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Navigating market entry decisions in the solar PV industry: The role of founders' pre-entry experience across the value chain

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Abstract

Research Summary: In emerging industries characterized by several technological generations giving rise to multiple submarkets that emerge at different points in time, start-ups entering with novel technologies encounter markets at varying development stages and are confronted with the choice to enter either a nascent or an established market. We study the solar photovoltaic industry between 1985 and 2017 to examine how founders' pre-entry experience along the industry value chain helps them navigate this complex decision. We find that founders with upstream industry experience possess operational acumen and manufacturing knowledge, prompting them to favor established markets. Conversely, founders with focal industry experience, guided by their unique insights into new applications and the limitations of existing technologies in fulfilling emerging customer needs, are more inclined to enter nascent markets.

Managerial Summary: New technologies often enable fulfillment of new user needs. In emerging industries witnessing successive waves of technologies,

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new markets materialize at different point in times. When firms enter these industries with fungible technologies, they can target markets in the early phases of formation or markets that are more mature and well developed. Evidence from the solar PV industry shows that the experience that entrepreneurs gained before founding their start-up in this industry influences the choice of market: founders with prior experience developing solar technologies enter markets addressing new and undefined user needs while founders with prior experience in upstream industries that supply components to the solar industry gravitate toward mature markets, which place greater value on value efficiency enhancements.

KEYWORDS

emerging industries, entry strategy, nascent markets, pre-entry experience along the value chain, solar photovoltaics

1 | INTRODUCTION

Entrepreneurial entry lies at the heart of market and industry growth (Moeen et al., 2020) and start-ups play a key role in developing newly created markets as well as introducing potentially disruptive innovations to existing markets (Schumpeter, 1934). In emerging industries, start-ups often grapple with pervasive demand uncertainty, especially when novel technologies give rise to multiple markets serving distinct uses and customer segments. Prior work has acknowledged the simultaneous existence of multiple intra-industry submarkets and examined how the resulting demand heterogeneity shapes competitive dynamics and product portfolios of industry participants (Shermon & Moeen, 2022; Uzunca, 2018; Uzunca & Cassiman, 2023). However, it remains silent about the possibility that markets may be at varying stages of development—emerging and evolving at different times—in response to the opportunities created by the sequential introduction of distinct novel technologies.

In early stage industries marked by successive technological generations each enabling one or more new applications, formation of new markets is a recurring phenomenon. This pattern has been observed across various industries, including the computer industry (Bresnahan & Greenstein, 1999), laser industry (Bhaskarabhatla, 2016; Bhaskarabhatla & Klepper, 2014), hard disk drive industry (King & Tucci, 2002), US tire industry (Buenstorf & Klepper, 2010), and the farm tractor industry (Buenstorf et al., 2022), each of which witnessed sequential emergence of technological generations, which fostered the creation of distinct markets over time. When a market first emerges, it is inherently nascent, characterized by undefined user needs and underdeveloped complementary assets (Lampert et al., 2020; Santos & Eisenhardt, 2009). Over time, nascent markets either evolve into established ones—marked by distinct customer bases with clear needs and mature complementary assets—or they disappear. This dynamic process of

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emergence and evolution of markets at different development stages amplifies the demand uncertainty faced by resource-constrained start-ups contemplating market entry.

While existing research on market entry and industry evolution has examined several aspects of start-ups' entry decisions—such as entry timing (Helfat & Lieberman, 2002; Lee, 2007, 2008; Lieberman & Montgomery, 1988; Mitchell, 1989), technology choices at entry (Kapoor & Furr, 2015), product design (Benner & Tripsas, 2012), and product portfolio composition (Shermon & Moeen, 2022)—we know little about the antecedents of how start-ups commercializing novel technologies navigate the complexities of market selection in industries in which multiple nascent and established markets coexist. This prompts our research question: What drives a start-up developing a novel technology to enter a nascent versus established application market in an emerging industry? Understanding this aspect of a start-up's calculus is crucial, as it shapes the subsequent strategy of the start-up, influencing whether it will focus on building new markets or enhancing efficiency in established ones. Moreover, the decision to target nascent versus established markets has implications for industry evolution, shedding light on how demand heterogeneity emerges in early stage industries and how intra-industry boundaries and structures evolve over time.

We explore how founders' pre-entry experience shapes this crucial market entry decision. Prior literature suggests that founders' experience is a critical asset influencing both start-up performance (Agarwal et al., 2004; Chatterji, 2009; Klepper & Simons, 2000), and strategic market entry choices (Benner & Tripsas, 2012; Fern et al., 2012; Furr, 2019; Shermon & Moeen, 2022). In industries with submarkets, the relevant experience comes not just from working in the focal industry but also from exposure to vertically linked industries. Upstream industries supply production equipment and technologies to submarkets in the focal industry, while downstream industries use the products manufactured by submarkets in the focal industry (Adams et al., 2016, 2019). Accordingly, we examine whether pre-entry experience along the industry value chain (Adams et al., 2016, 2019; Agarwal et al., 2004; Fontana et al., 2016; Klepper, 2009) influences the decision to enter a nascent or an established submarket in the focal industry. Since theory offers ambiguous guidance on this issue, we refrain from stating formal hypotheses and follow a question-driven approach (Graeber et al., 2022). We first explore the relationship between pre-entry experience along the industry value chain and entry into a nascent market. Then we examine potential explanations proposed by existing literature for the patterns we observe (King et al., 2021).

Our setting is the global solar photovoltaic (PV hereafter) industry from 1985 to 2017. Our sample encompasses the population of start-ups that entered the industry to commercialize thin film solar technologies. This industry provides an ideal context to study our research question as it witnessed the sequential introduction of multiple technological generations—silicon and thin film solar technologies—each enabling new application markets with novel use cases over time. Thin film technologies in particular, offered high versatility: they could be deployed in existing submarkets created by earlier silicon-based technologies, or leveraged to develop a wide range of new submarkets. This versatility afforded thin film entrepreneurs the latitude to strategically choose between nascent or established markets. Moreover, the industry attracted entrepreneurs with heterogeneous pre-entry experience across the industry value chain, enriching the context for analyzing their market entry strategies.

Our findings reveal significant variations in choice of market based on founders' pre-entry experience in different parts of the industry value chain (upstream, focal, downstream): founders with prior *focal industry experience* are more likely to choose nascent markets to commercialize their novel technology, while those with *upstream industry experience* favor established

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markets over nascent ones. *Downstream industry experience* is not correlated with market choice. Our abductive analyses reveal that tenure in the focal industry equips entrepreneurs with insights about unmet customer needs in nascent application markets that could only be addressed with the novel thin film solar technology, making such markets ideal for entry with the technology. Entrepreneurs from the focal industry with prior experience in nascent markets, repeatedly targeted other nascent markets, leveraging their second-order knowledge about one nascent market to identify opportunities in others. In contrast, entrepreneurs with upstream industry experience acquired substantial operational expertise in manufacturing processes, which proved to be essential for scaling up production and positioned them to compete effectively in established markets. Consistent with a question-based approach, our analyses are not meant to be interpreted as support for a specific causal mechanism but show whether our findings align with explanations put forth by existing literature.

Our study provides novel theoretical contributions. First, we show that founders from upstream industries inherit operational knowledge about manufacturing systems and processes, critical for scaling production—an aspect previously unexplored in the literature. We also demonstrate how focal industry experience fosters a higher order understanding of nascent market dynamics, which entrepreneurs can leverage over time in different nascent markets. This insight challenges existing notions linking experience to cognitive rigidity, suggesting instead that focal industry experience fosters flexibility in navigating new market opportunities. Second, by highlighting how different founder backgrounds affect firm entry strategies and shape demand and supply dynamics in new industries, we add further nuance to our understanding of industry evolution and the link between firm takeoff and sales takeoff.

2 | THEORETICAL BACKGROUND

2.1 | Segmented industries and the market entry choice

Much of the existing work on industry evolution equates the industry with the product-market during the early phases of industry emergence (Agarwal & Bayus, 2002; Benner & Tripsas, 2012), focusing on technological similarities on the supply side and homogeneous product use on the demand side. This perspective overlooks the possibility of multiple submarkets co-existing within an industry. Research on segmented industries has begun to relax this one-to-one mapping by examining contexts in which technologies enable multiple applications within the same industry, thereby creating distinct submarkets (Bhaskarabhatla & Klepper, 2014; De Figueiredo & Silverman, 2007; Uzunca, 2018; Uzunca & Cassiman, 2023). Only recently has the literature on industry evolution started integrating insights about segmented industries to explore demand heterogeneity in the early phases of an industry, particularly when a novel technology enables multiple uses across submarkets in the industry (Shermon & Moeen, 2022).

We define (sub)markets as specialized product clusters around distinct applications of a technology. This definition is in line with prior research on segmented industries which uses different labels such as product clusters (Sutton, 1998), product classes, product segments (De Figueiredo & Silverman, 2007), or submarkets (Bhaskarabhatla, 2016; Bhaskarabhatla & Klepper, 2014; Uzunca & Cassiman, 2023) to refer to "different product variants that appeal to different users and may also require different knowledge and methods to produce" (Buenstorf & Klepper, 2010, p. 1564).

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When they first emerge, markets are inherently nascent, characterized by intense uncertainty about potential opportunities. During early formative stages of markets, the expectations of potential customers regarding product functionalities and minimal performance levels are still unclear and evolving, making it critical to explore potential use cases (Santos & Eisenhardt, 2009). Additionally, in nascent markets, the market-specific complementary assets vital for commercializing the technology and engaging potential customers are yet to be fully developed (Lee et al., 2018).

Over time, nascent markets may follow one of two trajectories. They can either evolve and mature into established markets, or they may disappear entirely. Whether a nascent market transitions into an established one depends, among other things, on firm entry. The experimentation required to reduce demand uncertainty in nascent markets occurs only when firms actively enter these markets and take deliberate action to experiment. By generating knowledge about potential use cases and forming partnerships to commercialize these applications, firms contribute to the development of nascent markets (Moeen et al., 2020). A market is considered to have transitioned from nascent to established when it exhibits well-established use cases—where customers have well-defined preferences regarding product features and performance and when market-specific complementary assets are in place. The evolution of a market from nascent to established is not predicated on its eventual size; even smaller, niche markets can be considered established if they achieve clear use cases and well-developed complementary assets.

In industries where multiple competing technologies emerge over time, the processes of market emergence and transition to maturity occur at different intervals, coinciding with the emergence of the various technologies. Thus, the windows of nascency for different submarkets that emerge in an industry may be staggered unevenly over time. This irregular pattern in market evolution results in within-industry variation in demand uncertainty, as each market available for entry is at a different stage of development at any given time. Entrepreneurs entering such industries with novel and fungible technologies—capable of targeting existing markets or creating new ones—encounter multiple markets at varying stages of development rather than a homogenous industry landscape. As a result, their entry decisions must address not only whether and when to enter an industry (Helfat & Lieberman, 2002; Lee, 2007, 2008; Lieberman & Montgomery, 1988; Mitchell, 1989), which technology to adopt (Kapoor & Furr, 2015), or which product features to include (Benner & Tripsas, 2012), but also whether to target nascent versus established markets.

This aspect of a start-up's entry decision has received limited attention in current literature. While research on segmented industries has examined how the presence of submarkets shapes eventual industry structure and how submarket dynamics influence firm exit (Bhaskarabhatla, 2016; Bhaskarabhatla & Klepper, 2014; De Figueiredo & Silverman, 2007; Uzunca, 2018; Uzunca & Cassiman, 2023), it has remained silent on how the development stage of submarkets influence entry decisions. Even studies examining how demand heterogeneity affects the entry decision (Shermon & Moeen, 2022) have overlooked the different stages of development of different submarkets. This leads us to our research question: What drives a start-up developing a novel technology to choose between entering a nascent versus established application market in an emerging industry? Investigating this aspect of the entry decision is crucial because this choice influences not only the capabilities that start-ups need to develop to compete successfully, but also affects demand heterogeneity and evolution of submarkets.

The distinct characteristics of nascent and established markets have implications for the capabilities needed to successfully enter an industry with a novel technology. Nascent markets,

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where user needs are unclear and complementary assets are undefined, comprise an environment that fosters experimentation. Entrants test product variations to better understand customer needs, tailor the technology accordingly, and procure the complementary assets needed to deliver the product. Given the nature of nascent markets, these efforts often begin with rudimentary versions of the technology embodied in prototypes or partial products (Moeen et al., 2020). Thus, success in nascent markets hinges on the ability to produce a good-enough version of the technology. The critical skills involve setting up pilots to learn about user needs, identifying key market-related complementary assets, and maintaining adaptability to pivot as insights from this experimentation emerge (Gans et al., 2019).

In contrast, established markets present a different kind of demand uncertainty, shaped by the experimentation and progress made by early entrants. In established markets, user needs are clear and complementary assets are in place. Entrants commercializing a novel technology in an established market can leverage the market structure established by prior entrants. However, they also face competition from these incumbents who have had time to gradually improve their products over time to meet customers' expectations of reliable and sophisticated products with high performance thresholds (Moeen et al., 2020). Unlike nascent markets, success in established markets requires scaling the technology[1] (Rosenberg, 1976). Entrants commercializing the novel technology in established markets must quickly resolve any remaining technical issues, develop the manufacturing ecosystem to transition from pilot to full-scale production, move down the learning curve to meet customer expectations regarding existing performance standards. These challenges are intensified by competition from incumbents or early entrants whose technologies may already address scalability and reliability issues. Thus, the capabilities needed to compete in established markets revolve around setting up and optimizing complex manufacturing systems.

2.2 | The role of pre-entry experience and market entry choice

The literature on strategy and industry evolution suggests that the pre-entry experience of the founding team is crucial in shaping start-ups' early strategic choices, such as choice of markets, and their overall performance (Adams et al., 2016, 2019; Benner & Tripsas, 2012; Fern et al., 2012; Shermon & Moeen, 2022). Pre-entry experience acquired along the industry value chain has been identified as a source of heterogeneity among new entrants, providing knowledge and skills which form the basis for more effective competition within an industry and, consequently, conferring a survival advantage (Adams et al., 2016, 2019; Agarwal et al., 2004; Fontana et al., 2016; Klepper, 2009). This experience reduces the costs of addressing challenges associated with technology commercialization in specific types of markets, thereby influencing market entry decisions (Helfat & Lieberman, 2002).

Despite the acknowledged importance of experience along the industry value chain on performance, existing theoretical frameworks offer limited guidance on how this experience influences the choice between entering nascent versus established markets. To address this gap, we adopt a question-driven approach as recommended by Graeber et al., 2022. First, we present theoretical arguments that highlight the unique insights gained from founders' pre-entry experience along the industry value chain and we explore how specific aspects of this experience may

[1]We distinguish between technology scaling and market scaling. Market scaling focuses on customer acquisition whereas technology scaling is about the supply side, specifically enhancing the production capabilities of a technology.

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be advantageous for entering either nascent or established markets. We then examine the relationships between various types of pre-entry experience and market entry decisions within the global solar PV industry. Finally, as outlined by King et al. (2021), we employ abductive reasoning to undertake a series of analytical investigations, which delve deeper into these relationships, thereby unveiling the underlying mechanisms that shape the observed patterns.

2.2.1 | The role of pre-entry experience in upstream industries

Prior research suggests that founders with pre-entry experience in upstream industries may possess skills that enable them to target both nascent and established markets. These founders bring deep contextual knowledge of the complementarities between the upstream materials and equipment and the inputs and processes used in the focal industry (Adams et al., 2019; Fontana et al., 2016). On the one hand, they can leverage their broad knowledge of manufacturing and component technologies to devise new manufacturing methods (Alcacer & Oxley, 2014) and conduct technical experiments enabling new applications in the focal industry (Adams et al., 2019). This suggests a strong capability to target nascent markets. On the other hand, their expertise in materials and equipment (Alcacer & Oxley, 2014) suggests that they can also effectively address technical challenges, scale production, and achieve the cost efficiencies necessary for competing in established markets.

2.2.2 | The role of pre-entry experience in the focal industry

Founders with experience in the focal industry may also demonstrate capabilities that support entry into both nascent and established markets. On the one hand, start-ups led by such founders often exhibit stronger market-pioneering capabilities compared to other entrants (Agarwal et al., 2004; Franco et al., 2009). This enables them to adapt their technology to different customer use cases and to develop market-specific complementary assets, which is critical for competing in nascent markets. On the other hand, entrepreneurs with experience in the focal industry also develop capabilities and skills to resolve manufacturing challenges and bottlenecks, further develop the technology, and scale it from pilot phase to full-scale production (Agarwal et al., 2004). These skills make them well-prepared to compete in established markets as well.

2.2.3 | The role of pre-entry experience in downstream industries

Founders with pre-entry experience in a downstream industry, sometimes referred to as a user industry, may also possess skills that position them for successful entry into both markets. These founders possess deep knowledge about customer needs and complementary assets specific to their industry (Adams et al., 2016). They also possess technical knowledge that could help them innovate in both the downstream and the focal industries by embedding focal industry technologies into user products (Adams et al., 2013). Such founders excel at identifying unmet user needs, experimenting with complementary assets and developing functional prototypes for nascent markets (Adams et al., 2016). Moreover, their intimate knowledge about how customers use existing products may reveal performance shortcomings, incentivizing them to enter the focal industry to improve these products in established markets (Adams et al., 2013;

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Moeen et al., 2020). Overall, their customer centric knowledge and technical expertise may equip them to effectively tackle the challenges in both nascent and established markets.

2.2.4 | The joint role of different types of pre-entry experience

While we have discussed the impact of individual pre-entry experiences along the value chain, existing research also emphasizes the importance of considering these experiences collectively (Franco et al., 2009). Integrating diverse knowledge and capabilities has been shown to significantly enhance firm performance (Agarwal et al., 2004; Helfat & Raubitschek, 2000). Since high-technology industries often feature founding teams with heterogeneous backgrounds (Benner & Tripsas, 2012) or individual founders with diverse experience accumulated over time (Fontana et al., 2016), it is possible that overall, a founding team may possess experience in multiple vertically related industries. Thus, we do not rule out the possibility that combining different types of experience along the industry value chain may have interactive and interdependent effects on the decision to enter nascent or established markets.

3 | EMPIRICAL CONTEXT

This study is set in the global solar PV industry between 1985 and 2017 (Furr & Kapoor, 2018; Kapoor & Furr, 2015) and examines the market entry choices of start-ups entering the industry with thin film technologies. The solar PV industry, which includes technologies that transform sunlight into electricity experienced substantial growth in cumulative global installations, increasing from less than 20 Gigawatt (GW) in 2000 to more than 400 GW by 2017 (SolarPower Europe, 2023). The sector also consistently attracted substantial global investment, averaging over $120 billion annually over the past decade (Bloomberg, 2023). This surge in installations and investment has established solar PV as a cornerstone of the renewable energy sector and the focus of considerable hype since the early 2000s, driven by growing interest from environmentalists, policymakers, and the public in reducing dependency on fossil fuels and addressing climate change.

The solar PV industry is structured as a network of industries that are vertically integrated along a value chain, as illustrated in Figure 1. At the center of this value chain is the *focal*

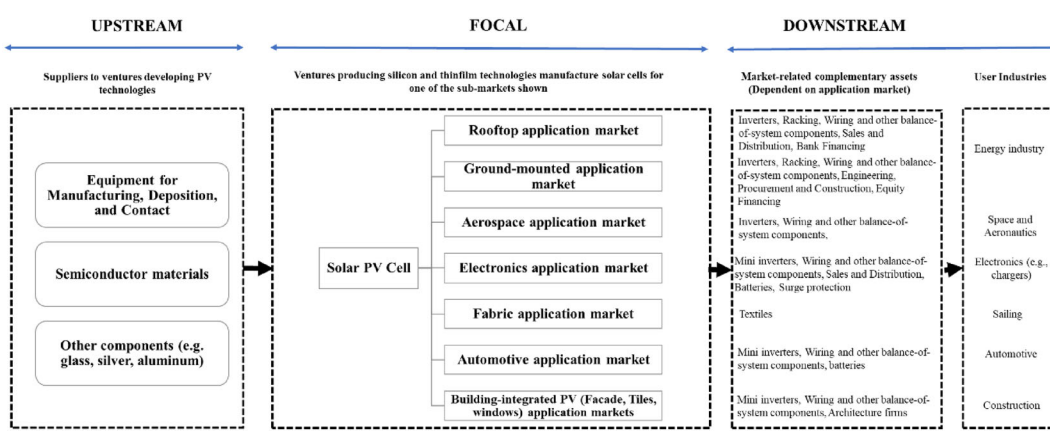

FIGURE 1 Stylized depiction of the value chain in the solar PV industry.

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industry, comprising firms focused on developing solar technologies—either silicon or thin film—embodied in solar cells. Upstream in the value chain are supplier firms in various industries that provide the focal industry with essential equipment and materials such as semiconductor materials, equipment for deposition and contact of these materials, and other necessary components such as glass. Downstream industries provide complementary assets and serve end-user or buyer firms that utilize solar cells in various applications. Downstream industries thus include two groups: those that manufacture the complementary assets needed to use solar cells in different markets and the user industries associated with specific markets. For example, in ground-mounted solar farms, solar panels are integrated with inverters, racking and other balance-of-system components to generate electricity. These large-scale projects often require equity financing and are executed by specialized engineering, procurement and construction firms, with the energy industry as the primary user. In contrast, building-integrated PV (BIPV) markets—such as solar tiles or windows—require the integration of solar cells with mini-inverters and balance-of-system components. Architecture firms play a key role in distribution in these markets, with the construction industry as the primary user.

3.1 | Technologies and markets in the solar PV industry

The solar PV industry is characterized by multiple technological generations, each utilizing different semiconductor materials and spawning several markets over time. The earliest solar cell technology, based on crystalline silicon, paved the way for early markets such as rooftop systems. In the 1970s, novel "thin film" technologies emerged, distinguished by their use of new semiconductor compounds such as copper indium gallium selenide (CIGS) and cadmium telluride, and more recent advancements in organics, polymers, and nanomaterials. Thin film solar cells also required innovative manufacturing methods that differed from those used for silicon-based technologies—while silicon-based solar cells are produced by slicing silicon ingots into wafers, which are then doped, wired, and coated, thin film solar cells are manufactured using deposition or electroplating techniques.

During the period under study, thin film solar technologies were considered pivotal for the evolution of the solar industry. Despite starting out as a smaller segment compared to silicon-based technology, thin film grew at a significantly faster rate, leading to widespread expectations of its potential to become a major industry player. According to the National Renewable Energy Laboratory (NREL), "*Thin-film PV technologies have grown faster than crystalline silicon over the past 5 years, with a 10-year CAGR of 47% and a 5-year CAGR of 87% for thin-film shipments through 2008*" (NREL, 2008). This rapid expansion positioned thin film as a key driver of the overall growth in the solar industry: "*The global thin film PV market, despite of caution in the overall PV industry, is expected to experience an overwhelming growth in coming years. By 2020, the industry is set to transform itself to become the face of Solar PV industry*" (PR Newswire, 2011).

Developing thin film technologies required considerable effort on multiple fronts due to the diversity of materials involved, each with unique characteristics and distinct knowledge bases. Thin film entrants needed to optimize the technology to demonstrate both efficiency (measured as $ per megawatt hours) and reliability (the dependability and durability of solar cells). To compete in established markets dominated by silicon-based technology, they also had to innovate on new equipment that could handle the new semiconductor materials and develop manufacturing processes capable of full-scale production. Additionally, thin film solar cells

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expanded the range of solar energy applications beyond traditional configurations by introducing unique properties, such as flexibility and transparency, enabling fresh design possibilities. As noted by NREL (2009), "*Thin film technologies are spurring innovative new solar applications, such as modules that double as roof shingles, and semi-transparent modules that can be integrated into building walls or roofs. It has the potential to dramatically increase the generation of clean electricity*." These innovations attracted new customer segments with needs distinct from the existing customers of the industry. This expansion of the customer base coupled with limited substitutability across applications, reduced direct competition between markets and stimulated entry by a diverse range of firms. While rooftop and ground-mounted markets were considered established markets, the flexibility of thin-film technologies supported promising markets like BIPV: "*CIGS technology has enabled the development of innovative, low cost solar shingles for roofs*. [...] *With BIPV being increasingly included in the construction of new buildings, many experts contend* that this is the fastest growing segment of the PV industry today" (Chemical Industry Digest, 2011).

Given the dynamics described above, the solar PV industry exhibited heterogeneous demand conditions due to the co-existence of multiple markets. Firms entering the industry to commercialize the very versatile thin film technology were able to target diverse markets and were faced with a strategic choice: enter one of the nascent markets in early stages of development or target one of the more established and mature markets. For example, entrepreneurs entering the industry with thin film technologies in the early 2000s could target the solar façade segment, which was still nascent at the time and was characterized by undefined potential use cases and underdeveloped market-specific complementary assets. Entering this market required developing downstream partnerships with complementary asset providers new to the solar industry, such as architecture or construction companies, to integrate thin film technologies in construction materials as well as into the designs of new buildings. Alternatively, they could enter the more established utility-scale market featuring relatively well-defined use cases and well-developed market-specific complementary assets. Competing in the utility-scale market against silicon-based technologies necessitated demonstrating efficiency, scalable production, and reliability of thin film solar cells. Table 1 shows the nine markets that existed in this industry, their inception years, and the year in which they were considered to have transitioned to an established market by industry experts (transition year).

3.2 | Pre-entry experience of start-ups entering the solar PV industry with thin film technology

Due to the factors described above, thin film solar attracted the attention of entrepreneurs with diverse skillsets and with prior experience in an array of industries. Between 1985 and 2017, 118 start-ups entered the solar PV industry to commercialize thin film technologies, led by 227 founders (with an average of 1.97 founders per firm). Figure 2 shows trends in start-ups entry, and the distribution of pre-entry experience among the thin film firms that entered the industry in each year. Entry trends show a steady upward trajectory increasing from the late 1990s and peaking in 2007–2008. Figure 3 provides an overview of the distribution of pre-entry experience for each firm in our sample, highlighting the diversity of experiences across the entire value chain. Taken together, the two graphs illustrate the heterogeneity in the pre-entry experience spanning the industry value chain for each entrant (Figure 3) and across the industry by year (Figure 2). Notably, this variety in experience is evident among both early and late

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TABLE 1 Overview of markets with windows of nascency in the solar PV industry.

Market	Inception year	Transition year	Comments
Rooftop market	1976	1995	In 1995, the downstream complementary assets in the rooftop market were crystallizing. By 1996, PV was being addressed as a mainstream source of energy with a well-established network of distributors and the focus shifted to decreasing costs and increasing efficiency.[a]
Ground-mounted (utility scale) market	1980	2000	In the late 1990s, the expectations of utilities were still unclear, and the PV industry was still focused on pilot projects to understand the process of characterizing utility-scale plants. From 2000, it became clear that utility-scale plants focused on efficiency and reliability and market-specific assets (e.g., specialized EPC contractors) had been developed.[a]
Aerospace market	1958	Always established	The satellite application market led to the inception of solar PV power. Because solar PV served as the traditional fuel for this market and addressed a specific user need, the focus was on maximizing efficiency, with cost considerations being largely irrelevant from the outset.[a]
Electronics market	1976	1995	Manufacturers of electronics and consumer products began integrating PV in multiple products (e.g., watches, calculators) in the 1980s. Around 1995, this market was a stronghold of PV and began being saturated.[a]
Fabric market	2007	Still nascent	In 2023, solar fabric remained a novel approach to harness solar energy. The specific use for solar fabric is still unclear and the technology has only recently started to be deployed.[a]
Automotive market	1990	Still nascent	During the 1990s, research was still focused on the feasibility of solar for this market. The user case is still unclear because it is not clear what part of the car solar PV panels should replace.[a]
Building-integrated photovoltaics (BIPV) façade market	1999	2007	In early 2000s, BIPV was a nascent market that relied heavily on institutional support to gain viability. Around 2007, architects' focus on aesthetics of PV panels became clear (use case) leading to commercialization of complementary assets (e.g., software to integrate PV panels in building design) to enhance its appeal for architects.[a]
BIPV tile market	1980	2007	Applied criteria identified for solar façades.
BIPV window	2000	Still nascent	In 2018, solar windows are discussed as the next application for solar and this market is only "dawning" (IEEE Spectrum, 2018)

[a]Summarized from industry reports.

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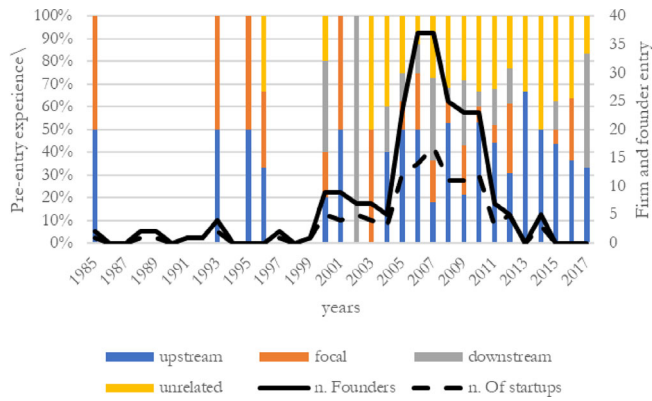

FIGURE 2 Annual entry by start-ups, founders and pre-entry experience distribution along the value chain in solar PV industry. Left axis and vertical bars: Distribution of experience across all start-ups that entered in each year. Right axis: Annual entry by number of start-ups (dashed black line) Number of founders (solid black line).

entrants (Figure 2). Figure 3 also reveals that for most start-ups, founder experience spanned different parts of the industry value chain. This varied expertise allowed them to navigate the technical and strategic challenges of commercializing thin-film technologies. Table 2 provides the distribution of the market entry choices made by the start-ups in the sample across the focal, upstream, and downstream industries.

4 | DATA AND METHODS

4.1 | Sample and data collection

4.1.1 | Sample definition

Our sample includes the population of start-ups that entered the "focal" solar PV industry between 1985 and 2017 to develop thin film technologies for manufacturing solar cells (see Figure 1 for the solar PV industry value chain). Following prior research in solar PV industry (Furr & Kapoor, 2018; Kapoor & Furr, 2015), we exclude start-ups that entered either upstream supplier industries or downstream sectors in the industry value chain.

To construct the sample, we first obtained a list of all entrants commercializing solar technologies in the solar PV industry from i3—a consultancy specializing in clean technology sectors. We then used industry reports and industry trade journals, such as Solar Monitor by Deutsche Bank, to identify additional entrants that were active in the solar PV industry but not included in the initial list. Triangulating across different sources allowed us to eventually obtain the entire population of entrants in the solar PV industry. We then classified all entrants based on whether they were diversifying entrants or start-ups. For all start-ups in the sample, we coded the type of technology they introduced. Our final sample consists of all 118 start-ups that commercialized thin film technologies in the solar PV industry between 1985 and 2017. As 35 start-ups targeted multiple markets at the same time, we study a total of 143 market entry decisions.

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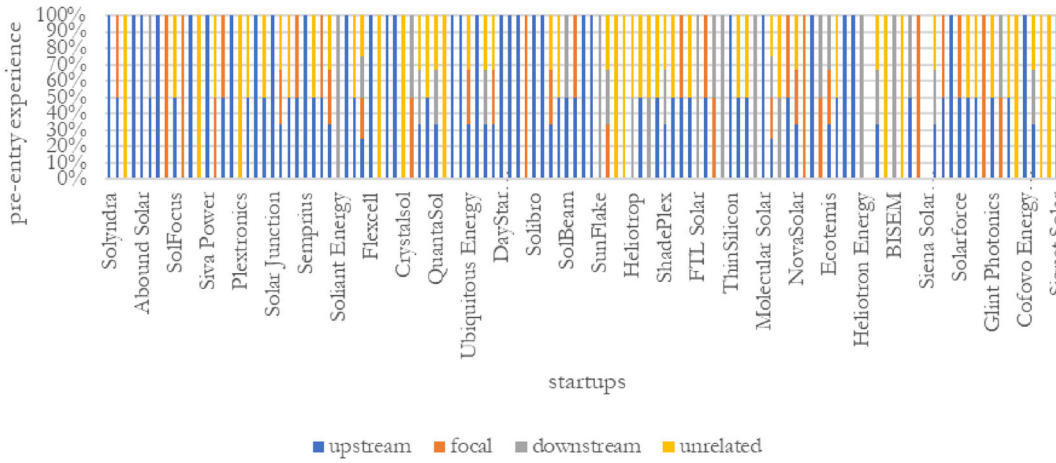

FIGURE 3 Distribution of pre-entry experience along the value chain for each start-up.

4.1.2 | Quantitative data

In line with prior industry studies (e.g., De Figueiredo & Silverman, 2007), we coded the market entry choices of each start-up using press releases and industry-specific media outlets such as Photon Magazine. Increasing public awareness of climate change coupled with substantial government investments in renewable technologies spurred extensive media coverage of the solar PV industry. This coverage served as a valuable resource, enabling accurate coding of market entry choices and supporting collection of additional data on the start-ups, including their technology development stage. We complemented this data with information on the financing received by these start-ups from i3 and Zephyr. Industry-level data, such as cumulative manufacturing capacity for thin film technologies, was obtained from academic sources such as Progress in PVs and publications from NREL.

We also compiled comprehensive data on the background of all founders of the start-ups in our sample. The extensive media coverage received by the solar PV industry facilitated identification of these founders and we followed prior research to gather data on their pre-entry experience from their employment histories (Beckman et al., 2007). These histories were assembled using companies' websites and triangulated using LinkedIn, Bloomberg, and founders' curricula vitae.

4.1.3 | Qualitative data

We supplemented our quantitative dataset with qualitative evidence by compiling business histories of start-ups in our sample from secondary sources, including press releases and archived versions of their websites. In total, we collected over 3,555 pages of archival material ranging from 4 to 353 pages per start-up, with an average of 65 pages per start-up. We were able to create detailed business histories for 55 of the start-ups in our sample by carefully reviewing the documents to identify the reasons cited for choosing specific markets. Our focus was on understanding the link between pre-entry experience and the skills needed to compete in a market, as well as how the skills of the founding team and early hires influenced their market choices.

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TABLE 2 Distribution of 143 market entry choices of 118 start-ups across pre-entry experience types.

Upstream industries	Start-ups	Choices	Focal industry	Start-ups	Choices	Downstream industries	Start-ups	Choices
Semiconductor	61	19	Silicon Solar	7	11	Aerospace	8	9
Electronics	9	14	Thin Film Solar	23	33	Energy (Oil & Gas)	4	6
Electronic Equipment Manuf.	8	24	Both Si & Tf	1	2	Renewable Energy	3	3
Chemistry	8	9				Glass	3	4
Imaging	7	2				Investor in Renewables	3	4
Optics	5	29				Consulting in Renewables	2	3
Telecom	4	25				Automotive	2	2
Materials	3	30				Plant Developers	1	1
Photonics	3	7				Solar Charge Controller	1	1
						Installer	1	2
						Tensile Structures	1	1
						Smart Meters	1	1
Total start-ups	**77**	**81**	**Total**	**31**	**46**	**Total**	**29**	**36**

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These business histories were instrumental in providing deeper insights into the mechanisms underlying the relationships identified in the quantitative analysis. We present illustrative quotes in the findings section (further quotes are available in the online Appendix). Finally, we conducted interviews with industry experts to further corroborate the findings from our analyses.

4.2 | Dependent variable

Our dependent variable is a dummy variable, which equals 1 if a start-up in the sample entered a nascent market and 0 if the start-up entered an established market. To construct this measure, we first developed a detailed coding scheme to classify each market in the solar PV industry as nascent or established for each year in the sample. We then applied this coding scheme to determine whether a start-up targeted a nascent or an established market in a given year.

To develop the coding scheme, we followed a three-step procedure using 60 industry specific reports (totaling 5273 pages) from sources such as the Department of Energy and NREL. This entailed (i) identifying the various markets that emerged in the solar PV industry over time, (ii) establishing the year each market emerged, and (iii) determining when each market transitioned from nascent to established status. This approach, which is detailed below, allowed us to define the "nascency window" for each market.

First, we identified the various distinct markets existing in the solar PV industry. Consistent with prior research on segmented industries (De Figueiredo & Silverman, 2007; Klepper & Thompson, 2006; Uzunca & Cassiman, 2023), we used the variation in the use cases—the products that the thin film technologies were being used in and the functionalities requested and valued by customers—to identify nine distinct application specific markets in the solar PV industry: rooftop systems, ground-mounted systems, three markets within the BIPV category and four markets within the integrated products category (Table 1 provides a full list of markets).

Second, in line with prior industry studies, we coded the year of market emergence for any market as the year when the first product was commercialized in that market (Agarwal & Bayus, 2002; Moeen & Agarwal, 2017). Third, we sought to establish the "window of nascency" for each market (i.e., the period during which the market could be considered nascent). To distinguish nascent versus established markets, we also relied on how developed the complementary assets are in each market. We used industry reports on each of the nine markets to gather data on three key indicators that would allow us to pinpoint the year when the market transitioned to a mature, established market: (i) when the use cases (i.e., the products that the thin film technologies were being used in and the functionalities requested and valued by customers) became clear and unambiguous, (ii) when complementary assets essential for commercializing the technology in that market became clearly identifiable, and (iii) when competition in a market shifted to offering improvements along functionalities requested by the customers. A market was classified as an established market from the first year in which two out of the above three characteristics were met. For example, the use case for the rooftop market was generating distributed energy for the commercial or residential customer segments. This market initially faced uncertainty regarding customers' needs for solar energy, the complementary assets needed to address those needs, and how to build them. Our analysis of industry reports identified 1995 as the year when clarity on customer expectations and complementary assets emerged. By then, a general consensus emerged in the industry highlighting cost and efficiency

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as the key criteria demanded by rooftop solar customers. Additionally, the complementary assets requirements crystallized unambiguously around inverters, racking, balance-of-system components such as wiring, sales and distribution networks, and bank financing. Thus, 1995 marked the end of the window of nascency for the rooftop market, signifying its transition to an established market.

When data were not available to precisely pinpoint the transition year, we extrapolated from similar markets. For example, the solar façade and solar tiles markets cater to analogous customer bases and share some complementary assets. While industry reports often discuss these two markets jointly, they yielded clear information on transition year (2007) for the solar façade market, but not for solar tiles. Given the similarities among the two markets, we applied 2007 as the transition year for solar tiles as well.

Using this methodology, we established the nascency window for each market in the industry (see Table 1). Start-ups were classified as entering a nascent market (coded as 1) if they entered the market during its window of nascency, and as entering an established market (coded as 0) otherwise. Within our dataset, start-ups opted for established markets 80% of the time.

4.3 | Explanatory variables

4.3.1 | Pre-entry experience in upstream industries

We measure the pre-entry experience of each founding team in upstream industries using a count of the number of founders previously employed in firms situated upstream relative to the focal industry in the solar PV industry value chain (see Figure 1). These upstream industries supply critical components for solar technology development and solar cell manufacturing, such as electronics or photonics (Table 2 shows a complete list).

4.3.2 | Pre-entry experience in the focal industry

We measure pre-entry experience of each founding team in the focal solar PV industry by counting the number of founders who were previously employed in firms developing solar technologies and manufacturing solar cells (see Figure 1).

4.3.3 | Pre-entry experience in downstream industries

We assess pre-entry experience in downstream industries by counting the number of founders who worked in firms either developing complementary assets for the solar PV industry or buying or using end products from the solar PV industry (see Figure 1).

4.4 | Control variables

We control for several factors that might impact a start-up's market choice. Specifically, we control for *Unrelated pre-entry experience*, that is, the number of founding team members with

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experience in industries outside the value chain of solar PV (e.g., the medical industry). We control for team size (*N. Founders*) by including a variable that counts the total number of founders in each founding team.

Following prior research (Agarwal et al., 2004), we include the age of each start-up to control for potential learning effects within the industry (*Age*). Prior studies on the solar PV industry suggest that the development stage of a start-up's technology influences its product related choices (Furr, 2019). Entrants in this industry often make substantial technical progress in developing their technology before selecting an application market and integrating their technology with complementary assets to target that market.

While all entrants aim to rapidly develop their technology, start-ups vary in how quickly they transition the technology from lab to market. Start-ups that have already reached the pilot manufacturing stage possess greater confidence in their ability to move the technology to full-scale manufacturing and ensure reliable performance once at scale. Such start-ups may be more inclined to enter established markets. Thus, in line with prior research (Furr, 2019), we control for the development stage of the technology (*Tech. Dev. Stage*) using a dummy variable that takes a value 1 when the start-up has reached the pilot manufacturing stage and 0 when the start-up is still in the R&D phase. In line with previous studies examining market entry choices of start-ups in nascent industries (Adams et al., 2016; Benner & Tripsas, 2012; Pontikes & Barnett, 2016; Shermon & Moeen, 2022), we also control for the cumulative number of patents filed by the start-up before selecting a market (*Cumulative patents*). Finally, since raising venture capital (VC) financing has been found to influence start-ups strategies (Adams et al., 2016; Pahnke et al., 2015), we also control for whether the start-up raised VC funding before deciding which market to enter—this is a dummy which equals 1 after the first round of funding has been received (*Raised VC funding*).

At the industry level, we control for the cumulative production of thin film technologies in megawatts (Industry TF Capacity—in MW) to account for technology-level maturity and the cumulative learning curve that can influence a start-up's ability to scale its technology and, in turn, its confidence in reaching full scale manufacturing (Kapoor & Furr, 2015). We also control for variations in regulatory policies across countries (Georgallis & Durand, 2017) that may affect a start-up's market entry choice by including two dummy variables indicating if the start-up is headquartered in Europe (HQ [Europe]) and another for Asia (HQ [Asia]). Finally, we include Time dummies for each 5-year period to control for differences in founding conditions (Agarwal et al., 2004).

4.5 | Analytic approach

We first use quantitative data to systematically document the relationship between different types of pre-entry experience along the industry value chain and the decision to enter a nascent market to commercialize thin film technology. Since our dependent variable is binary, we use logistic regression to estimate the model. Some start-ups entered multiple markets concurrently. Therefore, we cluster standard errors at the start-up level to account for potential correlations across multiple markets targeted simultaneously by the same start-up. We then use both quantitative and qualitative data to explore the mechanisms underpinning these relationships. Our analysis of start-up business histories provides supportive quotes that shed light on the reasons behind specific market choices, the role of pre-entry experience in addressing specific competitive challenges, and how competitive dynamics unfold in various markets. When the size of the

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subsamples used in the analysis is too small, we present descriptive statistics to support and contextualize our findings.

5 | EMPIRICAL FINDINGS

5.1 | Relationship between pre-entry experience and choice of markets

We first examine the descriptive statistics and pairwise correlations between the variables (Table 3). The dependent variable, entry into a nascent market, shows a negative correlation with pre-entry experience in upstream industries, a positive correlation with pre-entry experience in the focal industry, and a negligible correlation with prior experience in downstream industries. Table 4 reports the results of the logistic regression. Model 1 is the baseline model with only control variables, Models 2–4 introduce each of the three pre-entry experience variables on its own. Model 5 includes all the pre-entry experience variables together. Models 6–11 introduce the interaction terms to test the effect of the various combinations of the pre-entry experience variables. Model 12 is the full model.

The coefficient of the upstream pre-entry experience variable is negative (Model 12: $\beta = -1.223$, $p = .030$), with an average marginal effect (AME) of −0.156 ($p = .000$). This indicates a decrease in predicted probability of choosing a nascent market from 34.85% when none of the founders in the team has upstream pre-entry experience to 18.78% when one founder in the founding team has such experience. This probability further declines to 6.88% if two founders have upstream pre-entry experience. In contrast, the coefficient of focal pre-entry experience is positive (Model 12: $\beta = 2.294$, $p = .011$) with an AME of 0.152 ($p = .001$). The predicted probability of choosing a nascent market increases from 14.21% when none of the founders in the team has focal industry pre-entry experience to 33.48% when one founder in the founding team has this type of experience and to 52.70% when two founders have this type of experience. The coefficient of downstream pre-entry experience is negative (Model 12: $\beta = -.418$, $p = .62$) with an AME of −0.49 ($p = .39$). The probability of choosing a nascent market is 21.19% when there is no founder with downstream pre-entry experience, it drops to 16.68% is there is one founder with such experience and to 14.75% if there are two founders with this experience.

The results are robust to using a probit regression as an alternative specification. We also tested the robustness of results to alternative measures of pre-entry experience using dummy variables, counts of founders with latest (most recent) experience in a part of the value chain, as well as the average number of years of experience of the founding team in different parts of the value chain (unweighted, and decayed at 10%, 15%, and 20%). Results are qualitatively similar to those in Table 4. We also note that our results are not sensitive to controls, and they are robust to running our analysis on the subsample of companies targeting only one market.

Given that the nascency window for each market is coded using qualitative industry reports, we conducted sensitivity analyses using different cut-off points to determine when the nascency window ends. We explored the impact of cut-offs 1 year earlier or 1 year later than the coded year of transition. For example, for rooftop market, instead of using 1995 as the transition year, we used 1994 (1 year earlier) and 1996 (1 year later) as alternatives to test the robustness of our results. We also explored the sensitivity of the results to time dummies of various lengths using

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TABLE 3 Summary statistics and correlation table.

	Variables	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Nascent market	0.20	0.40	0	1	1																	
2	Upstream pre-entry exp.	0.96	0.95	0	5	−0.18	1																
3	Focal pre-entry exp.	0.41	0.76	0	4	0.26	0.09	1															
4	Downstream pre-entry exp.	0.27	0.57	0	4	−0.01	−0.11	0.12	1														
5	Unrelated pre-entry exp.	0.54	0.70	0	4	−0.11	0.19	−0.18	−0.02	1													
6	N. Founders	1.97	1.06	1	6	0.00	0.54	0.17	0.10	0.35	1												
7	Age	2.58	2.00	1	10	−0.09	0.02	0.06	−0.14	−0.15	0.08	1											
8	Tech. Dev. Stage	1.24	0.54	1	3	−0.13	0.16	0.08	−0.03	−0.09	0.04	0.60	1										
9	Cum. Patents	0.29	0.46	0	1	−0.21	0.22	−0.09	−0.09	0.04	0.30	0.26	0.23	1									
10	Raised VC funding	2.55	9.24	0	73	−0.08	0.13	0.21	0.01	−0.13	0.06	0.31	0.27	0.32	1								
11	Industry TF capacity	3786	5429	0	31,377	−0.12	0.08	−0.03	−0.04	0.08	−0.01	0.21	0.12	0.24	0.09	1							
12	HQ (Europe)	0.33	0.47	0	1	0.06	−0.16	0.01	0.02	0.04	0.10	−0.06	−0.09	−0.04	−0.11	0.10	1						
13	HQ (Asia)	0.06	0.23	0	1	0.02	−0.11	0.12	−0.12	0.04	−0.15	0.24	0.20	−0.16	−0.06	−0.14	−0.17	1					
14	Years 1993–1997	0.02	0.14	0	1	0.28	0.06	0.29	−0.07	−0.11	0.09	−0.02	0.02	−0.09	−0.04	−0.10	0.10	−0.03	1				
15	Years 1998–2003	0.13	0.34	0	1	−0.05	−0.20	−0.07	−0.02	−0.01	−0.15	0.14	0.14	−0.21	−0.06	−0.27	0.00	0.23	−0.05	1			
16	Years 2004–2008	0.36	0.48	0	1	−0.14	0.20	−0.21	0.02	0.07	0.16	−0.29	−0.16	0.05	−0.12	−0.44	−0.21	−0.01	−0.10	−0.29	1		
17	Years 2009–2013	0.36	0.48	0	1	−0.04	0.07	0.10	0.02	0.09	0.02	0.15	0.11	0.13	0.23	0.69	0.24	−0.13	−0.10	−0.29	−0.55	1	
18	Years 2014–2018	0.02	0.14	0	1	−0.07	0.06	−0.08	0.10	0.03	−0.04	0.03	0.02	0.11	−0.03	0.48	−0.10	−0.03	−0.02	−0.05	−0.10	−0.10	1

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alternative windows of 2, 3, 4, 6, and 7 years. Results of all our sensitivity analyses are similar to those in the main analysis (Table 4).[2]

Prior literature advises caution when interpreting interaction terms in logit models (Ai & Norton, 2003; Hoetker, 2007). Thus, we follow recent suggestions in the strategy literature (e.g., Hoetker, 2007; Srinivasan et al., 2021; Tandon et al., 2023; Wiersema & Bowen, 2009) and further examine the interaction effects in two ways. First, following Wiersema and Bowen (2009), we validate the results of the logistic regression by calculating the AME across observations using the Stata post-estimation command *inteff* (Norton et al., 2004; Srinivasan et al., 2021; Tandon et al., 2023). The result of the post-estimation analysis shows that the interaction across all observations between focal and upstream pre-entry experience is −0.126 (p = .10), which is in line with the results in Table 4. The interaction between upstream and downstream pre-entry experience is 0.098 (p = .34) and the one between focal and downstream pre-entry experience is 0.026 (p = .749).

Second, in line with Hoetker's (2007, pp. 336–337) recommendation, we use marginal analysis plots (using Stata's *margins* command) to validate the robustness of these findings across a range of values for each combination of pre-entry experience. Panel a (Figure 4) demonstrates that in teams with one founder possessing focal pre-entry experience, the probability of choosing nascent markets is higher when there is no member with upstream experience (61.8%) compared to when there is one member (25.7%) or two members with this type of experience (6.1%). When a team has two members with focal pre-entry experience, the probability of choosing nascent markets is 49.5% when there is one member with upstream experience and drops to 7% when there are two members with upstream experience. A visual examination of Panels b and c (Figure 4) does not show any difference in the probability of choosing nascent markets for teams with different combinations of downstream and upstream pre-entry experience (Panel b) and for teams with different combinations of focal and downstream pre-entry experience (Panel c).

The analyses above suggest that pre-entry experience in upstream industries and in the focal industry are related with the decision to target a nascent market, whereas downstream pre-entry experience is not. However, these findings are correlational and do not uncover the mechanisms driving these relationships. In the sections below, we closely examine the choices made by teams with pre-entry experience in upstream and focal industries to identify the underlying mechanisms.

5.2 | Unpacking pre-entry experience in upstream industries

Our main analysis (Table 4) revealed a negative correlation between upstream pre-entry experience and entering a nascent market. We delved deeper into the potential explanations underlying this pattern. Founders with upstream pre-entry experience have in-depth knowledge of the upstream part of the industry value chain. Prior literature suggests that this knowledge of the overall technological system can manifest in two distinct ways—founders may have *technical experience* related to the foundational scientific principles underlying solar cells or they may exhibit *operational acumen* related to assembling equipment and processes needed to building manufacturing systems (Arthur, 2007).

[2]Due to space limitations, we do not report these results here. These are available from the authors.

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TABLE 4 Logistic regression model (DV = 1 if the start-up enters a nascent market, 0 otherwise).

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Upstream pre-entry exp.		−1.083			−1.349	−0.852	−1.366	−1.624	−0.859	−1.101	−1.782	−1.223
		(.001)			(.001)	(.041)	(.002)	(.000)	(.037)	(.021)	(.002)	(.030)
Focal pre-entry exp.			0.561		0.930	1.798	0.972	1.099	2.205	1.799	1.336	2.294
			(.120)		(.014)	(.005)	(.023)	(.004)	(.010)	(.006)	(.015)	(.011)
Downstream pre-entry exp.				−0.050	−0.275	−0.336	−0.219	−0.747	−0.061	−0.675	−0.609	−0.418
				(.930)	(.622)	(.575)	(.747)	(.338)	(.928)	(.436)	(.433)	(.620)
Focal pre-entry exp. × upstream pre-entry exp						−0.874			−1.009	−0.810		−0.930
						(.053)			(.045)	(.080)		(.063)
Focal pre-entry exp. × downstream pre-entry exp							−0.179		−0.913		−0.757	−1.137
							(.831)		(.361)		(.434)	(.277)
Upstream pre-entry exp. × Downstream pre-entry exp								0.983		0.610	1.160	0.753
								(.112)		(.312)	(.066)	(.197)
Unrelated pre-entry exp.	−0.393	−0.583	−0.234	−0.393	−0.420	−0.413	−0.420	−0.400	−0.423	−0.404	−0.403	−0.423
	(.258)	(.132)	(.505)	(.256)	(.272)	(.294)	(.275)	(.304)	(.296)	(.311)	(.315)	(.313)
N. Founders	0.282	0.891	0.110	0.284	0.764	0.782	0.770	0.685	0.827	0.738	0.707	0.792
	(.237)	(.021)	(.674)	(.236)	(.038)	(.030)	(.041)	(.072)	(.034)	(.046)	(.074)	(.048)
Age	−0.011	−0.056	−0.012	−0.013	−0.047	−0.046	−0.044	−0.076	−0.032	−0.061	−0.067	−0.045
	(.949)	(.747)	(.949)	(.942)	(.778)	(.781)	(.791)	(.644)	(.842)	(.705)	(.677)	(.771)

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TABLE 4 (Continued)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Tech. Dev. Stage	−0.656	−0.482	−0.528	−0.663	−0.517	−0.617	−0.529	−0.486	−0.708	−0.602	−0.537	−0.718
	(.486)	(.599)	(.562)	(.482)	(.580)	(.496)	(.573)	(.607)	(.453)	(.515)	(.584)	(.468)
Post VC funding	−1.370	−2.096	−1.163	−1.374	−1.898	−2.158	−1.911	−1.815	−2.287	−2.088	−1.903	−2.264
	(.041)	(.031)	(.076)	(.040)	(.036)	(.014)	(.038)	(.035)	(.018)	(.013)	(.042)	(.020)
Cum. patents	−0.002	0.015	−0.010	−0.002	0.006	0.019	0.006	0.007	0.019	0.020	0.007	0.020
	(.909)	(.450)	(.637)	(.915)	(.766)	(.346)	(.783)	(.716)	(.374)	(.335)	(.749)	(.357)
Industry TF capacity	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000
	(.315)	(.149)	(.364)	(.312)	(.125)	(.116)	(.126)	(.222)	(.094)	(.152)	(.187)	(.110)
HQ (Europe)	0.167	−0.082	0.329	0.167	0.094	0.070	0.091	0.089	0.049	0.058	0.073	0.029
	(.751)	(.876)	(.533)	(.751)	(.858)	(.891)	(.864)	(.866)	(.923)	(.909)	(.889)	(.953)
HQ (Asia)	0.672	0.614	0.357	0.658	−0.044	0.288	−0.070	−0.172	0.224	0.095	−0.310	−0.046
	(.527)	(.555)	(.777)	(.540)	(.969)	(.847)	(.952)	(.880)	(.890)	(.949)	(.799)	(.978)
Constant	−0.309	−0.513	−0.542	−0.292	−0.867	−1.257	−0.909	−0.656	−1.548	−1.059	−0.793	−1.358
	(.674)	(.514)	(.460)	(.695)	(.264)	(.098)	(.268)	(.420)	(.070)	(.192)	(.345)	(.122)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	143	143	143	143	143	143	143	143	143	143	143	143
R-squared	.124	.190	.141	.124	.226	.252	.226	.240	.258	.257	.244	.266
Log-likelihood	−61.95	−57.28	−60.77	−61.95	−54.76	−52.88	−54.74	−53.77	−52.48	−52.51	−53.49	−51.91

Note: Two-tailed *p*-values in parentheses, based on robust standard errors clustered on the start-up.

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To delve deeper into this explanation, we investigated the nature of the founders' upstream pre-entry experience further to understand whether it is rooted in the scientific underpinnings of solar PV, or in developing the complementary assets, processes, and systems essential to manufacturing. Using data on the background of founders, we coded two new variables: (1) *technical upstream pre-entry experience*, which counts the number of founders with pre-entry experience pertinent to core scientific principles of solar PV such as physics, chemistry, and material science, and (2) *operational upstream pre-entry experience*, which counts the number of founders with experience related to equipment providers, telecom, optics, or imaging which provides knowledge related to manufacturing systems and processes. Table 5 presents our findings: the first column (Model 1, Table 5) replicates the results from the main analysis already shown in Table 4, Model 5.

In the second column (Model 2, Table 5), we show the results of a logistic regression replacing upstream experience with the newly constructed variables on the full sample. In the third column (Model 3, Table 5), we repeat the regression for the subsample in which at least one founder had upstream pre-entry experience. In Model 3, the coefficient of operational pre-entry experience is −2.241 (p = .037), while the coefficient of technical pre-entry experience is −1.742 (p = .172). The probability of choosing nascent markets decreases from 39.45% to 15% when the number of founders with operational upstream pre-entry experience in the founding team increases from zero to one. By contrast, it decreases only from 27.66% to 14.02% as the number of founders with technical upstream pre-entry experience in the team increases from 0 to 1. Thus, the probability of choosing a nascent market is lower with increasing number of members with operational upstream pre-entry experience than if there are more members with technical upstream experience. This suggests that operational pre-entry experience in upstream industries plays a key role in explaining the patterns we observe in the main analysis.

Consistent with these quantitative findings for operational pre-entry experience, our qualitative analysis unveiled manufacturing knowledge acquired during employment in upstream industries as the key mechanism underlying the decision to enter established markets. Founders and industry experts alike recognized that this knowledge is crucial for scaling the technology for high-volume production—a critical metric for competing in established markets in the solar PV industry. For instance, one of the firms in our sample, Miasole, targeted the rooftop market after this market had transitioned to an established market. Its founder and CEO emphasized the importance of manufacturing and scaling the technology: "*The battle is going to be won on the manufacturing floor. What we have to do is transfer this into high-volume production*" (CNET News.com, 2006). Similarly, Xunlight's founder highlighted the need to scale operations to lower costs and compete with manufacturers in the rooftop markets: "*The challenge we've had is we're competing against larger manufacturers, so it requires constant innovation to drive the cost down*" (Xunming Deng, Founder and CEO of Xunlight, via Industry Week, 2010). Solyndra's founder echoed this sentiment for rooftop markets: "*the whole focus of the company is ramping production*" (Chris Gronet, Founder, via VentureBeat, 2008). Further validation comes from other founders, who emphasized the critical role of manufacturing experience gained in upstream industries such as semiconductors and optics equipment:

> "Midsummer is a Swedish company with its roots in the optical disc manufacturing equipment and the photo mask industries. With expertise in utilizing sputtering for fast and efficient manufacturing processes, Midsummer has developed production lines for highly efficient and cost-effective manufacturing of flexible thin film CIGS solar cells" (Energy Monitor Worldwide, 2014).

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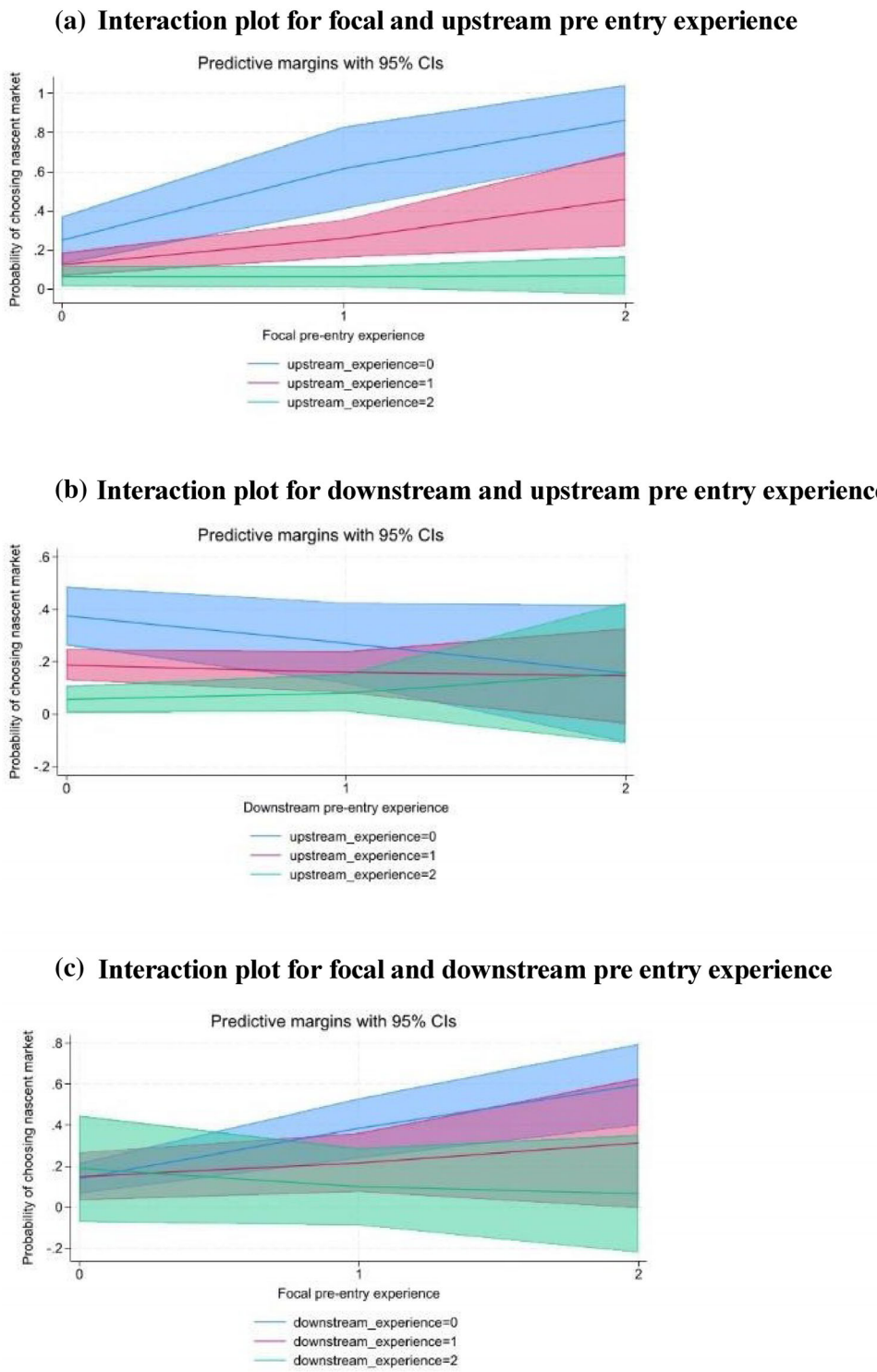

FIGURE 4 Interaction plots for probability of choosing a nascent market. Panel a: Interaction plot for focal and upstream pre entry experience. Panel b: Interaction plot for downstream and upstream pre entry experience. Panel c: Interaction plot for focal and downstream pre entry experience.

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TABLE 5 Logistic regression model for operational and technical upstream experience (DV = 1 if the start-up enters a nascent market, 0 otherwise).

Variables	Model 1 (Table 4, Model 5)	Model 2 (full sample)	Model 3 (subsample)
Upstream pre-entry exp.	−1.349		
	(.001)		
Operational upstream pre-entry exp.		−1.216	−2.241
		(.005)	(.037)
Technical upstream pre-entry exp.		−0.960	−1.742
		(.068)	(.172)
Focal pre-entry exp.	0.930	0.900	1.097
	(.014)	(.019)	(.130)
Downstream pre-entry exp.	−0.275	−0.327	−1.427
	(.622)	(.573)	(.298)
Constant	−0.867	−0.630	5.446
	(.264)	(.449)	(.037)
Control variables	Yes	Yes	Yes
Observations	143	143	81
R-squared	.226	.222	.443
Log-likelihood	−54.76	−55.01	−19.87

Note: (a) Two-tailed *p*-values in parentheses, based on robust standard errors clustered on the start-up. (b) Models include all control variables as per Table 4. (c) The subsample in Model 3 includes the entry choices made by start-ups in which at least one founder had upstream pre-entry experience.

The importance of high-volume manufacturing knowledge was evident not only from the founder's own experience, but also from the experience they valued when hiring new top management team members. The quotes below illustrate this for another start-up, Stion:

> "Dr. Dharmadhikari, a semiconductor industry veteran with 27 years of experience, joins Stion from KLA-Tencor, a provider of process control and yield management solutions for semiconductors and related industries, where he worked as Vice President/General Manager for the Metrology Division. Vineet brings an exceptional skill set to Stion that will be an excellent fit for our scale-up and production efforts," said Chet Farris, Stion's President and CEO. "He has a unique combination of semiconductor manufacturing and thin-film engineering experience, as well as a strong track record of leadership and management skills." (Business Wire, 2007)

Finally, equipment manufacturers also recognized the importance of manufacturing knowledge for competing in established markets. Mark Pinto, Senior Vice President (SVP) of Applied Materials' New Business and New Products Group, stated:

> "Solar module and semiconductor manufacturing are closely related. We believe that Signet Solar is strongly positioned to apply its management's extensive

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expertise in semiconductor technology and manufacturing to optimize state-of-the-art thin film solar module production. We are excited to have this contract from Signet Solar." (Business Wire, 2007)

The qualitative evidence underscores that operational knowledge of manufacturing processes and systems, gained during employment in an upstream industry, is a key mechanism influencing startups' decision to target established markets in the solar PV industry. Accordingly, start-ups in established markets prioritized scaling and high-volume manufacturing to lower costs and compete on price.

5.3 | Unpacking pre-entry experience in the focal industry

The analysis in Table 4 reveals a positive correlation between focal industry pre-entry experience and the likelihood of entering nascent markets. However, what drives this association? Prior research suggests that employees leaving parent companies in the focal industry are at the forefront of technological and market knowledge, which helps them establish their start-ups (Agarwal et al., 2004). We now explore whether technological or market knowledge drives the relationship observed in the main analysis.

5.3.1 | Prior experience in silicon versus thin film solar technologies

We first examine whether the technological knowledge inherited by founders during their employment in the focal industry influences their entry choices. In our context, pre-entry experience in the focal industry can be acquired in firms developing thin film as well as silicon-based solar technologies. To understand whether experience with these two different technologies influenced the market entry choice of start-ups with focal industry experience, we focus on the subsample of entry choices made by founding teams with this type of pre-entry experience ($n = 46$). Considering the limited size of this subsample, Table 6 shows the distributions of these choices. Of these 46 choices, 11 involve founders with backgrounds in parent companies developing silicon-based solar, 33 are associated with founders with thin film solar expertise, and 2 involve founders with experience developing both technologies. Founders with silicon-based solar experience chose nascent markets 55% of the time, as compared to 39% of founders with thin film solar expertise. These patterns suggest that founders with silicon technology experience were more inclined to target nascent markets than those with thin film experience. We return to this interesting finding later.

TABLE 6 Market entry choices of teams with pre-entry experience in focal industry in silicon and thin film firms.

Prior experience	Nascent market	%	Established market	%
Prior experience in silicon (11)	6	55%	5	45%
Prior experience in thin film (33)	13	39%	20	61%
Prior experience in both Silicon and thin film (2)	0	0%	2	100%
Total (46)	19	41%	27	59%

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5.3.2 | Prior experience in different markets

Next, we explore the potential role of market-related knowledge gained during a founder's previous tenure in the focal industry. This knowledge can take two forms: (1) prior experience in particular application markets (e.g., rooftop versus solar fabric market) or (2) prior experience in a market at a specific development stage (established vs. nascent).

Prior literature suggests that founders who have experience in the focal industry tend to reenter familiar application markets when they become entrepreneurs (Fern et al., 2012). In the solar PV domain, this means that a founder with pre-entry experience in the solar fabric market would gravitate toward applications in solar fabric again. Our results, however, show a more nuanced picture. We analyzed the market entry decisions of founders with focal industry pre-entry experience ($n = 46$) in Panel a of Table 7. Contrary to expectations, these founders frequently ventured beyond their comfort zone. Of the 46 market choices, only 13 choices (28.3%) involved re-entry into the same application market, while 33 (71.7%) involved different application markets. For example, a founder with prior experience in rooftop market targeted a different market like solar glass instead of reentering the rooftop market again. We further examined whether founders' pre-entry experience in markets at different stages of development (established vs. nascent) influences their market entry choices. Panel b of Table 7 reveals that founders with pre-entry experience in established markets targeted established markets again 67.7% of the time, while those with experience in nascent markets favored nascent markets 60% of the time.

Taken together, the descriptive patterns presented in Table 7 suggest that founders in the solar PV industry seldom reenter the exact same application market as the ones that they have prior experience in. Instead, they tend to specialize in commercializing their technology in markets at specific stages of development and display a tendency to reenter markets with familiar development stages, market structures and demand conditions. In other words, founders with nascent market experience enter *new application markets* with the *same structural* features as

TABLE 7 Market entry choices of teams with pre-entry experience in the focal industry.

Panel a: Experience in different submarkets				
	Same market	**%**	**Different markets**	**%**
Rooftop (27)	9	33.3%	18	66.7%
Ground mounted (7)	3	42.9%	4	57.1%
BIPV (6)	1	16.7%	5	83.3%
Electronics (5)	0	0.0%	5	100.0%
Space (1)	0	0.0%	1	100.0%
Total (46)	13	28.3%	33	71.7%
Panel b: Experience in established or nascent markets				
Pre-entry experience	**Nascent market**	**%**	**Established market**	**%**
Established (31)	10	32.3%	21	67.7%
Nascent (15)	9	60.0%	6	40.0%
Total (46)	19	41.3%	27	58.7%

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TABLE 8 Market entry choices of teams based on technology and market experience in focal industry.

	Prior experience in silicon (11)		**Prior experience in thin film (33)**		**Prior experience in both silicon and thin film (2)**	
Prior experience in established markets (31)	Total # market choices	6	Total # market choices	25	Total # market choices	0
	- Established	4 (67%)	- Established	17 (68%)	- Established	0 (0%)
	- Nascent	2 (33%)	- Nascent	8 (32%)	- Nascent	0 (0%)
Prior experience in nascent markets (15)	Total # market choices	5	Total # market choices	8	Total # market choices	2
	- Established	1 (20%)	- Established	3 (38%)	- Established	2 (100%)
	- Nascent	4 (80%)	- Nascent	5 (62%)	- Nascent	0 (0%)

that of a nascent market, and founders with established market experience target *different application markets* but choose those that are already established.

We also looked at the joint role of technological and market-related experience (Table 8). We find that founders with pre-entry technological experience in silicon-based solar chose nascent markets 80% of the times when their experience was gained in nascent markets and chose established markets 67% of the time when their experience came from established markets. These findings suggest that founders' market entry choices are more strongly influenced by their prior market-related experience than by their technological expertise. The inclination of founders from the focal industry to prefer nascent or established markets is linked to their broader familiarity with other nascent or established markets in the industry. Many founders with silicon-based experience moved beyond their specific technical expertise to learn about and experiment with new technologies. To capitalize on their broader market experience within similar structural contexts, they founded start-ups focused on commercializing thin film technology.

5.3.3 | Combination of prior experience in focal and upstream industries

Our analysis of the interactions between the experiences along the industry value chain revealed that teams with different combinations of focal and upstream experience have different probabilities of choosing nascent markets. To investigate further, we examined 30 founding teams that had both types of experience. In 25 of these 30 teams, this combination of experience manifested as within-founder experience[3] where a founder either (1) first gained experience in the upstream industry before transitioning to the focal industry and then founding a start-up in our sample, or (2) gained experience in the focal industry and later transitioned to an upstream industry before founding a start-up in our sample. Taking into account the

[3]Founding team experience exhibits within-founder variety when the same founder possesses both focal industry and upstream industries experience (Honoré, 2022).

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recency of experience and the leadership roles[4] that founders assumed, we find interesting patterns—when a founder's most recent experience was in the focal industry, those who assumed CEO roles chose nascent markets 58.8% of the time, whereas founders in CTO roles did so only 22.2% of the time. Thus, CEO founders chose nascent markets more often than CTO founders when their most recent pre-entry experience was in the focal industry. In contrast, when founders' most recent experience was in an upstream industry, the likelihood of choosing nascent markets dropped to 14% of the time, regardless of whether the founder held a CEO or CTO role.

To gain a deeper understanding of why founders with focal industry experience found nascent markets more attractive, we turned to qualitative evidence from their business histories. The data suggest that these founders recognized the potential of new materials and thin film manufacturing processes to expand the use of solar to new applications which were not feasible using the older silicon technology. For example, Ubiquitous Energy, which targeted the solar glass market, highlighted how the new method developed to create solar cells could lead to wider adoption of solar:

> Barr's most recent inventive breakthrough—a pioneering approach to fabricating solar cells on a variety of everyday surfaces—could lead to widespread adoption of solar power. Barr's approach, which enables solar cells to be printed directly on common materials like paper and textiles, could reduce the cost of solar energy by eliminating the need for specialized installation. (Business Wire, 2012)

Similarly, HelioVolt, also an early entrant in the BIPV market, pointed out that their manufacturing process enabled the creation of new markets:

> HelioVolt Corp. (Austin, Texas) has developed a process based on rapid thermal annealing and anodic bonding that allows high-performance copper-indium-gallium-selinide (CIGS) films to be deposited on just about any substrate. Founder and photovoltaic pioneer Billy Stanbery claims the process can dramatically shorten manufacturing time and reduce the thermal budget by a factor of 10 to 100. The process could allow a new class of materials for building integrated photovoltaics that serve, for example, as a robust coating on external building materials or on interior furnishings like curtains, to turn buildings into self-powered photovoltaic plants (Electronic Engineering Times, 2006)

Moreover, start-ups with founders from the focal industry often referenced the limitations of silicon technology in offering new applications, as illustrated by the quote below:

> Solarmer Energy Inc. is a developer of translucent, flexible plastic solar cells, the next wave in generating renewable energy from the sun. These solar cells are opening the door for a wide range of new application areas in renewable energy, which are not currently addressable with conventional silicon solar cell technology. (Solarmer website, 2008)

[4]We thank one of the anonymous reviewers for this suggestion.

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The quotes suggest that start-ups founded by individuals with focal industry experience often targeted nascent markets due to the unique opportunities presented by thin film technologies. These founders recognized the limitations of silicon-based solar technology—such as a lack of transparency and flexibility—and identified new application possibilities enabled by thin film. When the founders had gained their experience in companies developing silicon-based solar technologies, they chose to bypass their prior expertise in silicon-based solar technologies, instead focusing on thin film solutions to address the unmet demands of nascent markets.

6 | DISCUSSION

We examined whether founders' pre-entry experience along the industry value chain systematically influences the decision of start-ups entering an industry with a novel technology to target nascent versus established markets in that industry. Our quantitative analysis reveals that pre-entry experience in the focal industry increases the likelihood of targeting nascent markets, whereas pre-entry experience in upstream industries deters entry into nascent markets. Abductive analyses leveraging both quantitative and qualitative data suggest that (a) upstream industry experience equips founders with operational knowledge and a deep understanding of manufacturing systems, which is crucial for scaling technology production to compete in established markets, and (b) founders with prior focal industry experience are more inclined to enter markets with similar *structural features* as the ones that they have experience in rather than the exact same *application markets* over time. Our qualitative data further suggest that founders with focal industry experience often identify opportunities available in nascent markets by leveraging knowledge about how novel thin-film technologies enable new uses and applications that older silicon technology cannot address.

6.1 | Literature on pre-entry experience

Extant research has begun to unpack how founders' pre-entry experience influences their strategic choices. Prior experience equips founders with valuable knowledge that is critical for successful entry and competition. This includes knowledge of effective managerial practices (Feldman et al., 2019), marketing and institutional knowledge (Chatterji, 2009), and technical and market related knowledge (Agarwal et al., 2004). Much of this research focuses on employee spinouts, start-ups originating from the *focal* industry (e.g., Agarwal et al., 2004; Chatterji, 2009; Klepper, 2009). Only recently, a complementary line of research has focused attention on the value of experience gained in *vertically linked* industries, emphasizing its role in providing a competitive advantage (Adams et al., 2016, 2019).

Building on this research, we examine how prior experience acquired across different stages of the industry value chain impacts founders' market entry strategies in the focal industry. Our study identifies novel forms of knowledge relevant for entry and successful competition in an industry where submarkets are abundant. Our empirical findings demonstrate that founders from upstream industries acquire operational experience, particularly in manufacturing systems and processes. This knowledge is essential for successfully entering established markets, where scaling production is critical for competing effectively against other technological solutions in the market. To the best of our knowledge, our study is the first to identify operational experience as a form of relevant knowledge that is useful for competing in new industries. This

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insight into manufacturing knowledge gained in upstream industries complements existing literature on employee spinouts. While these studies emphasize that experience within the focal industry endows start-ups with technical knowledge enabling them to be at the forefront of the technological frontier (Agarwal et al., 2004), we demonstrate that upstream industry experience imparts technical knowledge important for addressing operational challenges. Thus, we refine our understanding of technical knowledge inherited from prior employment and show that the nature of technical experience and knowledge differs depending on where it has been acquired along the industry value chain.

Our findings challenge the notion that founders with focal industry pre-entry experience consistently reenter the same application market (Fern et al., 2012). We show instead that these founders are more likely to enter markets with similar structural features rather than returning to the exact same application markets. Experience in the focal industry allows founders to develop second-order knowledge, allowing them to identify and address market gaps using novel technology, regardless of whether the founding team's prior focal industry experience involved the old or novel technology. This capability positions them to repeatedly target nascent markets. Thus, we extend current research by demonstrating that pre-entry experience equips founders with a broader, higher order understanding of how to operate successfully in a given type of market, which they can leverage across multiple opportunities. This finding also contrasts with current literature on expertise which suggests that experiential knowledge can lead to cognitive entrenchment (Fern et al., 2012). Instead, we find that the development of second-order knowledge about market types can potentially enhance flexibility and reduce cognitive rigidity. This allows founders to apply their knowledge across various markets of the same type, facilitating adaptability and strategic innovation.

In our study, we found no evidence that pre-entry experience in downstream industries influences the decision to enter established versus nascent markets. While we had no theoretical priors to propose directional hypotheses, we initially anticipated a potential relationship between downstream industry experience and market entry choices. Prior research on spinouts from downstream (user) industries suggests that these start-ups often focus on market-specific product categories (Adams et al., 2016) and adopt narrower product portfolios, typically selecting markets that are closely related to the user industry in which experience was gained (Shermon & Moeen, 2022). We speculate that while downstream (user) industry experience provides founders with deep insights about customer needs, complementary assets needed, and about how to embed novel technologies into products, this knowledge is highly use-specific and thus difficult to generalize.

Extant research on pre-entry experience has found a survival advantage for different types of start-ups. One set of studies demonstrates that spinouts from upstream industries outperform other start-ups (Adams et al., 2019; Malerba et al., 2020). Our study offers a potential explanation for this survival advantage: these start-ups inherit valuable knowledge of manufacturing systems and processes, which provides a competitive edge in established markets where they need to compete with other technologies. Another set of studies examining employee spinouts has also noted a survival advantage, attributing it to superior technical and marketing capabilities (Agarwal et al., 2004; Chatterji, 2009; Klepper, 2009). Our findings extend this line of research by identifying an additional source of survival advantage attributable to market entry choices. Specifically, these start-ups originating from the focal industry are more likely to enter nascent markets, where they can benefit from more time to refine their technology, less intense competition from other technologies, and experience reduced pressure to scale their novel

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solutions to meet high performance benchmarks. These factors collectively enhance their ability to establish a foothold and thrive in the industry.

6.2 | Literature on industry evolution

We also extend existing research that links firm entry to industry sales takeoff (Agarwal & Bayus, 2002; Golder & Tellis, 1997) and that highlights the importance of pre-entry capabilities in shaping industry evolution (Helfat & Lieberman, 2002; Moeen & Agarwal, 2017). Prior studies have shown that firm entry contributes to sales takeoff through both supply-side effects—by increasing industry-wide capacity and lowering prices (Golder & Tellis, 1997)—and demand-side effects, such as product improvement and development of sales channels (Agarwal & Bayus, 2002). We provide evidence that adds nuance to the link between firm entry and sales takeoff by demonstrating how the heterogeneity of entrants' pre-entry capabilities and strategic choices significantly influence supply and demand dynamics.

For example, entry by firms from upstream industries is likely to primarily affect the supply-side by focusing on scaling manufacturing in established markets, thereby expanding capacity and reducing prices. Conversely, start-ups originating from the focal industry are more likely to stimulate the demand side by introducing new product variants that attract new types of users. Product variety is particularly influential in shifting the demand curve in new industries (Agarwal & Bayus, 2002; Moeen et al., 2020). Thus, robust firm entry alone may not suffice and a successful sales takeoff is more likely when founders with diverse pre-entry experiences enter the industry, bringing a wide range of capabilities and positively affecting both supply and demand mechanisms. This suggests that the relationship between firm entry and sales takeoff is more complex than previously understood.

Moreover, the staggered emergence and the different paces of submarket development can prolong an industry's nascency phase. As some markets mature, the emergence of other markets reintroduces uncertainty extending the nascency period of the entire industry. This can result in multiple growth spurts rather than the smooth, linear progressions that have been well documented across different industries (Agarwal & Bayus, 2002; Golder & Tellis, 1997; Gort & Klepper, 1982). Industries may experience several rounds of firm and sales takeoffs with each new submarket emergence, collectively shaping the industry's overall growth trajectory. These dynamics also offer a complementary explanation for the "mini shakeout" observed in many industries (Agarwal et al., 2014).

Finally, current work on segmented industries has primarily focused on how the presence of submarkets shapes industry structure and exit patterns (Bhaskarabhatla, 2016; Bhaskarabhatla & Klepper, 2014; De Figueiredo & Silverman, 2007; Uzunca, 2018; Uzunca & Cassiman, 2023). However, less attention has been paid to how these dynamics shape firm strategy. For instance, a firm's initial submarket choice has been shown to critically impact its survival and longevity in industries as diverse as the British automotive industry (Rong et al., 2018), the Digital Audio Player industry (Camerani et al., 2020) and the German farm tractor industry (Buenstorf et al., 2022). We extend work on segmented industries by demonstrating that submarket dynamics not only influence survival patterns, but also shape entry strategies of firms. Our results reveal that initial positioning in a submarket is not random; rather it can be a strategic choice reflecting an alignment between submarket characteristics and entrants' prior value chain experience.

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6.3 | Limitations and generalizability

This work is not without limitations. While we examine entry choices by ventures within a single industry, future work could explore whether these findings generalize beyond this context to other industries with similar dynamics. The solar PV industry is characterized by the emergence of new technologies that facilitate creation of new markets, which then co-exist over time. The insights from this study may be relevant to other industries where multiple markets emerge and evolve concurrently. For example, in the laser industry, technological advancements led to new applications that attracted distinct customer bases (Bhaskarabhatla, 2016; Bhaskarabhatla & Klepper, 2014). Similarly, in the disk-drive industry, emergence of new technologies enabled new features and improved existing markets, bringing new customers to the industry (King & Tucci, 2002). Finally, in the farm tractor industry, the introduction of standardized power takeoff in the late 1920s facilitated the creation of "additive" submarkets that attracted new users to the industry (Buenstorf et al., 2022).

The solar PV industry is fundamentally manufacturing-intensive, where success depends on a deep understanding of manufacturing systems and processes. This expertise is crucial not only for scaling technology rapidly in established markets but also for developing new products in emerging ones. Therefore, the associations we found between pre-entry experience and market entry choices may not fully apply to non-manufacturing industries. For example, in digitally enabled industries, competing successfully might require different capabilities such that the more valuable pre-entry experience may come from having worked downstream in the value chain or in horizontally linked (rather than vertically linked) industries. Thus, in such industries, the relationship between upstream prior experience, manufacturing expertise, and entry into established markets may not hold, as the scaling processes for digital products differ fundamentally from those in manufactured products.

Additionally, the relationships and the underlying mechanisms identified in this study may be specific to markets that emerge when new technologies enable new applications. In industries where the same technology enables new markets over time, the relative importance of upstream and focal pre-entry experience might manifest differently. For example, in the drone industry (Shermon & Moeen, 2022), new applications like drones for entertainment and air taxis are emerging, thus creating a dynamic where different markets arise at different times to serve several different industries. However, these new markets were driven by user engagement in the innovation process rather than by introducing a novel drone technology. As the drone technology is available off the shelf, the founding team capabilities required to enter and succeed in established and nascent markets in the drone industry may differ significantly from those needed in the solar PV industry.

We propose several avenues for future research. First, we employed a question-driven approach to explore factors explaining observed patterns related to entry in the solar PV industry. These findings should not be interpreted as evidence of causality. There is an opportunity for future research to establish causal evidence for the correlations we observed. Second, while pre-entry experience shapes both cognition and knowledge, which then affect founding team decisions, our measures of experience do not allow us to clearly disentangle cognition from knowledge. Future studies can attempt to tease out whether cognition or knowledge differentially shape entrepreneurial strategies. Third, while this study focused on pre-entry experience as a driver of firm entry strategy, future research can consider the performance implications of these market entry choices and consider the role that regulation plays in shaping such decisions. Finally, our dataset does not include start-ups that worked on thin film technologies but

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did not eventually enter a market. Therefore, our sample and analyses are conditional upon actual market entry. Future research can investigate whether the patterns we identified hold when also considering the intention to enter a market.

Overall, this study highlights that in segmented industries with multiple technologies, different submarkets may emerge at different times and mature at different rates. The variety in development stages of the markets adds complexity to entry decisions in these industries. We provide evidence that pre-entry experience along the value chain is a critical, yet understudied, factor affecting start-ups' decision to enter nascent or established markets, thereby affecting supply-side and demand-side dynamics in nascent industries. Thus, heterogeneity in pre-entry experience along the value chain plays a pivotal role not only in shaping entry strategies but also in driving emergence of segmented industries.

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