the business model canvas on the platform, teams record each instance of negative feedback, the specific business idea component that it targeted, and any resulting changes (e.g., adding, removing, or altering content) each week. As a result, the platform serves as a repository of detailed, real-time documentation of external stakeholder feedback and subsequent business idea changes, making it uniquely suited to this study. Because teams must update the data weekly, throughout the program's duration, the data captures both fine-grained detail and a comprehensive view of a business idea's evolution. This allows us to examine with unusual accuracy the relationship between feedback and changes to each team's business idea.

We also collected data on the teams' commercialization outcomes through several data sources.[9] To determine whether an I-Corps team turned into an operational business after the program concluded, we collected data on incorporation and operational activity. To track whether a team incorporated a venture, we utilized OpenCorporates and triangulated information regarding the individual team members' names, the I-Corps team name, geographical location, and idea description. To track operational activity, we searched the team's information through digital trace data including LinkedIn, social media sites (Twitter, Google, Instagram, Facebook), Pitchbook, and by accessing the I-Corps cohort's post-program survey. This approach, consistent with recent studies, mitigates the risks associated with relying solely on survey data (e.g., Gonzalez-Uribe & Leatherbee, 2018).

To provide additional robustness with respect to commercialization outcomes, we collected data on whether academic teams received grant funding for the development and commercialization of their technologies. Data were collected from the Small Business Innovation Research (SBIR) grant database.[10]

Overall, we analyze a dataset of 316 teams across 20 cohorts of the I-Corps program. These 316 academic teams solicited feedback and made business idea changes across all weeks of the program, yielding 2212 team-weeks. Due to the availability of control variables, the final sample for the analysis of commercialization outcomes is 247 teams. The results remain consistent when we drop the control variables for human capital and the university research expenditures of the academic teams and use the full sample of 316 teams.

4.2 | Measures

4.2.1 | Dependent variables

For the analyses of the antecedents of business idea change (H1, H2a, and H2b), the dependent variables focus on the changes that the academic teams make to their business ideas. The first dependent variable tracks the number of weekly business idea changes recorded by each team (*Total Weekly Changes*). It is a count variable tallying all the weekly changes to a team's business idea across all nine business idea components. This is a reliable measure since it is a program requirement to record the changes weekly, and completion is closely tracked.

The second set of dependent variables identifies *where* changes were implemented, that is, in the business idea's core or periphery (*Weekly Core Changes*; *Weekly Periphery Changes*). We constructed these variables by categorizing each of the nine business idea components as either core or peripheral. Following prior research, we distinguished the core from the periphery by the business idea component's interdependence with the other components. The core comprises the most interdependent components, while the more independent components compose the periphery. The business model canvas used by the academic teams to track progress on the platform has four highly interdependent components: the Value Proposition, Customer Segments, Key Resources, and Key Activities (Osterwalder & Pigneur, 2010). These four components comprise the core. The remaining components of the business model canvas (Key Partners, Cost Structure, Revenue Streams, Channels, and Customer Relationships) are more independent. Therefore, these five components make up the business model canvas's periphery.[11] Because all academic teams are in the commercialization stage and all teams commercialize NSF-funded technologies, they share relatively similar core and peripheral business idea components, making the measures comparable. We calculated the number of weekly changes to a business idea's core by tallying all the weekly changes made across the core business

idea components (*Weekly Core Changes*). We calculated the number of weekly changes to a business idea's periphery by tallying all the weekly changes across the peripheral business idea components (*Weekly Periphery Changes*).

The primary dependent variable in the analyses of teams' commercialization outcomes (H3) indicates whether an I-Corps team produced an operationally active business after the program concluded (*Active Venture*). Because most academic teams fail before their business ideas reach the market, whether a team navigates the commercialization stage to produce an operationally active venture after completing the I-Corps program is a relevant first-order measure of commercialization outcomes. In our context specifically, the latest I-Corps Biennial Report to Congress (2023) indicates that approximately half of the teams do not continue their business ideas at the conclusion of the I-Corps program. We operationalize commercialization outcomes as a binary dependent variable capturing whether teams produce operationally active businesses after the I-Corps concludes (*Active Venture*). *Active Venture is* a binary variable that takes a value of one when an academic team forms an incorporated venture *and* the venture demonstrates continued operational activity after the I-Corps program concludes, and zero otherwise.

Finally, for a robustness check, we operationalized commercialization outcomes using SBIR Phase I funding (*Grant Funding Received*). We chose SBIR funding because the highly selective program is a significant funding source for academic technology-based ventures, enabling these ventures to continue working on commercializing their innovations (Dutta et al., 2022; Lanahan et al., 2022). Moreover, SBIR funding is a logical outcome to study because the I-Corps curriculum ends with a session introducing the SBIR program and encouraging teams to apply. Therefore, all teams are aware of the program and would have considered it as a source of funding. Teams are incentivized to apply for the maximum grant award amount; therefore, all teams that win SBIR Phase I funding in the same year tend to receive the same award total. Additionally, while SBIR Phase II funding data are available, Phase II funding is contingent upon receiving SBIR Phase I funding, so we focus exclusively on Phase I funding. We created a dummy variable that takes a value of one if a team secured SBIR Phase I funding after I-Corps and zero otherwise.

4.2.2 | Independent variables

As noted above, teams were required to report all the external feedback on their business idea components using an online platform at the conclusion of each interview and to categorize each piece of feedback as either positive or negative. For example, a typical instance of negative feedback would involve the team reporting that the person they interviewed shared that a particular business idea component does not add value. Using the weekly platform data for each team, we measured negative feedback received by each academic team about their business idea's core and about the periphery (*Core Negative Feedback*; *Periphery Negative Feedback*) by counting the number of instances an external stakeholder reacted negatively to a component of a business idea's core or periphery, respectively, during an interview. We measured *Core Negative Feedback* each week for each team by tallying all the instances of negative feedback targeting any of the core components of their business idea. We measured *Periphery Negative Feedback* each week for each team by tallying all the instances of negative feedback targeting any of the periphery components of their business idea. We logged the measures to mitigate skew.

In analyses where commercialization outcomes are the dependent variable, the independent variables comprise the business idea changes implemented by the academic teams during the I-Corps program, as described above (*Total Core Changes*; *Total Periphery Changes*). We measured changes to a business idea's core by counting the total number of weekly changes the academic teams made to their business idea's core over the I-Corps program. Similarly, we measured changes to a business idea's periphery by counting the total number of weekly changes the academic teams made to their business idea's periphery over the I-Corps program.

4.2.3 | Control variables

We included several controls in the equations predicting business idea change. Prior research indicates that various team-level characteristics can impact the team's willingness to change its business idea, including the way teams

respond to negative feedback (Furr et al., 2012); therefore, we included *Academic Team Fixed Effects* to account for heterogeneity across teams.

Because team members' attention is limited (Ocasio, 1997), spending time interviewing people may drain the attention that team members have available each week (i.e., there is likely a tradeoff between the time spent interviewing stakeholders and the time spent implementing changes into the business idea). Accordingly, we controlled for the number of interviews each team conducted on a weekly basis (*Weekly Interviews*). Academic teams may also adjust their responses to feedback and learn to become more effective as they progress through the I-Corps program, so we controlled for *Week Fixed Effects*.

We also included several controls in the regression models when analyzing commercialization outcomes as the dependent variable. Prior work suggests that the ability to gather information and implement changes can be influenced by the size of the team (Barker & Duhaime, 1997; Leatherbee & Katila, 2020). Therefore, we controlled for *Team Size*, measured as the number of individuals on each academic team. We controlled for the total negative external stakeholder feedback a team received, which may relate to commercialization outcomes.[12] Our measure, *Total Program Negative Feedback*, counts each instance of negative feedback received during the I-Corps program, similar to our measures for business idea changes.

Team members' educational backgrounds and expertise have also been shown to connect to commercialization outcomes (Eesley et al., 2014). Therefore, we controlled for team members' educational background (*Number of Team Members with Doctorates*; *Number of Team Members with MBAs*). Prior work also indicates that venture incorporation rates vary across universities due to university-specific policies and resources (Di Gregorio & Shane, 2003; Siegel et al., 2003; Siegel & Wright, 2015). Therefore, we also controlled for the university rankings of each team member's home institution. We searched for each academic team member's university affiliation using LinkedIn. Using the Carnegie Classification of Institutions of Higher Education,[13] we included dummy variables to indicate whether a given team had a member in any of the tiers (*Has Team Member from Tier 1*, *Has Team Member from Tier 2*, *Has Team Member from Tier 3*, and *Has Team Member from Unranked Tier*).

Because university research expenditures are linked to reputation (Cyrenne & Grant, 2009) and innovation outputs (Aghion et al., 2010), we also controlled for the resources available to each academic team by including a control for the research expenditures of their home institution. We calculated each university's research expenditure using data from the NSF HERD survey. We operationalized the measure (*Average NSF HERD Expenditure*) by taking the average of the research expenditures of the home institutions of all team members.

While NSF's I-Corps provides a standardized program across cohorts, we additionally control for any further differences in program execution by including cohort random effects to account for differences between cohorts along with the cohort year (*Cohort Year*). Finally, to address additional endogeneity concerns in our analysis of commercialization outcomes, we also include an instrumental variable analysis described in the methods section below.

4.3 | Methods

To analyze the antecedents of business idea change, we used negative binomial regressions to test the relationship between different types of negative feedback and business idea changes (a count variable). In the panel regressions, the number of observations equals the total number of team-week observations in the sample (316 teams across 7 weeks, with 2212 team-week observations). Team and week fixed effects were included, and our independent and control variables were lagged by one week to facilitate causal inference. Poisson regression results, included for robustness, were consistent.

To analyze commercialization outcomes, we used probit regression, clustering standard errors by I-Corps program cohort. While we can include only random effects when using a probit model, OLS regressions with cohort-level fixed effects, which account for unobserved time-invariant differences between cohorts, yielded consistent results.

We also included an instrumental variable analysis for regressions with *Active Venture* as the dependent variable to account for potential endogeneity concerns. We instrumented the following variables: *Total Program Negative Feedback*, *Total Program Core Changes*, and *Total Program Periphery Changes*, because a Durbin–Wu Hausman test indicated that these variables may be endogenous. Instrumental variable analysis requires a variable that is relevant (affects the independent variable of interest, i.e., business idea change) but has no direct effect on commercialization outcomes, thereby meeting the exclusion restriction. We considered several instruments: the amount of feedback an academic team received from program leadership, encouraging them to implement changes to their business idea;[14] the total number of engagements an academic team experienced with their instructors and mentors; and cohort dummy variables[15] (Leatherbee & Katila, 2020).[16]

We utilized a probit instrumental variable regression, and the Cragg–Donald *F*-statistic from the first stage is 1.29, indicating that these instruments are not particularly strong (Stock & Yogo, 2005). However, this is common in management studies. The first-stage results of our instrumental variable analysis are included in the Appendix (Table A1).

5 | RESULTS

Tables 1 and 2 provide the descriptive statistics and correlations. On average, each of the 316 academic teams included in the analysis conducts approximately ten external stakeholder interviews each week and receive, on average, about two instances of negative feedback about the core of their business idea and just under one instance of negative feedback about the periphery. Further, academic teams make approximately five business idea changes each week, with an average of about three changes affecting the business idea's core and about two affecting its periphery, on average.[17]

Throughout the I-Corps program, the full sample of 316 teams received an average of 22 instances of negative feedback about their business ideas. On average, teams made a total of 58 business idea changes. More specifically, academic teams made an average of 32 changes to the core, and 27 to the periphery.[18] Finally, a variance inflation factor (VIF) analysis shows that the highest VIF across all models is 1.85, alleviating concerns about multicollinearity.

Of the 247 teams included in the analysis of commercialization outcomes for which the complete set of control variables was available (out of 316 total teams), we identified 154 teams that incorporated a venture. Of the 154 incorporated ventures, 96 teams showed ongoing operational activity (i.e., the venture remained active). In particular, of the 96 ventures, we were able to track 75 that had online corporate websites, such as LinkedIn, or social media accounts; 45 with Pitchbook profiles; and 27 that responded to the post-I-Corps survey, stating that the venture was operationally active. There is significant overlap in sources (e.g., 33 ventures had both Pitchbook and online websites). These details are available from the authors.

5.1 | Antecedents of business idea changes

5.1.1 | Main results

The first set of results focuses on the different types of critique (i.e., negative feedback) the teams receive, and the business idea changes they make (H1, H2a, and H2b). The negative binomial regressions are presented in Table 3. The dependent variable in Models 1–3 is the total number of business idea changes the teams make (*Total Weekly Changes*), corresponding to Hypothesis 1. The dependent variable in Models 4–6 is the number of changes in the business idea's core (*Weekly Core Changes*), and the dependent variable in Models 7–9 is the number of changes in the business idea's periphery (*Weekly Periphery Changes*), corresponding to Hypotheses 2a and 2b.

TABLE 1 Descriptive statistics and correlations for the analysis of the antecedents of business idea change.

Variable	Mean	SD			
1. Total weekly changes ($t + 1$)	5.137	7.456			
2. Weekly core changes ($t + 1$)	2.934	4.436			
3. Weekly periphery changes ($t + 1$)	2.204	3.917			
4. Weekly core negative feedback (t)	2.296	5.361			
5. Weekly periphery negative feedback (t)	0.705	3.044			
6. Number of weekly interviews (t)	9.782	7.019			
Variable	**1**	**2**	**3**	**4**	**5**
2. Weekly core changes ($t + 1$)	0.906				
3. Weekly periphery changes ($t + 1$)	0.878	0.592			
4. Weekly core negative feedback (t)	0.079	0.094	0.045		
5. Weekly periphery negative feedback (t)	−0.008	−0.023	0.012	0.132	
6. Number of weekly interviews (t)	−0.004	−0.009	0.002	0.369	0.192

Note: The sample size is 2212 total team-week observations with 316 teams across 7 weeks of data. All change count variables above are the various dependent variables measured in time-period $t + 1$ (i.e., 1 week after the independent variables listed with t).

The results in Models 1–3 support H1. The coefficient in the full model (Model 3) indicates that teams that receive negative feedback on core components will make more total weekly changes to their business idea ($\beta = 0.017$, $p = .007$). In contrast, negative feedback on the periphery has no relationship with total weekly changes ($\beta = -0.010$, $p = .428$). We used average marginal effect (AME) analysis to interpret the effect sizes. This analysis indicates that a single additional instance of core negative feedback results in about a 1.7 percent increase in the total number of weekly business idea changes made.[19] It is also interesting to note that the number of weekly interviews that teams conduct is negatively related to the number of business idea changes that they make, supporting the notion that teams have limited time and attention that need to be split between interviewing and changing the business idea.

Hypothesis 2a argues that negative feedback about the core of the business idea is associated with the team making changes to both the core and the periphery of the business idea. The results provide support. Negative feedback about the core is positively related to the total number of weekly changes made to both the core ($\beta = 0.018$, $p = .008$) and the periphery ($\beta = 0.015$, $p = .042$). AME analysis indicates that receiving one additional instance of core negative feedback over the average is associated with a 1.8 percent increase in the total weekly changes made to the core and a 1.5 percent increase in the total weekly changes made to the periphery.

Hypothesis 2b suggests that negative feedback about the periphery of the business idea would be related to changes localized on the periphery. This hypothesis does not receive direct support. Negative feedback about the periphery of the business idea is neither associated with total weekly changes to the periphery ($\beta = -0.015$, $p = .330$) nor with total weekly changes to the core ($\beta = -0.008$, $p = .592$). Overall, our results suggest that negative feedback about the periphery is unrelated to business idea change.

5.1.2 | Robustness checks

We ran additional analyses to confirm the robustness of our findings. The main analysis assumes that all business idea changes are of equal magnitude. However, the intensity of change could differ. For example, a team could change who they intend to partner with by refining from an abstract group to a specific firm. Alternatively, teams

TABLE 2 Descriptive statistics and correlations for the analysis of commercialization outcomes.

	Variable	Mean	SD	1	2	3	4	5	6
1.	Active venture	0.389	0.488						
2.	Grant funding received	0.170	0.376	0.391					
3.	Total program core changes	33.081	14.552	0.141	0.111				
4.	Total program periphery changes	28.174	12.780	0.067	0.025	0.625			
5.	Total program negative feedback	23.405	27.930	−0.105	−0.070	0.246	0.167		
6.	Cohort year	2014.0	0.746	−0.132	−0.049	0.065	−0.067	0.099	
7.	Team size	3.891	1.498	0.153	−0.075	0.217	0.282	0.070	−0.037
8.	Num. of team members w/ doctorates	1.040	1.154	0.131	0.171	0.155	0.176	0.029	0.036
9.	Num. of team members w/ MBA	0.530	0.864	0.136	−0.103	−0.061	0.005	0.013	−0.065
10.	Has team member from Tier 1	0.907	0.291	0.084	0.034	0.008	0.085	0.058	0.026
11.	Has team member from Tier 2	0.223	0.417	−0.047	−0.009	0.016	0.035	0.025	−0.056
12.	Has team member from Tier 3	0.061	0.239	0.041	−0.025	0.004	0.094	−0.004	0.008
13.	Has team member from unranked tier	0.526	0.500	0.074	−0.089	−0.022	0.031	−0.174	−0.027
14.	Average NSF HERD expenditure	104.565	153.502	−0.102	−0.152	−0.124	−0.102	0.032	−0.051

	Variable	7	8	9	10	11	12	13
8.	Num. of team members w/ doctorates	0.233						
9.	Num. of team members w/ MBA	0.413	−0.099					
10.	Has team member from Tier 1	0.060	0.048	0.116				
11.	Has team member from Tier 2	0.052	−0.010	−0.036	−0.398			
12.	Has team member from Tier 3	0.189	−0.038	0.178	−0.035	−0.095		
13.	Has team member from unranked tier	0.175	0.174	0.207	0.031	−0.174	0.004	
14.	Average NSF HERD expenditure	−0.037	−0.181	−0.077	−0.332	0.232	0.113	−0.076

Note: Due to the availability of control variable data when analyzing commercialization outcomes, the final sample is 247 teams. University tiers are coded such that Tier 1 is the highest and the unranked tier is the lowest.

could entirely change the type of firm they want to partner with, such as switching from telecom firms to medical device firms.

To account for differences in magnitude, we created an index that tracks the magnitude of each change. A Likert scale was used, where 0 represents no change, and 5 represents a significant change to a particular business idea component. We reviewed all changes made to the business idea for each team every week, and hand-coded the index. The results from this additional analysis were consistent with those reported in the main analyses above.

TABLE 3 Analysis of the antecedents of business idea change.

Dependent variable	Model 1 Total weekly changes	Model 2 Total weekly changes	Model 3 Total weekly changes	Model 4 Weekly core changes	Model 5 Weekly core changes	Model 6 Weekly core changes	Model 7 Weekly periphery changes	Model 8 Weekly periphery changes	Model 9 Weekly periphery changes
Weekly core negative feedback	0.016		0.017	0.018		0.018	0.015		0.015
	(.008)		(.007)	(.009)		(.008)	(.047)		(.042)
Weekly periphery negative feedback		−0.008	−0.010		−0.005	−0.008			−0.013
		(.550)	(.428)		(.712)	(.592)		(.395)	(.330)
Number of weekly interviews	−0.013	−0.007	−0.012	−0.016	−0.010	−0.016	−0.010	−0.004	−0.009
	(.018)	(.197)	(.025)	(.006)	(.077)	(.008)	(.144)	(.567)	(.190)
Constant	1.206	1.203	1.202	−0.199	−0.201	−0.202	0.584	0.579	0.577
	(.019)	(.020)	(.020)	(.813)	(.812)	(.811)	(.319)	(.324)	(.325)
N	2212	2212	2212	2212	2212	2212	2212	2212	2212
Number of teams	316	316	316	316	316	316	316	316	316
Ln(alpha)	0.040	0.045	0.039	0.085	0.091	0.084	0.362	0.366	0.361
Log-likelihood	−5387.049	−5390.746	−5386.738	−4295.256	−4298.929	−4295.109	−3742.993	−3744.710	−3742.523
χ^2 (df)	967.884 (323)	960.489 (323)	968.506 (324)	907.296 (323)	899.95 (323)	907.59 (324)	795.184 (323)	791.75 (323)	796.125 (324)

Note: *p*-values are in parentheses. *Weekly Core Negative Feedback* and *Weekly Periphery Negative Feedback* represent the total amount of negative feedback targeting the core and the periphery of the business idea, respectively, in week *t*. The DVs in all models capture the number of changes the teams make to their business ideas in week $t + 1$. All models use academic-team and week fixed effects.

5.2 | Consequences of business idea changes

5.2.1 | Main results

The second set of results examines the relationship between business idea changes and commercialization outcomes, tracking whether an I-Corps team incorporated a venture that was operationally active after the I-Corps cohort ended (Hypothesis 3).

Models 1–3 in Table 4 report the results. Models 1 and 2 employ a probit regression with cluster-robust standard errors at the cohort level and cohort-level random effects. Model 3 uses IV probit regression with cohort dummies and robust standard errors clustered at the cohort level.

Hypothesis 3 predicted that changes to the core of the academic teams' business idea will be more positively associated with improved commercialization outcomes than peripheral changes. We find support for H3. Specifically, the results indicate that making a greater number of changes to the core of the business idea over the course of the I-Corps program is positively associated with commercialization outcomes, as shown in Model 2 ($\beta = 0.024$, $p < .0005$). In fact, although not hypothesized, the results of Model 2 suggest that the total number of peripheral business idea changes made across the I-Corps program is negatively related to active venture creation ($\beta = -0.015$, $p = .001$). We calculated both the average marginal effect (AME) and the marginal effect at representative values (MER) to interpret the effect size using the results from Model 2. Our AME analysis indicates that a single additional core business idea change increases the likelihood of an operationally active venture being created by about three-quarters of a percentage point. Our MER analysis indicates that if a team increases the number of core business idea changes it makes by one standard deviation compared to the average, the team's probability of incorporating an operationally active venture increases by 10.6 percentage points.[20] Overall, the H3 findings provide additional evidence to support the argument that lean startup training benefits academic teams: the program's prompts to gather feedback lead to more subsequent changes to academic teams' business ideas, and these changes are positively associated with commercialization.

To address endogeneity concerns, as described above, we conducted instrumental variable analysis for the regressions where *Active Venture* was the dependent variable. Model 3 in Table 4 presents the results of the second stage of our instrumental variable analysis, examining the relationship between negative feedback, business idea changes, and commercialization outcomes. This instrumental variable analysis is consistent with our main findings. Specifically, Model 3 indicates that making a greater number of total changes to the core of the business idea across the program is positively associated with commercialization outcomes ($\beta = 0.090$, $p < .0005$). Again, there is no evidence that the total number of periphery changes made across the program is positively related to commercialization outcomes. The results of the instrumental variable analysis in Model 3 are directionally consistent with those of the single-stage probit analysis ($\beta = -0.042$, $p = .168$).

5.2.2 | Robustness checks

We ran additional analyses to confirm that our analysis of commercialization outcomes is robust to alternative specifications of our variables, including an index representing the overall magnitude of the changes. Hypothesis 3 continued to receive support, with the total number of core changes made across the program positively related to commercialization outcomes. These results are available from the authors upon request.

We also conducted a robustness check on our analysis of commercialization outcomes using SBIR grant funding as the dependent variable.[21] The results, as shown in Models 4 and 5 of Table 4, provide further support for H3. Model 5 in Table 4 indicates a positive relationship between the number of core changes and the probability of *Grant Funding Received* ($\beta = 0.013$, $p = .039$). To interpret the effect size, we use both AME and MER analyses again. AME analysis indicated that a single additional core business idea change during the I-Corps program increases the

TABLE 4 Analysis of commercialization outcomes.

	Model 1 Active venture	Model 2 Active venture	Model 3 Active venture	Model 4 Grant funding received	Model 5 Grant funding received
Total program core changes		0.024	0.090		0.013
		(.000)	(.000)		(.039)
Total program periphery changes		−0.015	−0.042		−0.002
		(.001)	(.168)		(.645)
Total program negative feedback	−0.008	−0.010	−0.021	−0.011	−0.013
	(.005)	(.003)	(.000)	(.064)	(.032)
Team size	0.050	0.027	−0.118	0.008	−0.031
	(.555)	(.746)	(.162)	(.944)	(.805)
Num. of team members w/ doctorates	0.044	0.047	0.044	0.376	0.382
	(.680)	(.645)	(.581)	(.010)	(.010)
Num. of team members w/ MBA	0.039	0.054	0.262	−0.182	−0.157
	(.843)	(.786)	(.002)	(.299)	(.361)
Has team member from Tier 1	−0.012	0.105	0.487	0.548	0.564
	(.969)	(.665)	(.155)	(.265)	(.263)
Has team member from Tier 2	−0.143	−0.113	0.008	0.343	0.348
	(.530)	(.605)	(.966)	(.480)	(.479)
Has team member from Tier 3	−0.130	−0.063	0.136	0.472	0.466
	(.746)	(.870)	(.604)	(.266)	(.211)
Has team member from unranked tier	−0.212	−0.181	−0.199	−0.563	−0.558
	(.387)	(.435)	(.181)	(.036)	(.034)
Average NSF HERD expenditure	0.000	0.000	0.001	−0.003	−0.003
	(.597)	(.737)	(.239)	(.091)	(.106)
Cohort year	−0.249	−0.285		−0.182	−0.197
	(.112)	(.076)		(.531)	(.506)
Time Since Cohort Ended				−1.034	−1.087
				(.278)	(.257)
Constant	501.100	573.500	−1.530	2087.600	2196.000
	(.112)	(.076)	(.006)	(.279)	(.259)
Cohort effects	Random	Random	Dummies	Random	Random
Model	Probit	Probit	IV Probit	Probit	Probit
N	247	247	225	247	247
Log likelihood	−154.4	−150.4		−81.16	−80.48
χ^2	18.6	40.15	546.9	93.85	100.6

Note: *p*-values in parentheses. Due to the availability of control variable data when analyzing commercialization outcomes, the final sample is 247 teams. Models 1, 2, 4, and 5 employ probit regression with cluster-robust standard errors at the cohort level and cohort-level random effects. Model 3 uses IV probit regression with cohort dummies and robust standard errors clustered at the cohort level. The IV Probit regression uses the amount of academic engagement, the amount of program instructor feedback that actively encourages change, and cohort dummies as instruments. The inclusion of cohort dummies means that the *Cohort Year* is excluded as a control variable. If no team in a particular cohort created a company, that cohort was dropped from the IV analysis. Twenty-two teams from cohorts with uniform outcomes were excluded from the analysis in Model 3 of Table 4 because it is an instrumental variable analysis, with the cohorts as dummies, resulting in a sample of 225 teams.

likelihood of obtaining an SBIR award by 0.2 percentage points. MER analysis indicated that an academic team that increases the number of core changes by one standard deviation above the average amount increases the probability of an SBIR Phase I grant by three percentage points.[22]

6 | DISCUSSION

6.1 | Main contributions

Research on academic entrepreneurship highlights that the initial business models of academic entrepreneurs often require substantial improvement, given the unique challenges academic teams face in developing their ideas (Lubik & Garnsey, 2016; Siegel & Wessner, 2012; Vohora et al., 2004). Entrepreneurial strategy research, in turn, emphasizes both the barriers to changing an original business idea and the inertia entrepreneurs exhibit in doing so, particularly when facing external critique (Bocken & Snihur, 2020; Hampel et al., 2019; Zott & Amit, 2008). Yet we still lack a clear understanding of whether and how academic teams would be willing to change their business ideas in response to critique, and whether such changes would improve commercialization outcomes. To address this gap, we develop and test hypotheses explaining how external stakeholder feedback—particularly negative feedback—shapes academic teams' business ideas during the commercialization stage, and how these changes to different business idea components relate to commercialization outcomes.

Our analysis of 316 academic teams seeking to commercialize a new technology provides evidence that academic teams are generally responsive to critiques, and particularly responsive to critiques about the *core* of their business ideas. Specifically, the teams make both a greater number of business idea changes and changes to more different parts of the business idea after receiving negative feedback about the core, relative to negative feedback about the periphery. We also find evidence that a team's commercialization outcomes are positively related only to changes to the business idea's core.

The findings provide several contributions to academic entrepreneurship research. First, extending prior work (Burnell et al., 2023; Leatherbee & Katila, 2020), we demonstrate how the business idea construct—and differentiating between the core and the periphery of business ideas—is relevant to academic entrepreneurship research. The core components of the business ideas are more relevant to business idea changes and commercialization outcomes than the peripheral components of the business idea. Using the core-periphery framework also draws attention away from *whether* academic entrepreneurs resist change when receiving feedback (Berends et al., 2021; Grimes, 2017) and focuses on *what* these entrepreneurs change. Our results indicate that academic teams' decisions to implement business idea changes depend on which part of the business idea is critiqued: negative feedback to the core is linked to both more changes to the business idea *and* better commercialization outcomes.

Second, we contribute to research on how academic entrepreneurs develop business ideas. While previous research presents cross-sectional comparisons of business ideas (Lehoux et al., 2014; Shane, 2000) and highlights how academic entrepreneurs struggle to identify effective business ideas (Vohora et al., 2004), our study explicitly investigates *what* types of changes academic entrepreneurs implement and how they develop business ideas. Our results indicate that academic teams implement many changes, both to the core and the periphery of their business idea, in response to negative feedback about the core of their idea; however, they do not react similary to critique about the business idea's periphery. Trained in scientific thinking and causal reasoning, academic teams may understand the causal links between business idea components, enabling them to prioritize critiques of the core—those with downstream effects on the periphery—before responding to critiques that target only the periphery.

In addition to improving our understanding of the dynamics of business idea development, we provide insight into entrepreneurial resilience in the face of critique and failure. The finding that academic entrepreneurs can utilize lean startup methods to change their business ideas identifies a crucial boundary condition on prior claims that entrepreneurs may exhibit significant resistance to implementing change (e.g., Burnell et al., 2023). One explanation for our

results may be (lack of) prior business experience, which enables academic entrepreneurs to uniquely harness feedback—perhaps even pointing to the ability to embrace feedback as a unique pathway through which lean startup works as an engine for change. Alternatively, recent research indicates that the large-scale pivots analyzed in many previous studies often result from the accumulation of these small changes rather than a single large shift (Kirtley & O'Mahony, 2020). Therefore, another explanation could be that prior studies, which often focus on large-scale, may inadvertently have overlooked how more granular changes are made. Our study reinforces this qualitative finding and highlights the need for our theories of academic entrepreneurship and business idea development to account for the impact of granular change, and how such change can be supported, for example, through lean startup methods.

Finally, our theory and findings regarding the commercialization outcomes achieved by academic teams also contribute to entrepreneurial strategy research. While prior research identifies strategies for effectively implementing business idea changes, emphasizing the benefits of changing at the right moment (Hampel et al., 2019; McDonald & Gao, 2019), current theory is inadequate in explaining *what* should be changed. Integrating theory from the organizational learning literature, we find that the relationship between business idea changes and commercialization outcomes depends on whether academic teams change the core or the periphery of the business idea. Specifically, a team that focuses on making core changes during the commercialization stage achieves better commercialization outcomes. This suggests that validating the core (i.e., identifying the right opportunity for the business idea) may be more important than adjusting the periphery (i.e., figuring out the operational tactics) during the commercialization stage. Overall, our findings call for strategic prioritization: academic teams and their advisors should focus their limited attention on the core before the periphery—at least during the commercialization stage.

In terms of practical implications, this paper improves our understanding of the effectiveness of the Lean Startup Method and the I-Corps program in helping academic teams validate business ideas, building on prior research (Bocken & Snihur, 2020; Leatherbee & Katila, 2020; Zott & Amit, 2007). Our findings indicate that the Lean Startup Method facilitates the management of external stakeholder feedback, particularly when entrepreneurs differentiate between the core and the periphery. Thus, our paper encourages academic entrepreneurs using the Lean Startup Method to focus on the core of their business idea when validating it, and we suggest that changes to the core of a business idea facilitate improved outcomes in the commercialization stage. Translating our theoretical contributions into the language of practitioners provides a clear practical takeaway: academic entrepreneurs and their mentors should focus on optimizing how to create value (defined mainly by the business idea's core components) before working on how to capture value (defined mainly by the business idea's periphery). This takeaway is especially relevant for technology transfer offices and research institutions, emphasizing the importance of focusing on the core of the business idea when providing feedback to academic entrepreneurs. More broadly, our study supports the claim that the Lean Startup Method and the I-Corps program facilitate the development of successful business ideas and positive commercialization outcomes.

6.2 | Boundary conditions and future research

As in any study, there are limitations and boundary conditions that can guide future work. First, this study focuses on academic teams. While academic entrepreneurship is an important phenomenon, boosting economic well-being for founders and providing new resources to institutions and regions (Fini et al., 2018; Miranda et al., 2018), our theoretical logic argues that academic teams are unique, often starting with strong technical skills but less commercial experience and less-developed business ideas than non-academic teams. Thus, our findings are likely relevant to other teams that have limited business experience and are pursuing new technologies but may be less relevant for teams with substantial prior experience, such as corporate spinoffs. Future research could examine whether these results extend to other early-stage, technology-driven entrepreneurs, especially those who lack business experience.

Another important boundary condition is the stage of development. While we find that commercialization-stage academic teams are quite responsive to negative feedback, venture maturity likely influences responsiveness

(Amburgey et al., 1993; Thompson, 1967). Traditional sources of inertia will appear over time. Future research should investigate how the risks and benefits of modifying the core evolve as ventures mature.

While our analysis considers multiple commercialization outcomes, our main dependent variable (whether teams produced an operationally active venture after the I-Corps program ended) and our robustness check (receipt of grant funding) cannot provide significant information regarding the longer-term trajectory of academic ventures. More research is needed to understand how critiques across different loci of the business idea affect other later-stage outcome measures, such as revenue, profits, size, or exit events, which become increasingly important as ventures mature. Overall, the results of this study are limited to teams in the commercialization stage.

Finally, we acknowledge that causal interpretations of our results are limited. It is exceedingly challenging to manipulate the nature of the negative feedback that real academic teams receive, leaving some endogeneity concerns. Follow-on studies could employ additional causal inference methods in controlled environments to build on our findings. For example, future research in the lab could manipulate *where* academic teams receive negative feedback and analyze how critiques targeting different components of the business idea affect changes to the business idea and subsequent outcomes.

7 | CONCLUSION

This study examined how academic entrepreneurs develop and refine their business ideas in response to negative feedback from external stakeholders. We found that the distinction between the core and the periphery of a business idea is relevant, and we outlined a framework that links critiques, business idea changes, and commercialization outcomes. Using a unique and granular dataset of academic scientists funded by the U.S. National Science Foundation going through a Lean Startup Method training program to pursue new-technology-based business ideas, we found that critiques to the core motivated more changes than critiques to the business idea's periphery. Moreover, results indicate that only changes to the core—rather than peripheral ones—were positively linked to improved commercialization outcomes. Overall, it appears that the I-Corps program both accelerates business idea changes and contributes to economic growth.

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DATA AVAILABILITY STATEMENT

Research data are not shared.

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ENDNOTES

[1] We define academic-led teams as teams with at least one academic founder.

[2] We follow Leatherbee and Katila (2020: 570) and define "business idea" as a startup's business concept, including all the elements that would typically be included in a business model.

[3] We label the distinct changes that entrepreneurs make to their business ideas as "business idea changes." The term "pivot" is similar, but not as precisely defined, and it typically refers to a combination of several types of business idea changes. The label "pivot" is used to describe a range of changes from concrete changes in a venture's strategy requiring a restructuring of a venture's resources and realized activities (Grimes, 2017; Kirtley & O'Mahony, 2020; McDonald & Gao, 2019; Snihur & Clarysse, 2022) to conceptual changes that occur in the commercialization stage (Denoo et al., 2021; Nicholls-Nixon et al., 2000; Shepherd & Gruber, 2021).

[4] While studies in this stream often examine business idea changes after teams form an initial venture, the findings regarding business idea change are likely relevant for commercialization stage teams as well.

[5] The I-Corps program is a fixed-length (8-week) program that provides educational training and mentoring to help teams commercialize technology.

[6] The NSF's program excludes ventures with significant revenue or private financing but requires entrepreneurs to formalize an initial business plan by the program's start.

[7] We use the venture as the unit of analysis when analyzing teams' commercialization outcomes.

[8] The online platform used to track each venture's progress through the lean startup curriculum is called Glidr, formerly known as LaunchPad Central.

[9] The search was conducted in the first half of 2025, allowing at least 10 years to pass after an I-Corps cohort had concluded. Post-program surveys were distributed to team members 6, 12, and 24 months after the I-Corps cohorts concluded.

[10] The SBIR program is a grant funding program piloted at NSF in 1980.

[11] Results are consistent when defining the core as only the Value Proposition and Key Customer Segments and the other seven components as the periphery.

[12] More negative feedback could either predict worse results if tied to idea quality, or better outcomes if linked to feedback openness.

[13] The Carnegie system is standardized and comprehensive, including all US institutions that grant at least 20 research-based doctoral degrees annually. The more research-active the school, the lower the score, that is, Tier 1 universities labeled as R1 represent the most research-active schools in the country; Tier 2 schools labeled as R2 have less research activity than R1 universities, and Tier 3 schools have the least research activity among the three tiers. Our data include several institutions that were unranked by the Carnegie Classification system; therefore, we created a tier for these unranked schools.

[14] For example, an I-Corps instructor might directly encourage entrepreneurs to implement business idea changes by telling them, "You need to rework your Value Proposition component."

[15] Although the curriculum is standardized across different cohorts of the I-Corps program, each cohort is unique, providing some exogenous variation.

[16] We note that our instruments should be relevant, driving variation in the potential endogenous variables of negative feedback received and the business idea changes implemented, and these instruments should meet the exclusion restriction since they should only affect an academic team's commercialization outcomes through their effect on negative feedback and implemented business idea changes.

[17] For the analysis of business idea changes, we only analyze changes over the final seven weeks of the I-Corps program because our independent variables are lagged by one week.

[18] These descriptive statistics are for the full sample of 316 teams. We note that the analysis of commercialization outcomes only includes the 247 teams for which the full set of control variables was available. The descriptive statistics reported in Table 2 are based on the 247 teams included in the analysis. These teams make a similar amount of business idea changes.

[19] On average, a team receives 2.30 instances of negative feedback about the core each week with a standard deviation of 5.36. Our marginal effect at representative values (MER) analysis indicates that teams receiving 2.30 instances of negative feedback about the core in a particular week make a total of 5.21 business idea changes. However, teams receiving one standard deviation more negative feedback about the core (7.66 instances of negative feedback) make 5.70 business idea changes. This additional 0.5 business idea changes represents an approximately 10 percent increase in the total number of business idea changes made.

[20] The average team makes 33 changes to the core of their business idea, and the standard deviation is 14.6. Our results indicate that academic teams making 33 business idea changes over the course of the I-Corps program have a 58.9 percent chance of incorporating an operationally active venture. However, teams making one standard deviation more (14.6) changes to the core of their business ideas have a 69.5 percent chance of incorporating an operationally active venture. This is a 10.6 percentage point increase (18 percent).

[21] We include a control variable for the time since a team's I-Corps cohort ended because teams may have continued to make business idea changes after the I-Corps program ended (*Time Since Cohort Ended*).

[22] Our results indicate that academic teams making the average number (33) of business idea changes over the course of the I-Corps program have a 16.4 percent chance of securing SBIR phase I grant funding. However, teams making one standard deviation more changes (a total of 47 changes) to the core of their business ideas have a 19.4 percent chance of securing grant funding. This is an 18 percent increase (3 percentage points).

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APPENDIX

TABLE A1 Analysis of commercialization outcomes: First stage results of the instrumental variable analysis (Second stage in Table 4 Model 3).

Stage 1 DV	Model 1 Total program negative feedback	Model 2 Total program core change	Model 3 Total program periphery change
Instructor engagement	16.160	4.375	1.116
	(.001)	(.031)	(.491)
Instructor feedback encouraging change	−16.720	−3.082	1.107
	(.028)	(.259)	(.441)
Team size	0.459	1.502	0.174
	(.816)	(.024)	(.872)
Num. of team members w/ doctorates	0.940	−0.443	0.198
	(.631)	(.721)	(.722)
Num. of team members w/ MBA	7.113	−1.406	−0.558
	(.018)	(.145)	(.422)
Has team member from Tier 1	2.454	−3.073	2.164
	(.704)	(.515)	(.553)
Has team member from Tier 2	−5.403	−0.782	0.663
	(.306)	(.689)	(.751)
Has team member from Tier 3	0.516	0.209	3.717
	(.956)	(.965)	(.262)
Has team member from unranked tier	−11.410	−1.132	0.333
	(.025)	(.593)	(.883)
Average NSF HERD expenditure	0.029	−0.004	−0.001
	(.121)	(.606)	(.863)
Cohort year	30.500	23.880	−0.631
	(.004)	(.007)	(.945)
Cohort dummies	Yes	Yes	Yes
Constant	16.160	4.375	1.116
	(.001)	(.031)	(.491)
N	225	225	225

Note: *p*-values in parentheses. IV probit uses maximum-likelihood estimators, and the first-stage parameters are estimated jointly with the parameters of the second-stage probit equation. Models 1 to 3 represent the first-stage regression results for the three endogenous variables in the second-stage analysis of *Active Venture*. The exogenous instruments used in IV Probit regression are the amount of academic engagement, the amount of program instructor feedback actively encouraging change, and cohort dummies. Fifteen teams were dropped from the IV analysis due to uniform outcomes (if no teams from a particular cohort of I-Corps turned into incorporated and operationally active ventures after their particular I-Corps cohort concluded, then that cohort has uniform outcomes and all teams from the cohort were dropped from the analysis).