

Chapter 1: Technology Commercialization & Motivations for Starting a Business

Clarisse Alpaert

Prof. Dr. Bart Clarysse

Chapter 1: Technology Commercialization & Motivations for Starting a Business

1. Starting a New Business

1.1 Introduction

1.1.1 Types of Motivations when Starting a Business

When starting a business, individuals are typically driven by a particular motivation. We can distinguish three types of motivations; the first one regarding the exploration of a new technology (Agarwal, Moeen & Shah, 2017). For instance, scientists have discovered a technological or scientific breakthrough and want to explore this technology and its possibilities. A main focus lies on the further development of the technology with the ultimate goal of transforming the novel discovery into a commercialized product. During a later stage of a certain technology's evolution timeline, when the technology is more advanced, firms also tend to emerge driven by fascination for the technology and an eagerness to search for particular ways to commercialize the already evolved technology in a certain market space.

A second motivation for starting a new business stems from a feeling of frustration that users experience when a certain buying option is insufficient or even worse, non-existent. These users discover a so-called "hole in the market", eager to explore potential solutions to the detected unmet user need.

Lastly, companies pop up driven by the mission to do good and/or change the world as we know it. These mission-oriented individuals, motivated to (partly) address a grand challenge, such as reducing water usage or CO₂ emissions, start their own business in order to make a difference in the world.

Frequently, people are driven by more than one motivation. When setting up an own business, overlap of motivations occur. For instance, the internet was triggered by a mission-oriented grand challenge (DARPA funded and coordinated scientists and firms in order to develop packet switching data network) as well as based on discoveries shifting the scientific frontier. The internet can thus be considered a hybrid of a technological discovery and a mission-oriented motivation.

1.1.2. The Inception Stage of a Business

Disregarding the motivation(s) at the foundation of a new business, all firms have to mobilize resources and people, engaging a heterogeneous pool of individuals such as university and industry scientists, entrepreneurs as well as established and diversified firms, user communities and government agencies (Agarwal, Moeen & Shah, 2017). We call them "actors". They come from various backgrounds and draw from numerous different knowledge bases. During the inception phase, these actors participate in a wide variety of actions. Engagements hold, for instance; the development of functioning prototypes, product improvement, sharing of knowledge through formal as well as informal interaction, engaging with potential adopters and stakeholders, among many other technology-focused obligations.

Actors participate in these efforts in order to solve certain technological problems. To transform an idea into a viable commercial product, they aim to eliminate certain uncertainties firms generally face throughout the inception stage. Two types of uncertainty are primarily at play throughout this period: technological and demand uncertainty (Agarwal & Bayus, 2004). Especially for businesses triggered by a recent technological or scientific discovery, there tends to be a large gap between the technological knowledge that is required to design a product towards commercialization, and the amount of technological knowledge the firm and its actors already possess. This gap results in a type of uncertainty we label "technological uncertainty". Throughout the inception stage, some firms also tend to struggle with doubts regarding which market space to focus on, whether or not there will be an actual demand, and if so, what the willingness-to-pay will be for the envisioned technology, product or service. This is what we label "demand uncertainty".

Even though the initial motivation, the level of the respective uncertainties, and the pool of actors may vary across different firms throughout the inception stage, every firm focuses to a certain extent on reducing uncertainty towards shaping the firm strategy for subsequent commercialization phases.

1.2. Deep-dive Into the Three Types of Motivations

1.2.1. Scientific and/or Technological Discovery

A first type of motivation for individuals to found a new company stems from a scientific discovery. Firms based on a new scientific discovery are considered pioneers. Pioneering firms often emerge in a university setting or corporate research unit, and privileges academics and industry scientists as actors. A group of scientists discover something fascinating in the lab and are motivated to start a company in order to transform their scientific discovery into a commercialized product or service. The main focus for these firms revolves around the further advancement of the technology (Agarwal & Moeen, 2017).

Alternatively, firms also emerge when a certain technology is already advanced to a further stage of maturity. These firms are generally incentivized by a strong interest to pursue the technology in a certain market space, often created through the combined forces of academics, entrepreneurs, scientists and whoever familiar with the technology. These firms tend to focus less on pure technology improvement and more on establishing particular ways of commercializing the - by then often seen as "ready-to-launch" - technology.

Disregarding the stage that the technology is in, the underlying motivation for these actors to start a business is generally the quest for science, the fascination for a certain scientific field and the curiosity in what the technology can potentially establish (Agarwal & Moeen, 2017). It is crucial for them to perform internal research experimentation as well as setting up collaboration between universities, spin-offs, external scientists and external stakeholders. Based on the extensive formal and informal collaborations, actors are able to gather a great variety of knowledge, build prototypes, explore practical applications and sometimes even advance complementary domains. These activities target the decrease

of the level of technological uncertainty. Additionally, actors also engage in actions such as shaping customers' perceptions, securing lead users, and securing sales contracts in order to reduce the level of demand uncertainty.

1.2.2. Unmet User Need

A second motivation incentivizing the start of a business focuses on users that are determined to design a potential solution for a need that has not yet been, fully or efficiently, addressed (Agarwal & Moeen, 2017). Actors at play commonly start by setting up the design of a first "prototype". This prototype is solely for own use, in order to optimize the solution. After several iterations, prototypes are shared with others within their close environment, such as family, colleagues and friends.

While prototyping, it is crucial for the actors to exchange thoughts and information within the user community. Several feedback rounds and successive prototype versions allow them to tackle the technological uncertainty as well as demand uncertainty, eventually obtaining a prototype that meets the need of the general user. Even though demand uncertainty for these firms seems less severe as for a company that aims to commercialize a recent scientific discovery, demand for the designed solution is never certain. Throughout the inception stage, it often remains unclear to what extent a set of potential consumers face a similar need and are willing to adopt the product or service.

Let us introduce a real-life example featuring Josephine Cochrane, a woman who was tired of washing her china by hand in the 1870s and decided to design a machine that cleans dirty dishes. Throughout the first years, Josephine used her design of a dishwashing machine mainly privately while also exposing it occasionally within the neighborhood. Doing this, she identified an unmet user need that would later underlie the emergence of the dishwashing machine industry. Josephine hired a mechanic named George Butters and collaborated with him towards setting up the design of a first dishwashing machine, solely using available mechanical technologies. After several iterations, they managed to construct an operational prototype. While the need for dishwashers as a replacement for handwashing is fairly straight-forward, housewives were initially not interested. In order to gain interest within a broader community, Josephine had to visit potential customers such as hotels and restaurants and provide direct product experience for potential users. This way she sparked the interest of a broad audience and her initial design (upgraded to current standards) is, till today, indispensable in countless households.

1.2.3. Grand Challenges

Lastly, we will discuss firms that emerge constructed around the mission to make the world a better place. These firms are based on a motivation that responds to national security, public health or social issues. The actors are determined to make a positive contribution to the world by providing a solution to (part of) a grand challenge (Agarwal & Moeen, 2017). The mission-oriented actors tend to be from many various backgrounds, diverse communities and organizations. They undertake actions in order to

achieve a solution with a real social, environmental and/or global impact. This typically involves extensive partnerships between private sector and public sector actors, scientists and firms as key actors and government agencies and foundations as coordinators. As to achieve their mission, actors try to reduce technological uncertainty by doing research within firms, collaborate with universities and the industry as a whole. One would assume this type of initiatives would be received effortlessly by the grand public as their very existence is meant to have a positive and significant impact on the world. However, the assessment and actualization of potential commercial value is a tough undertaking. It is fundamental for these firms to enter into procurement and purchasing agreements or the convincing of the actors of the merits of the technology through information provision. Firms engage in these types of efforts in order to decrease the demand uncertainty throughout the inception stage (Agarwal & Moeen, 2017).

A Real-Life Example of a Grand-Challenge Oriented Startup

Let's dive into an example featuring the engineers Christoph Gebald and Jan Wurzbacher. It's 2007. They are both in their master studies at the Professorship of Renewable Energy Carriers at ETH Zürich. The day they meet at university in 2003, they decide to start a company together. Flashforward to 2007, Jan and Christoph are doing research on direct air capture. By 2009, the first system concepts and working prototypes were developed in the laboratories of ETH Zürich, after which they founded Climeworks.

Climeworks was founded in order to address climate change. Climate change commonly refers to the rapid increase in global surface temperatures and its projected continuation. Human activities, such as burning fossil fuels, release carbon dioxide into the air. This causes global warming which, if left uncontrolled, poses an unprecedented threat to the ecosystems on this planet and to human civilization as a whole. The 2016 Paris Agreement aims to keep the increase in the global average temperature to “well below” 2 °C. This would significantly reduce the risks and impacts of climate change on the planet. Although significant strides have been made in renewable energy and energy efficiency, these are not enough to meet the critical 2 °C target. Additional CO₂ removal from the atmosphere will be required. Climate change mitigation therefore urgently needs carbon removal technologies.

Driven by the urgency of climate change reaction, Climeworks developed a commercial carbon removal technology, allowing to physically remove any organization's or individual's past, present and future CO₂ emissions. In 2004, their website stated the following mission: "It is our goal to commercialize a patent pending, highly efficient technology for CO₂ capture from ambient air, which has been developed at the Professorship of Renewable Energy Carriers at ETH Zurich. With this technology we will provide our customers with a competitive and environmentally friendly solution for their CO₂ supply." *website Climeworks*

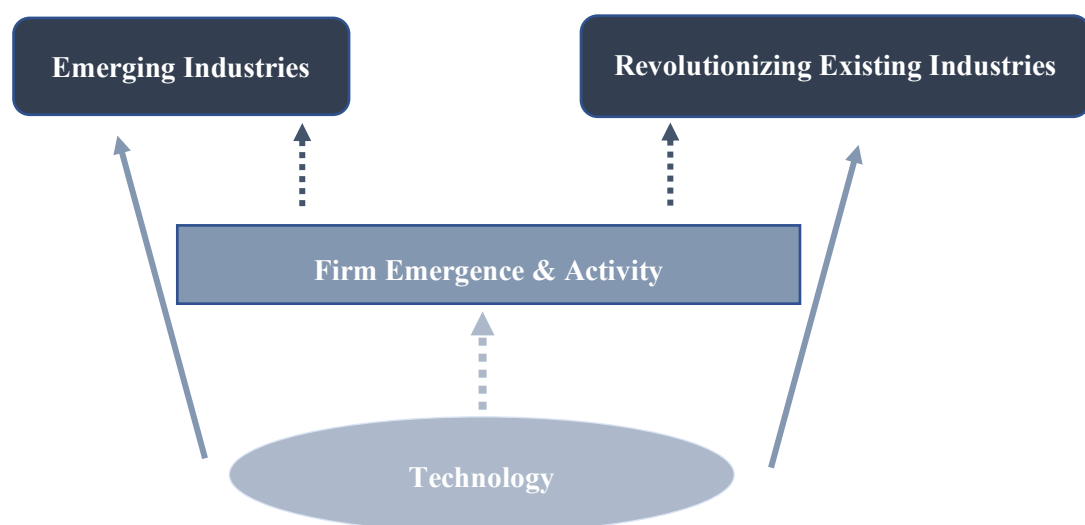
During the past decade, they communicated frequently in the public press that "they could rise to one of the human race's biggest challenges: the two PhD students from ETH Zurich Christoph Gebald and Jan Wurzbacher filter CO₂ out of the air, and in a way that is completely environmentally friendly and emission-free at that. The interview also mentions that "with their development, the ETH-Zurich researchers are "killing two birds with one stone": the climate problem and the threat of an oil shortage. That sounds very much like saving the planet..." *ETH Life, published 18.06.10* In another interview, they say: "CO₂ is poison for the climate ... Part of the solution could be a Swiss invention: the "CO₂-Sauger" from the Zurich company Climeworks. It filters the air and converts greenhouse gasses into fertilizer or carbon dioxide and enables the production of synthetic fuel with green electricity." *Blick, Publiziert: 15.04.2014 + NY Times, Published 12.02.19*

Climeworks is a clear example of a mission-driven startup. Throughout the 10 years of Climeworks being active, they have raised over 50 million CHF by grants and several funding rounds, and recently received support from incumbents such as Coca Cola and Audi, 2 companies eager to jump on the bandwagon of CO₂ capturing. Up until today, it is still trying to achieve their main goal of net benefit CO₂ capturing. This example shows how much time and resources are required in order to get commercialization to fruition for challenge-driven startups.

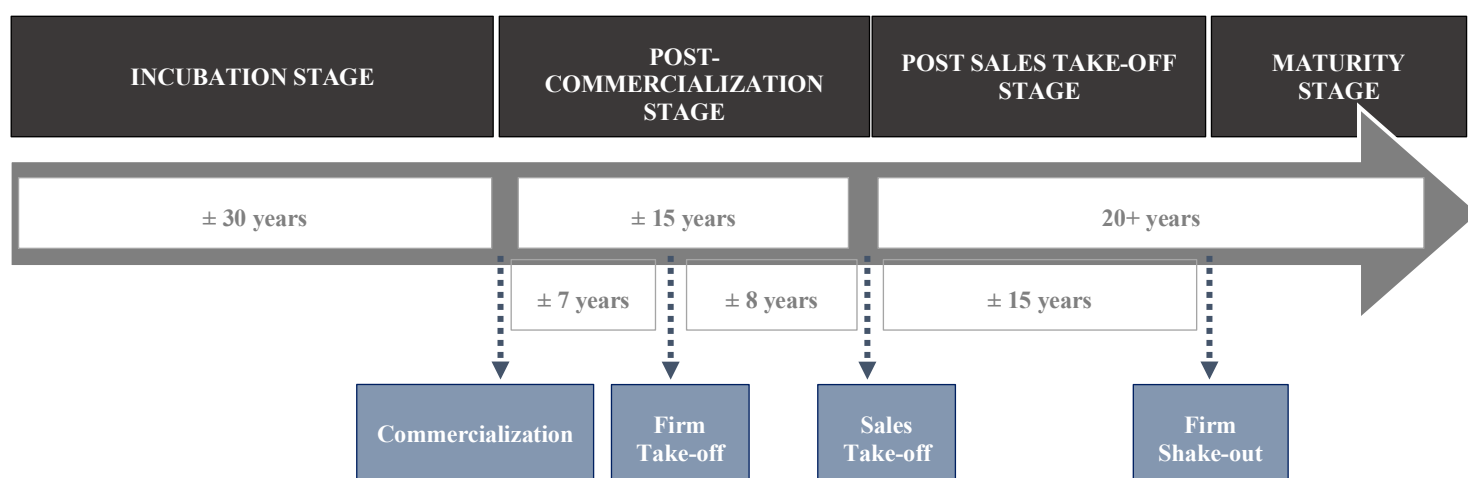
2. Context of Technology Evolution

2.1. In Brief

Throughout the past decades, new technology streams emerge at an increasingly rapid pace. Numerous visionaries such as entrepreneurs, scientists, managers, and academics combine their efforts, starting pioneering companies and undertaking actions in order to advance these new technologies. Through firm emergence and activity, technology streams lead to the emergence of numerous industries and revolution within existing industries.



The evolution of nascent technologies can be demonstrated on a timeline, advancing through three subsequent stages. The duration of these three phases are an indication rather than a fixed number of years. The first stage, the "incubation stage", throughout which a technology emerges and evolves from scientific discovery towards commercialization, has been shown to last for about 30 years on average (Agarwal & Bayus, 2004). After the first (fruitful) commercialization, a subsequent stage takes off. Commercialization often co-occurs with firm take-off within one or several industries. Duration-wise, this period tends to be shorter than the incubation stage, generally lasting 8 to 10 years, culminating in a sales take-off. In the last stage, industries mature, taking on average 15 years for firm shake-out to take place while the industry's growth stabilizes (Agarwal & Bayus, 2004, Moeen, 2017).



These three stages of technology evolution are very different in nature and have implications on what best to focus on when starting a new business throughout any of the three stages. They have different levels of technology and demand uncertainty. Firms entering early on, throughout the incubation stage of a technology, face a high degree of risk and uncertainty as the potential future rewards are unsure. At this early stage, they are often confronted with an inability to clearly determine the market potential. The technological potential also rests unclear. The risk of lock-in emerges, which happens when a firm focuses solely on one application based on their new technology. When this application ends up being infeasible or unscalable, they are "locked in", having difficulties to move away from this market space and explore other applications based on the technology (Moeen & Agarwal, 2017). On the positive side, early entrants have the ability to shape and mold the early definition of the technology and product innovation and match their capabilities and core competencies towards where the technology is leading. This can give them a competitive advantage over later entrants.

Below we will discuss three subsequent stages of technology evolution. When starting a business using a certain technology, the stage the technology is in will have implications on the approach to adopt in order to maximize the chance of survival and success. Additionally, there also exist differences

depending on type of industry, the initial motivation which triggered the entry of the firm as well as the individual case specifics (Agarwal et al, 2002, Moeen, 2017, Moeen & Agarwal, 2017).

2.2. Technology Stages

2.2.1. Stage 1 - Technology Incubation Stage

The incubation stage covers the period between the initial discovery and commercialization. This period has a duration of 30 years on average (Agarwal & Bayus, 2002, Agarwal & Bayus, 2004, Golder, Shachram & Mitra, 2009).

Throughout the incubation phase, technologies are at a primitive level. As aforementioned, the uncertainty concerning what the technology can do and what it will evolve into is high. Entrants have to do efforts aiming at reducing both technological and demand uncertainty. They need to gain legitimacy and prove the feasibility of the technology by focusing on technological advancement and product improvement (Agarwal & Bayus, 2002, Agarwal & Bayus, 2004). Doing this, it is crucial to build up knowledge and skills by implementing variation in backgrounds and experience within the team/across firms. This will determine the growth opportunity of the various industries building on this technology.

Besides overcoming technological hurdles, it has also proven important (but often extremely difficult) for early entrants to assess the actual potential and the willingness-to-pay within the market. Firms undertake managerial activities in an attempt to determine which market spaces and applications to explore, which collaborations to set up, and which strategies to implement (Agarwal & Bayus, 2004). They do this by collaborating within the firm as well as with external partners/stakeholders.

Firm's Accepting vs. Avoiding Mindsets towards Market Ambiguity

There exists a high level of market ambiguity throughout the incubation stage of a technology. While doing efforts to overcoming several hurdles, firms will take on a certain mindset towards this ambiguity, ranging from accepting (the firm tries to gradually resolve the ambiguity) to avoiding (the firm tries to quickly get rid of market ambiguity) (Molner, Prabhu & Yadav, 2019).

When a firm has an avoiding mindset, they try to get rid of the uncertainty as quickly as possible. This often goes hand in hand with pro-actively convincing specific market segments. They try to find applications based on their technology within that market space and try to get a collaboration going. When one segment does not work out, they rapidly go to the next market space and spend time and resources on convincing them (Andries, Clarysse, Costa, 2020). When a firm has an accepting mindset, they tend to expose and broadcast their technology to potential customers in a variety of market segment. They take their time and often wait to be approached. They follow up by entering into collaborations with interested parties within certain market spaces. Together, they dive into how their technology could be of use for that particular interested market segment. By also validating interest

with similar players in that market space, they strive to ensure feasibility in that certain market space (Molner, Prabhu, Yadav, 2019, Andries, Clarysse, Costa, 2020).

When a firm has an avoiding mindset and pro-actively tries out market spaces, they often end up not having enough resources to develop prototypes and accurately determine the potential of their technology within every single market space. Implementing an accepting mindset that only invests into the interested parties rather than pro-actively convinces, firms overcome these cognitive constraints; by letting partners come to you, you acquire the required knowledge in order to validate the opportunities within that market space. By doing this, firms with an accepting mindset will also overcome resource constraints; they do not waste money and time on developing and investing within many several market spaces that are not yet interested nor convinced about the potential of the technology (Molner, Prabhu, Yadav, 2019, Andries, Clarysse, Costa, 2020).

The mindset a firm holds will shape decisions and outcomes concerning the application(s) and market space(s) identified and explored. Generally, it is favorable to apply a mindset which embraces ambiguity. This proved to result in favorable outcomes such as a higher value creation and appropriation, more commercialization opportunities and faster initial investment.

Competition & Survival for Entrants throughout the Technology Incubation Stage

Generally, less than 15% of the total amount of firms entering throughout all 3 phases, enter within this first stage of a technology, before commercialization. About 70% of the firms entering at this early stage of the technology evolution survive throughout all subsequent phases (Agarwal and Bayus, 2002, Agarwal and Bayus, 2004).

For firms entering throughout the incubation stage to be competitive in the future, the technology innovation needs to be at the top of the economic technology frontier. This is a first "requirement" for long-term firm survival and success. Firms thus spend a lot of effort on advancement of the technology as a whole without putting much effort into the commercialization of the technology. During this stage, there thus will be little to compete for. Firms co-create rather than compete, a process which is called parallel play (MacDonald & Eisenhardt, 2019).

Even though the competitive spirit during the incubation stage is rather low, the number of firms in the incubation stage does have an impact on the chances of survival; firm density throughout the incubation stage has a negative relationship with survival. This indicates that firms entering throughout the incubation stage have a higher chance of survival when less players are in the nascent market (Agarwal and Bayus, 2002, Agarwal and Bayus, 2004).

2.2.2. Stage 2 - Post-Commercialization/Firm Take-Off

The second stage in a certain technology's evolution covers the period between the first fruitful commercialization (and often firm take-off) and the sales take-off. This period has a duration of 6 to 8

years on average. Relative to the incubation stage, technologies are typically at a further advanced level. The main focus shifts from a rather narrow focus on technological advancement towards a focus on application innovation. This shift holds a certain amount of agency: firms entering at this stage of a certain technology generally benefit when centering their focus on one market space and one or a limited amount of applications. Most entrants throughout this stage aim to prove that the technology is feasible in this certain market space (Agarwal and Bayus, 2002, Agarwal and Bayus, 2004).

Competition & Survival for Enters throughout the Technology Incubation Stage

About one third of all firm entry takes place during this stage, with a slightly lower survival rate compared to the incubation stage, respectively 65% compared to 70%. Two firm-specific factors have a particular influence on firm survival/success throughout the second stage (Bayus & Agarwal, 2002). Both firm age and firm size positively relate with firm success/survival. This implies that the larger, older, and more established the firm is when entering the market, the higher the chance on survival and success. This can be motivated by the overall mindset entrants hold during this stage; anticipating a real market opportunity - contrary to the lack of a certain/defined market opportunity in the incubation stage.

This anticipated market opportunity enables entrants to target a certain positioning which can lead to market(ing) advantages. In line with the former, it is crucial for entrants to expand the customer base, to gain consumer acceptance, set up a supply chain infrastructure among other initiatives. This facilitates the growth opportunity of the firm as well as the industry as a whole.

2.2.3. Stage 3 - Post-Sales Take-Off

The last stage we discuss is often initiated with the take-off of sales. A successful entry into the market is never guaranteed, but when entering this stage, it is suggested to focus on business model innovation. At this point on the technology timeline, the (perceived) quality of the technology is at a mature level. There is a high level of distribution awareness and consumers start selling the product en masse. The higher the amount of firm entry throughout the previous stage, the quicker the sales take-off takes place. After the so-called sales take-off, over half of the companies still have to enter, about 55% of the total entrants. Survival rates are the lowest during this stage, at about 60% (Agarwal and Bayus, 2004).

As mentioned, business model innovation of great importance when entering throughout this stage. On a firm-level, experience prior to entry, age and moment of entry within cohort proved to be determining factors when it comes to survival (Agarwal and Bayus, 2004, Moeen & Agarwal, 2017). Both prior experience and age are positively related with firm survival, indicating that older firms with knowledge and expertise in similar industries are more likely to survive when entering throughout this stage. Additionally, the moment of entry within the cohort is negatively related to survival, indicating the advantage of entering later rather than soon after the sales take-off - by finding a niche when the market has matured. After the improvements of the technology over the past 2 stages, entrants benefit most from focusing on process improvements, which often have a price decrease as result. On average, 15

years after take-off a firm shake-out takes place as the industry has matured. Several advantages concerning entering after sales take-off are the minimization of R&D costs (level of technological uncertainty is low) and the rather high level of market certainty. The customer value proposition has been established; technological and demand uncertainty thus have been minimized to a certain substantial extent.

3. References

- Agarwal, R., and Bayus, B. L. 2004. 'Creating and Surviving in New Industries'. *Advances in Strategic Management*, 21
- Agarwal, R., Moeen, M., and Shah, S. K. 2017. 'Athena's birth: Triggers, actors, and actions preceding industry inception'. *Strategic Entrepreneurship Journal*, 11(3), 287-305
- Agarwal, R., and Bayus, B. L. 2002. 'The market evolution and sales takeoff of product innovations'. *Management Science*, 48(8), 1024-1041
- Andries, P., Clarysse, B., Costa, S. 2020. 'How do technology-ventures search for markets? Insights on designated market search and technology broadcasting'. *ETH working paper*.
- Golder, P.N., Shacham, R., & Mitra, D. 2009. 'Innovations' origins: When, by whom, and how are radical innovations developed?'. *Marketing Science*, 28(1), 166–179.
- Moeen, M. 2017. 'Entry into nascent industries: disentangling a firm's capability portfolio at the time of investment versus market entry'. *Strategic Management Journal*, 38(10), 1986-2004
- Molner, S., Prabhu, J. C. and Yadav, M. S. 2019. 'Lost in a Universe of Markets: Toward a Theory of Market Scoping for Early-Stage Technologies'. *Journal of Marketing*, 83(2), 37-61