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Dynamic managerial capabilities and entrant survival: What we have learned from the solar photovoltaic industry life cycle

Abstract

This study identifies the dynamic management capabilities which command firms' survival in their entries into both new and uncertain industries at the maturity stage of an industry lifecycle. Through quantitative data analysis, we reveal that the effect of these capabilities is asymmetrical: whilst dynamic management capabilities (reflected by prior industry experience of executive management) do not assist in entry during the evolution stage, more so, the length of prior industry experience available to entrants at a time of entry correlates to post-entry mortality rates, these capabilities are important to succeed in market entry during the maturity stage of an ILC. Our analysis comprises data from the energy sector during the evolution and maturity stages of solar photovoltaic industry. The empirical setting of the energy sector over the last three decades provides a fresh an ideal domain in which to test the success of entry timing decisions at various stage of an industry lifecycle in uncertain industry. Our results overwhelmingly support our central thesis regarding the specific impact of dynamic management capabilities on post-entry survival. We test and find a partial support for our hypotheses by analyzing the acquisitions and joint ventures of 149 energy firms in years between 1997 and 2016. These findings have important implications for the literature on entry timing and dynamic management capabilities.

Keywords: industry life cycle, [environmental] uncertainty, entry, dynamic management capabilities, survival

1 Introduction

Oil and gas companies (e.g., Royal Dutch/Shell), as part of their strategic renewal, have invested in renewable energy sector through acquisition of renewable energy technologies, such as solar photovoltaic (PV), comprising an entry to the new and uncertain industry for these companies (Wu & Mathews, 2012). Notably, at the evolution phase of the solar PV industry lifecycle (ILC), many traditional energy companies failed in their entry attempts because they selected and invested in the wrong technology; one which never became a dominant technology (Agarwal & Tripsas, 2011; Argyres, 2015; Furr, 2018). Yet, they successfully re-entered the solar PV industry during its maturity phase. Accordingly, this phenomenon has triggered important questions: under the conditions of emerging and uncertain industry[1], why did some firms succeed in their entry during the maturity stage, but failed in earlier entry attempts during the industry evolution phase? An answer to this inquiry aids to strategic entry-timing decision-making, enabling companies to succeed in their repositioning strategies leading them to enter a new and an uncertain industry.

To address this question, the study utilizes quantitative market data which was culled from carefully selected statistics generated by the energy sector over the last three decades. One must note that this is a sector which is moving through unprecedented transformation—from a mature sector that relied on energy derived predominantly from fossil fuels, to an industry characterized by fast-paced technological changes, changes which are driven by new entrants into the sector who are creating renewable energy technologies that are disrupting the existing energy sector. In addition, it is an industry which is characterized by the tendency of these fossil fuel giants to subsequently acquire these recent, renewable energy, technologies (Pinkse & Buuseb, 2012). Therefore, this empirical setting provides an ideal domain to test an entry-timing advantage in relation to the various stages of ILC, when applied under the condition of uncertain environments.

There is significant potential in establishing closer links between entry timing and ILC theories (Fosfuri, Lanzolla, & Suarez, 2013). A substantial volume of academic literature argues that order of entry advantage is dictated by entrants' capabilities (Teece et al., 1997). Yet, distinct capabilities are needed to succeed at different stages of ILC (Lee, 2009; Robinson et al., 1992). These theories are important to understanding the contrasting capabilities which entrants require to prosper at different stages of ILC (Fosfuri, Lanzolla, & Suarez, 2013; Moeen, Agarwal, Shah, 2020; Agarwal, R.,

1 For the purposes of this study, following Miller (1992), 'environmental uncertainty' is defined as 'the unpredictability of environmental contingencies caused by new technologies.' Thus, when using *'an uncertain industry'* we refer to *'a fast-paced technological industry.'*

Braguinsky S., Shah S., Wormald A,, 2019), calling for more research to explore how ILC effects may influence failure patterns as they interact with various causal factors.

The rather insignificant quantity of academic research on this subject regrettably prevents theoretical generalizability regarding the complimentary fit between ILC and the capabilities needed to accompany successful entries generally, and into a fast-paced technological industry in particular, an uncertain industry such as renewable energy industry, at maturity stage of ILC. The commencement of industry's maturity, followed after the access of an industry's dominant design shifts the attention of competition toward production processes, commercialisation and economies of scale over radical product innovation capabilities necessary at the evolution stage of ILC (Gort and Klepper, 1982; Markard, 2020). Capabilities to successfully commercialize technology are important to achieve favourable performance outcomes and are inevitable for survival at large (Cooper, 2000) once the dominant design is established, thus is at the maturity stage of ILC. The new technology, dominant design, generally and especially in fast paced technological industries must be rapidly commercialised to expand a customer base, to come in on a large scale and to accept a cost advantageous economy of scale; which should be executed faster than competitor, i.e. a substitute technology, enters the market. By acting speedily entrants are able to introduce a dominant technology to the market (Stevens, Burley, and Divine, 1999) faster than a substitute technology enters a market (Adner & Kapoor, 2016) by attacking its competitors, reducing costs, absorbing new dominant technologies and expediting learning from customers (Eisenhardt, 1990; Iansiti, 1995).

The knowledge derived from internal and external firm specific competences attained from human resources and capabilities (Teece, 1986; Teece, 1997) dictates technology commercialisation (TC) speed - success (Zahra, et al, 2002). Thus, following dynamic management capability approach (Helfat & Martin, 2014) we argue that entrants who have an access to, thus may exploit, internal and external firm specific competences attained from human assets enabling commercialisation, nourishment and economies of scale of the dominant technology, capabilities which are difficult to imitate and are acquired with firms age will benefit during entry at the stage of ILC where TC plays a weighty importance to succeed.

Industry evolution scholars compare entrants in an industry based on their pre-entry experience (Bayus & Agarwal, 2007; Carroll et al., 1996; Klepper & Simons, 2000) and some firms experience a mismatch between their pre-entry experience, existing capabilities, and the required capabilities to succeed at certain phase of ILC. For example, strong dynamic management capabilities adversely affect the post-entry success at the evolution stage of ILC, because they negatively correlate with R&D - due to increased rigidity in managerial cognition, mental models (Dane, 2010) being a result of a long personnel's prior experience in specific functions and industry – an essential task to innovate a new dominant design at the evolution phase of ILC, a stage at which entrants with related technical capabilities (Moeen, 2017) would have much higher chance to succeed. Thus, firms who understand their capabilities and benefits they bring to them during entry at different stages of ILC can not only avoid a post entry mortality but foster their financial returns by capitalizing on their unique capabilities. Unfortunately, scholarly enquiry into strategic decision-making within the context of entry-timing advantages during the maturity phase of ILC in general, and particularly with reference to fast-paced technological industries, is exiguous. This is a significant gap; in the past few decades, scholars reviewed the order of entry (Lieberman & Montgomery, 1988, 2013; Garcia-Sanchez, Mesquita, & Vassolo, 2013), entry timing in relation to industry competitive structure (Klingebiel & Joseph, 2017; Cawley, 2019), entry timing in relation to functional product evolution (Querbes, & Frenken, 2016); entry advantages during the industry incubation and evolution life cycle phases (Uzunca, 2018; Furr, 2018); and the relationship between entry-timing and firms' capabilities (Lee, 2009; Robinson, Fornell, & Sullivan, 1992). Although different stages of ILC demand individual sets of capabilities (Lee, 2009), academic literature on capability precedents of a firm's entry in connection to ILC theory previously focused predominantly on the evolution phase of ILC (Moeen, Agarwal, Shah, 2020 ; Moeen & Agarwal, 2016). Researchers have not yet identified what capabilities entrants must possess at the time of entry to succeed in entry during the maturity phase of ILC (Markard, 2020). Although, there is unity in opinion that entrants are distinguished by their pre-entry capabilities (Bayus & Agarwal, 2007; Carroll et al., 1996; Klepper & Simons, 2000), which predetermine a post-entry survival – what exactly pre-entry capabilities are needed to succeed in entry to maturity stage of ILC remains an unexplored research avenue.

We address these gaps and test these hypotheses using data on 149 M&A and JV transactions in the energy industry in the period 1997 to 2016. We review how energy companies repositioned via M&As and JVs to an uncertain solar photovoltaic (PV) industry. Despite, its prominence in economic, political and environmental terms, the industry's cosmic growth, technological evolution, price decline, shakeout and 'dominant technology' emergence in 2011 provides a distinct data sample at unique time. Our results support our hypotheses and provide two key theoretical contributions. First, at the highest level, the study provides novel insights on the pre-entry capabilities that underpin firms' potential to survive after the entry to an uncertain industry when it matures. Second, we arrive to a conclusion that effect of these capabilities is asymmetrical: Whilst they are important to succeed in market entry to the maturity stage of an emerging and uncertain ILC, they do not assist, and rather hinder, an entry during the evolution stage of an ILC. A destructive effect of DMC on entry is a novel research area, and we believe that this type of research is much-needed, to protect companies rich with DMC from the high probability of failure during the evolution stage of ILC.

2 Theoretical background

This study draws on two distinctive theories: entry timing and industry life cycle (ILC).

2.1 Industry life cycle theory

The ILC theory documents the industry aging trajectory, aiming to explain changes in technological development, scale of demand, and industry structure over the industry ageing lifetime (Miles, Snow, & Sharfman, 1993). The ILC patterns and stages are well documented in the literature and continuously attract novel research interest (Giarratana, 2004; Santos & Eisenhardt, 2009; Sine & Lee, 2009; Dobrev & Gotsopoulos, 2010; Forbes & Kirsch, 2011; Gustafsson, Jääskeläinen, Maula, Uotila, 2016; Markard, 2020).

Commonly examined stages of ILC are growth, maturity and decline (Miles, Snow, & Sharfman, 1993). An era of experimentation accompanies industry emergence, characterized by high levels of heterogeneity between firms, such as unstandardized products and high product variation (Mazzucato & Semmler, 1999), where various players strive to understand and develop 'design' which meets the best consumer interests (Anderson & Tushman, 1990; Suarez, Grodal, & Gotsopoulos, 2015). As industry progresses, a dominant design tends to emerge (Abernathy & Clark 1985, Anderson & Tushman, 1990), leading to the more standardized product (Langlois, 1992), what reduces uncertainty regarding the future nature of the technology (Wolter & Veloso, 2008).

The emergence of 'dominant design' is a dominant factor in the LCT theory. There are numerous explanations on why the technological innovation culminate in a 'dominant set' (refer to Murmann & Frenken, 2006 for a review); and there is unity of opinion that 'dominant design' triggers the onset of industry maturity (Agarwal & Bayus, 2002; Utterback, 1994).

The dominant design concept has been recently challenged. Suarez et al. (2015) arrives to the existence of a 'window of opportunity' for firm entry that starts with the emergence of the 'dominant category' —the conceptual schema that most stakeholders adhere to when referring to products that address similar needs and compete for the same market space— and ends with the rise of the 'dominant design'. Notably, in relation to the triggers of an industry structure change and its convergence, Argyres et al. (2015) argue that it is not the dominant design that triggers it, but one pioneering firm's innovation shock design which emphasizes the role of the arrival of an unanticipated, sudden, and substantial demand for a particular composition of product and service elements.

There is a lack of understanding in terms of the transitions between the industry stages (Gustafsson, Jaaskelainen, Maula, Uotila, 2016). However, it is agreed that the industry shakeout period, marked by a substantial portion of industry participants exiting an industry, is associated with the emergence of ‘dominant set’ and industry divergence to its maturity stage (Agarwal & Gort, 2002; Agarwal & Tripsas, 2011; Utterback & Suarez, 1993). In this study, we classify a ‘dominant set’ which emerges post industry shakeout and initiates the industry maturity stage.

The ILC treats industries as homogeneous (Knudsen et al., 2014), with three core stages: growth, evolution and maturity, as mentioned earlier. Recently, however, this view was challenged by Uzunca (2018), who reviewed the conditions under which alternative industry evolution patterns at the already matured industry can be observed. In line with Schumpeterian “waves of creative destruction” and competition the continued innovative activity disrupts established dominant firms and creates evolutionally paths in matured industries as well. Helfat (2015) states that subsequent innovation occur within throughout various ILCs.

Weak firms exit the industry after emergence of ‘dominant set’ (Carroll, 1985). The sharp price competition and scale economies start to benefit elephantine corporations during industry maturity phase. These entities nourish the dominant design and gradually acquire a cost leadership position (Jovanovic & MacDonald, 1994).

As a result, limited intra-industry heterogeneity accompanies industry at its maturity stage when industry effects, or drivers of firm performance, become more important than they were during the industry evolution phase (Karniouchina, Stephen & Short, Jeremy & David, 2013). As variance in performance increases with the industry maturity, performance measurement gains substance as industry progresses.

2.2 Entry timing

The entry timing and its implications have gathered a substantial interest from scholars over the last three decades with vast conceptual structures developed in innovation theory (Foster, 1986), strategic management (Mitchell, 1991), and organizational ecology (Hannan & Freeman, 1989). These include the relationship between firms’ capabilities and entry-timing (Lee, 2009; Robinson, Fornell, & Sullivan, 1992), entry timing in relation to industry competitive structure (Klingebier & Joseph, 2017; Cawley, 2019), entry timing in relation to functional product evolution (Querbes, & Frenken, 2016); and entry advantages during the industry incubation and evolution life cycle phases (Suarez, Grodal & Gotsopoulos, 2015; Argyres, 2015; Moeen & Agarwal, 2016; Uzunca, 2018; Furr, 2018).

From the beginning of 1980s, researchers in strategic management widely focused on the First Mover Advantage (FMA) in relation to the evolution stage of ILC. The theoretical and empirical literature survey on mechanisms that confer advantages and disadvantages on first-mover firms was first formulated by Lieberman and Montgomery (1988). They review the early and late entrant's strengths and point to the early entrants' advantage deriving from the ability to hold off and wait until the consumer filters among various innovations the final product he/ she wants, before entering the market the full-force mode. They revised their literature survey 10 years later and suggested that the resource-based view (RBV) and first-mover advantage (FMA) are related conceptual frameworks that can benefit from closer linkage to identify whether the initial resources and capabilities of a firm affect its optimal timing of entry. Fraction of research followed on this subject, outlining both, first-mover and latecomer, advantages from the resource-based perspective.

However, as research on this subject progressed, so contradictory findings on it. One of the FMA criticisms is that it is not applicable from dynamic capabilities view. For example, Mathews (2002) defines the 'latecomer firm' [LCF] and based on an example of Samsung's successful late entry to the Dynamic Random Access Memory industry recognizes numerous competitive advantages the latecomer firm benefits from in a resource-based view, with a particular emphasis to the dynamic capabilities of latecomers - even if entered with few, still can be created after entry through repeated applications of linkage and leverage —such as linking with advanced firms in various kinds of contracting or licensing arrangements, and leveraging resources (knowledge, technology, market access channels) from such linkages to compete with incumbent.

Imitation decisions, seen as core for market leaders by scholars in the past, do not compliment FMA theory neither, because imitative response can lower the durability of the first-mover advantages (Boyd & Bresser, 2008; Lee, Smith, Grimm, & Schomburg, 2000), and even if imitation of follower actions can be an effective competitive strategy for a leader, its effect is receded by 1) the difference between leader and follower capabilities, because a follower with a capability advantage over the leader at certain environmental conditions will gain more from the information provided by the leader's action imitation strategy than would a follower with inferior capabilities, and a follower can use this information along with their superior capabilities to overtake a leader; and 2) the degree of environmental uncertainty. In the view of environmental uncertainty - a follower that undertakes new actions in such environment creates upside opportunities that increase its chances of overtaking up the leader, if a leader decides not to imitate the follower's actions. Lee et al. (2017), proposes a framework to explain catch-up cycles, in which latecomer firms emerge as international leaders, whereas incumbents lose their previous positions, and identify several windows of opportunity in sectoral systems for LCF, such as changes in knowledge and technology, demand, institutions and public policy.

Cawley (2019) extends the previous concept, calling it 'multiple windows' of advantage during the cycle, with a conclusion that firms who base their investment decision on the estimated next phase of a cycle can gain the entry time advantage when rivalry in the industry and the price sensitivity of competitors are high. High rivalry in the industry is assimilated with the industry evolution stage. These findings contradict an earlier opinion: organizations founded during periods of intense competition will have persistently higher age-specific rates of mortality than those founded during periods with lower numbers of competitors (Utterback, Suárez, 1993), heralding in turn the late entrants advantage.

Breadth of research with contradictory findings is performed with an attempt to explore the right entry timing during the industry evolution stage (Suarez Grodal, & Gotsopoulos, 2015; Agarwal & Bayus, 2004; Christensen et al., 1999; Markides & Geroski, 2005); with scholars proposing a 'window of learning' (Christensen & Gordon, 1998) and 'window of opportunity' (Suarez, Grodal, & Gotsopoulos, 2015) to gain the entry advantage during the industry evolution stage.

Despite the amplitude of the academic literature on the FMA, it has been unable to provide conclusive empirical evidence to support or refuse the existence of FMA (Suarez, 2007). Suarez et al. (2007) recommend that FMA theory should be advanced in its macro aspects, the interplay between the environment, the pace of technology evolution and the pace of market evolution. Calling for theoretical frameworks where environmental dynamics may render late entry more advantageous than early entry. Numerous scholars analyzed environmental dynamics at which FMA are difficult to maintain. For example, Christensen, Suarez, and Utterback found that 'the notion of first mover advantage is not applicable' in the fast-changing rigid disk drive industry (1998: S207), and in product categories which significantly advance in product quality over time (Suarez & Lanzolla, 2007; Bohlmann, Golder, & Mitra; 2002). At times of past paced technological turbulence, dominant incumbent firms, which were long successful in an existing technology, are often much less successful in new technological eras, and rather than being able to take advantage of scope economies, often find themselves at a significant disadvantage relative to de novo entrants and often fail (Bresnahan, Greenstein, Henderson, 2011), because their long developed internal capabilities and cognitive frames that make them slow to sense and respond effectively to new opportunities (Henderson & Clark, 1990). Querbes et al. (2016) argues that vibrant environmental dynamics lead to new product functionalities and designs enabling late movers to start designing 'from scratch,' which leads them to come up with radically new design propositions, overtaking slow incumbent firms, especially in high complexity technological markets.

Although environments at which FMA theory is (not) applicable were determined by several scholars. To date, there was no attempt to assess entry timing (dis)advantages in relation to industry lifecycle under conditions of uncertain environment. Despite past, recent and continuing research on time entry (dis)advantages during the industry evolution phase (Moeen, Agarwal, Shah, 2020; Agarwal, R., Braguinsky S., Shah S., Wormald A,, 2019; Uzunca, 2018; Furr, 2018; Suarez, Grodal & Gotsopoulos, 2015; Argyres, 2015; Moeen & Agarwal, 2016), scholars did not link the entry time advantages to the industry maturity phase for companies competing under conditions of environmental uncertainty today in fast-paced technological industries.

3 Research framework and hypotheses development

3.1 Entry timing and industry lifecycle – the role of dynamic managerial capabilities

Research on entry-timing strategies, with a particular focus on first-mover and follower advantages, already constitutes an established body of literature (Fosfuri, Lanzolla, Suarez, 2013; Furr, 2018; Moeen & Agarwal, 2016; Uzunca, 2018). However, there is disagreement regarding entry timing and its effect on post-entry survival at different stages of entry. The FMA, a widely focused research area in the last 3 decades, is subjected to criticism. One of the objections to the FMA is that it is not applicable from the dynamic capabilities' perspective (Mathews; 2002; Finney, 2008), because entrants that add value through dynamic management capabilities bear success at the late entry over those who do not have them. This, in turn, prompts an important question which was not reflected in the literature: what is the reason DMC benefit entrant only at the late entry; We suggest, the answer to this question lies beneath the industry structure pertinent to an early and late entry and specific industry characteristics prevailing at related stages of ILC Following Fosfuri et al. (2013) 'there is significant potential in establishing closer links between entry timing and ILC theories [p. 300]', we argue that in order to address the DMC effect on entry, its compatibility to unique industry characteristics pertinent at various stages of ILC with specific reference to the evolution and maturity stages of ILC must be addressed first.

For example, the entrants at the evolution stage of ILC face different challenges, one of them is technological uncertainty (Anderson and Tushman, 1990; Sorenson, 2000), because they can tie themselves to wrong technologies, ones which will be discontinued and will never see the light of a dominant design (referred to as 'dominant set' and 'dominant technology' in this study)(Suarez & Utterback, 1995). This phenomenon was observed in many companies in the energy industry, including Royal Dutch/ Shell (Pinkse & Buuseb, 2012), an oil/gas industry giant who invested in the solar PV industry during its evolution stage of ILC and failed in their entry because they selected and invested in the wrong technology, one which never became a dominant technology. the one that would win the allegiance of the marketplace. As a result, entrants who enter after the emergence of a dominant set—thus during the maturity stage of an ILC—are exempt from the risk of binding themselves to the wrong technology.

Yet, at the same time, early entrants—with specific reference to early entrants who enter during the evolution stage of an ILC—can actually select the correct future dominant technology and thus begin pioneering business models that are required to commercialize and nourish it. However, as Teece (2018) explains, pioneering a new business model is not always a path to advantage since the challenge of trial and error—to which pioneering companies are exposed during the innovation process of a business model—may be costlier, even more detrimental, than imitation by late entrant.

Thus, when entering a new industry at the evolution phase of an ILC, an entrant exposes itself to numerous challenges that range from the risk of a poor technology selection to the risk of new business model innovation. Additionally, being first with an imitable business model may teach the customers about the new value proposition, priming the way for entry by rivals (Teece, 2018). These late entrants, known as rivals to pioneering companies, can benefit by waiting for industry standards to mature. This in turn ends the tech confusion faced at the industry evolution stage (Strebel, 1987) to scale the product and dominant set, benefiting from an imitable set of business models created and pre-tested by industry pioneers and early entrants (Teece, 2018).

We further confirm the previous argument using an example of the containerized shipping industry. The containerized shipping industry was pioneered in the late 1950s by a shipper known later as Sea-Land Service, which possessed a future dominant set and simultaneously pioneered business models early (Pedersen & Sornn-Friese, 2015). The industry took off in the 1980s, and the largest firm in the containerized shipping today, Maersk Line, waited nearly two decades after industry took off before it adopted containerization, subsequently acquiring Sea-Land Service in 1999 at a time when high levels of standardization started to drive product enhancement and increases in vessel size. Maersk was able to wait for standards, which predetermine a dominant set, to mature before moving into the industry decisively to enhance (nourish), and rapidly scale it by building large ships that it was then able to orchestrate effectively (Pedersen & Sornn-Friese, 2015). The high standardization levels during industry shakeout and maturity phases opened possibilities to exploit economies of scale in containerized shipping (Wilmsmeier & Monios, 2020). By waiting for the product standard to become established before a full-force entry to the industry, Maersk emerged as a winner, becoming the industry leader today. However, the question remains: what exactly were the capabilities Maersk possessed that enabled it to move so smoothly, rapidly, and successfully into a new industry, to nourish and scale container ships? That is, w*hat capabilities must an entrant possess so as to succeed in their entry into a new industry at its maturity stage*?

The specific characteristics of firms from the organizational structure perspective that tend to succeed at each stage of an ILC (Utterback and Abernathy, 1975) were identified in the ILC theory. A careful review of these characteristics could shed additional light on the types of capabilities that entrants need to succeed at different points of entry (Fosfuri, Lanzolla, Suarez, 2013), given that individual sets of capabilities are demanded by different stages of ILCs (Lee, 2009).

The maturity phase of an ILC is triggered by the emergence of 'dominant design' (Utterback & Abernathy, 1975; Suarez & Utterback, 1995) – a core determinant of an ILC stage in technology studies-which is a product design whose main components and underlying core characteristics do not vary from one model to another, and features that competitors and innovators must adhere if they hope to command significant market share –when cost of it becomes the primary competing base

To survive when dominant set is identified, entrants must pass through key industry milestones - commercialization and sales take off - to be able to reach the next level (Agarwal & Bayus, 2002; Moeen & Agarwal, 2017; Moeen, Agarwal, Shah, 2020). To commercialise a dominant technology firms must introduce it to a market by communicating of a value proposition to a customer, deliver this value and convincing a customer to pay for it which must be done fast (Stevens, Burley, and Divine, 1999); and to pass through the sales take off stage firms must increase a production capacity which in turn decreases a cost of a dominant set (Utterback & Abernathy,1974). After successful and fast communication of a value proposition to a customer, firms must expand a customer base so as to scale a newly introduced technology- to achieve economy of scale (Klepper, 1997). In other words, dominant technology, reveals new information about the capabilities needed to capture income streams available in the new industry (Argyres, 2016) – which are capabilities to commercialise and sell it. Technology commercialisation is not only a resource and skill intensive process; but predominantly a task demanding specific capabilities. These specific capabilities to rapidly commercialise the new technology are imperative for firms, because the failure to speedily commercialise it faster than a rival with a substitute technology, prohibits its expansion to a cost advantageous economy of scale (Teece, 1992), shoving mass production beyond reach, subsequently leaving a new technology in a too expensive cost bracket, thus entry failure.

Technology commercialization and sales take off of a product are key milestones an entrant must successfully accomplish to survive when dominant technology is identified, which can be at the early stages of ILC (Moeen & Agarwal, 2017; Moeen, Agarwal, Shah, 2020), if a firm is successful in identifying a future dominant set early; and necessarily when dominant set -guaranteeing that competitors and innovators will adhere to its features if they hope to command significant market share

- is established, thus at the early maturity stage of an ILC (Utterback & Abernathy, 1975; Suarez & Utterback, 1995).

Dominant technology reveals new information about the capabilities needed to capture income streams available in the new industry (Argyres, 2016). Consistently with the dominant technology theory dominant technology triggers the maturity stage of ILC. The existence of capabilities to commercialise technology immediately after dominant set is identified—when an industry enters a mature phase—predetermines firms' ability to scale it (Klepper, 1997) and thus generate higher sales volumes at lower costs, translating to profits, necessary for entrant to survive.

The ability and success of a dominant technology commercialisation is facilitated by the knowledge derived from internal and external firm-specific competences, which are attained from human assets and resources (Teece, 1986; Teece, 1997, Zahra & Nielsen, 2002), that is, dynamic capabilities. 'Dynamic capabilities'—the foundations of enterprise-level competitive advantage in regimes of rapid technological change (Teece, 2007, p. 1341)—are the capabilities necessary to successfully commercialize innovations in a new industry (Zahra & Nielsen, 2002; Mathews, 2002).

Concurrently, dynamic capabilities are core enablers to effectively fine-tune business models (BM) (Teece, 2018). BMs describe the design or architecture of the value creation, delivery, and capture mechanisms (that a firm) employs (Teece, 2010: 172). The essence of a BM is in defining the manner by which the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit. However, BMs are seldom successful 'out of the box' and must be fine-tuned, sometimes completely overhauled—before they can become profit engines (Teece, 2018), which requires time. Subsequently, the longer a firm spends in a specific industry, the more time it has to fine-tune its BM whilst it is identifying, creating, and modifying the route to a customer, manifesting in the entrant's age benefit and the liability of newness during the maturity phase of an ILC (Agarwal, Sarkar, & Echambadi, 2002).

Consistently with Helfat and Lieberman (2002) and Klepper (2002) on the origin of firm capabilities being the prior experiences of its executive management, executive management who bear the primary responsibility for inventing and adjusting business models (Leih, Linden & Teece, 2015), and intentionally intervene into product development processes (Salvato, 2009). Top managers, who were involved in functional roles to create and modify BMs to introduce, nourish and/or distribute the product in a specific industry, gained experience and understanding of the product development processes to nourish it and in the product distribution processes required to commercialise (Gilbert, 2006; Tripsas & Gavetti, 2000).

An increase of production capacity to produce a necessary quantity of a dominant technology to distribute it on a scale is inevitable to achieve the economies needed to succeed and there is a strong argument that an expansion of production which results in the cheaper end-product, thus higher value proposition to a customer, is also facilitated by the prior industry experience of top management (Yanik, 2001; Klepper; 2002). Yanik (2001) produces an example from the automotive industry of a former Ford's production manager, Walter Flanders, known as a production genius who had reorganized Ford's production in 1906–1908 to achieve the economies needed to make the Model N successful. He recognized the benefits of large-scale, high-precision production and introduced many of the same production process innovations he created for Ford to the new automobile manufacturer, E-M-F, thus succeeded with the large-scale production.

The prior top managers' industry experiential knowledge helps to establish processes to nourish a product and scale its production (Yanik, 2001; Salvato, 2009), distribute it, provided the basis for the decision-making routines (Nelson & Winter, 1982) being also the main reason a number of new firms became leaders in the specific industry - a sequel of the backgrounds of their executives (Klepper, 2002) - all heralding that the prior top managements' industry experience provides distinctive advantages to an entrant.

Top managers' experiential knowledge—which has been developed through involvement in specific industries, fulfilling functional roles, and employment with specific firms (Mackey et al., 2014)—is a dynamic managerial capability known as 'management human capital'—that is, top management's prior industry experience. The prior experiences provided the basis for the decision-making routines (Klepper, 2002) and top managers utilise it to absorb opportunities and reconfigure resources. The industry specific experience and the functional area in which they were involved previously determines managers' absorbing capacity (Cohen & Levinthal, 1990) of different information. So, in light of the differences in managers' future absorbing capacity, based on specific prior industry expertise at different functional roles, they are likely to make different investments and other commitments in the future, as dictated by the extent of their ability to filter the information and to reconfigure organizational resources (Vinokurova & Kapoor, 2020; Helfat & Peteraf, 2015; Teece, 2007). In order to create and derive the best value proposition route to a customer, firms must reconfigure their organisation resources, so as to create appropriate business models-an efficiency of which depends on the specific top management's prior industry experience.

On the other hand, the existence of responsive and intentional top management's intervention into product development processes (Salvato, 2009) affects firms' ability to nourish the new dominant technology, supporting their route to a cost leadership position (Jovanovic & MacDonald, 1994).

To summarise, to survive entry at the maturity stage of an ILC, firms have to be able to quickly commercialise, sell and scale the recently emerged and newly acquired dominant technology. New technology commercialisation is a resource-intensive process demanding skills and resources which are often insufficient (O'Connor, 2008; O'Connor & Rice, 2001) due to scarcity related to knowledge and expertise (Bartlett and Ghoshal, 1993). Entrants who have these skills– knowledge and expertise, prior executive management industry experience, on hand during entry to the mature stage of ILC and allocate them to the new venture to commercialisation a newly acquired dominant technology are en route to success in the technology commercialisation task. The knowledge derived from internal and external firm specific competences attained from human resources and capabilities (Teece, 1986; Teece, 1997) dictates technology commercialisation (TC) speed (Zahra, et al, 2002), imperative for entry success, because the failure to speedily commercialise it faster than a rival with a substitute technology and stronger dynamic management capabilities prohibits its expansion to a cost advantageous economy of scale (Teece, 1992), shoving mass production beyond reach, subsequently leaving a new technology in a too expensive cost bracket, thus entry failure. Further, previous industry experience of internally based personnel affects their ability to fine-tune business models to derive the best value proposition route to a customer, to nourish a dominant technology increase its production, reduce its cost and to distribute it. This industry specific, tacit-knowledge, experience takes years to develop (Nonaka and Takeuchi, 1995). Thus, we argue that the personnel's experience length, expressed in top management's prior industry experience tenure in certain functional roles, an important indicator of dynamic managerial capabilities (Helfat & Martin, 2015), that an entrant possesses at a time of entry, will positively correlate to their ability to commercialise, nourish and scale a dominant technology acquired, thus implying entry survival in a matured industry. Thus, we hypothesize:

Hypothesis 1A: *The length of prior industry experience of executive management available to entrants at time of entry will correlate to lower mortality rates at the maturity phase of an industry lifecycle, regardless of industry status (new or uncertain industry[2]).*

3.2 A destructive effect of the prior industry experience of executive management on entry at the evolution stage ILC

As top management personnel gains industry experience it acquires the focal industry knowledge, The focal industry knowledge provides the basis for the decision-making routines (Klepper, 2002).

[2] The study utilizes quantitative market data from the energy sector, which is moving through unprecedented transformation—from a mature sector that relied on energy derived predominantly from fossil fuels, to an industry characterized by fast-paced technological changes in the industry, changes which are driven by new entrants into the sector who are creating renewable energy technologies that are disrupting the existing energy sector. In addition, it is an industry which is characterized by the tendency of these fossil fuel giants to subsequently acquire these recent, renewable energy, technologies (Pinkse & Buuseb, 2012). Therefore, this empirical setting provides an ideal domain in which to test an entry-timing advantage in relation to the various stages of ILC, in relation to entry to the emerging industry, under the condition of uncertain environments.

determines managers' problem-solving skills, thus increases their 'absorptive capacity,' their ability to recognize the value of knowledge produced elsewhere and to effectively assimilate it (Cohen & Levinthal, 1989, p. 128), - thus benefits an entrant in many ways. Managers may use the accrued industry knowledge to sense the way the technology is evolving to select and jump on the emerging technological trajectory (Suarez & Utterback, 1995), simply - to identify the future dominant set early. Further. entrants may leverage the focal industry knowledge to develop and commercialise a new technology – as to be 'adaptable' [3](Kapoor & Klueter, 2o15; Eggers & Kaplan, 2009; Rothaermel, 2001; Tripsas, 1997).

However, this knowledge functions as a double-edged sword, because it creates rigidity in mental models (Dane, 2010) to tie the firm more closely to its historic practices and lock it into a particular technological trajectory that is consistent with its historic technology (Dosi, 1982) but not consistent with current practises (Bettis & Prahalad, 1995: 7). In other words, whilst the prior executive management industry experience supports entrants to select the dominant technology, and subsequently to commercialise and scale the new technology (i.e., being essential for entrants to survive at the maturity stage), these capabilities may bring a rigidity risk. That is, a risk that rigidity in managerial cognition and mental models to innovate will outpace a managerial adaptability Kapoor & Klueter, 2o15), necessary to innovate and subsequently nourish a new dominant technology.

In effect, the negative effects the dynamic management capabilities on new market entry has started to gain some attention. For example, Ener (2019) concluded that greater top management experience can have less value in fast-changing markets on an example of biotechnology industry. An early entry—an entry during the evolution phase of an ILC—is associated with fast-changing markets and greater risk (Klingebiel & Joseph, 2017) because the dominant technology is not identified at this stage of an ILC. Since the length of prior management experience negatively correlates with R&D (Dane, 2010)- it has a negative effect on innovation, because managers become rigid to experimentation, and tend stick to their ways of doing things rather than exploring new practises (Sørensen & Stuart, 2000). The rigidity in managerial cognition, developed through managers' prior experience, reduces managerial flexibility, which is necessary to innovate and thus create a new dominant technology. Top executives' greater commitment to existing technologies (Furr et al, 2012) further impedes the development of a new dominant technology. Entrants who enter during the evolving phase of an ILC – a time they must exercise a flexibility to part with their believes and commitments to old technologies, and be adaptive to innovate a new dominant technology. But, rigidity of entrants who

[3] Entrants' adaptability - entrant ability to leverage its specialized assets, like DMC – the prior executive management's industry experience, that are necessary to commercial the new technology (Kapoor & Klueter, 2o15; Eggers & Kaplan, 2009; Rothaermel, 2001; Tripsas, 1997)

are rich with capabilities impeding innovation –a long prior executive management industry experience – are deemed to impede the innovation of a new technology; thus predetermines a failure of that entry. Thus, we hypothesise:

Hypothesis 1B: *The length of prior industry experience of executive management available to entrants at time of entry will correlate to higher mortality rates at the evolution phase of an industry lifecycle regardless of industry status (new or uncertain industry).*

As discussed earlier, the prior industry experience creates rigidity in mental models, and as managers' prior industry experience increases, so too does a rigidity in managerial cognition and mental models (Dane, 2010). Its negative effects are likely to increase at market conditions when rigidity in managerial cognition and mental models does not compliment – thus at fast changing technological markets. Ener (2019) statesthat increasing experience beyond 2 years results in a higher failure rate of entry attempts in the biotechnology industry. Although the study serves as a firm starting point in the strategic management literature to address prior experience as a 'hindrance to entry,' and calls for necessity to analyse it in various industry settings- there are a few limitations in it. The foremost limitation is that it does not relate to the industry life-cycle theory, which after this study hopefully will answer the questions on why entrants analysed by Ener (2019) who possessed strong DMC failed, if they entered the evolution stage of ILC – a stage of an ILC when we argue DMC create an entry hindrance.

However, whilst we argue that the prior industry experience is a hurdle for entry at the evolutions stage of ILC and supports an early entry to the maturity stage of ILC; the open sphere remains on effect of *'length'* of prior executive management industry experience at entry during both stages of ILC, evolution and maturity. Whilst a shorter length of prior industry experience, when rigid mental modes did not develop and cement yet, may be not so detrimental to entry at the evolution stage of ILC; a very long prior experiences can also obstruct the entry at the maturity stage of the industry life-cycle, because the rigidity of managerial cognition and mental models, and affiliations to old ways of doing things, as well as old technologies, may start to slack a production process of a new technology in fast changing technology markets, when managerial inflexibility impedes the entrants development effort to commercialize new technology and production process adaptability to rapidly changing automation necessary to foster its efficiency and speed, core to produce, nourish and scale the dominant technology, thus both-thus long prior executive experience is an entry hindrance at both, the evolution and the maturity stages of ILC.

Entrant ability to leverage its specialized assets, like DMC, that are necessary to commercial the new technology – support adaptability (Kapoor & Klueter, 2o15; Eggers & Kaplan, 2009; Rothaermel, 2001; Tripsas, 1997), which declines with rigidity, when research efforts toward creation of a new technology and its development attempts towards its commercialization and nourishment gets overshadowed by previous habits, remaining as unsuccessful attempts

We endeavor to determine the experience edge -prior executive management experience in years – which supports development efforts towards new technological innovation to derive to the dominant technology – evolution stage of ILC, subsequently its commercialization and expansion to economies of scale-– maturity stages of ILC, but saturates to rigidity and starts to impede development efforts applicable to specific stage of ILC from that point.

Taking in account the threshold of 2 years of prior industry experience arrived to by Ener (2019), and increasing experience beyond it resulting in a declining probability of achieving market entry in biotechnology industry; we argue that specific, tacit knowledge takes years to develop (Nonaka and Takeuchi, 1995) and especially in knowledge intensive industries like the energy technology is. Therefore, the experience edge in years – or prior executive management experience in years –when entrants may reap highest benefit upon its entry to various stages of ILC will be higher than 2 years in the knowledge intensive energy technology, and will vary at both ILC stages – evolution and maturity stages. Thus, we hypothesize:

Hypothesis 2: *The relationship between the length of prior industry experience of top management and the survival of new entrants at maturity stage would have an invert U shape.*

4 Research approach

4.1 Energy industry

The study utilizes quantitative market data which was culled from carefully selected statistics generated by the energy sector over the last three decades. One must note that this is a sector which is moving through unprecedented transformation—from a mature industry that relied on energy derived predominantly from fossil fuels, to an industry characterized by fast-paced technological changes in the industry, changes which are driven by new entrants into the market who are creating renewable energy technologies that are disrupting the existing energy market. In addition, it is an industry which is characterized by the tendency of these fossil fuel giants to subsequently acquire these recent, renewable energy technologies, predominantly through acquisitions and joint ventures (Pinkse & Buuseb, 2012). Therefore, this empirical setting provides an ideal domain in which to test an entry-timing advantage in relation to the various stages of ILC, while simultaneously assessing the effectiveness of mergers and acquisitions (M&As) and joint ventures (JVs), as repositioning strategies, when applied under the condition of uncertain environments.

The use of repositioning strategies, including M&As and JVs, as a response to uncertainties caused by disruptive innovation is a known and well-analysed tactic in the strategic management literature (Argyres, 2015). In this study, therefore, we focus on M&A and JVs, which were used as repositioning strategies by oil & gas companies to acquire new disruptive technologies, to understand how firms can stimulate the commercialization and nourishment of disruptive technological innovations.

4.2 Data Sources and Sample

We extracted a list of M&A deals from Thomson Reuters' SDC database: Public acquiror, date = 01/01/2000 to 31/12/2018, deal value – 10 $ Mil and above, Acquiror Macro Industry (Code) – Energy. Total of 4,334 deals. Due to a lack of a unique industry classification by renewable energy type, we filtered this Target companies with Codes - 499A, 499A, 4911, 9631, 3511, 3674 - (renewable industry) includes solar PV, wind, hydro energy, other energy. From this data set we individually reviewed all companies to subdivide renewables companies and select only solar PV operation and technology companies, to arrive to data for Acquiror Macro Industry - Energy, Target – Solar PV.

We added to the dataset M&A and JVs: oil companies (Total, BP and Shell) invested to solar PV companies from the dataset compiled by Pinkse & Buuseb (2012) for years 1997 – 2009, and added M&A and JVs by Total, BP and Shell for years 2010-2016 to the database.

We construct a larger database gathering data on M&A and JV transactions following the above mentioned criteria from industry reviews, reports and press releases compiled by GreentechMedia. Greentech Media is known as the leading industry analysis organization for the solar PV industry. We identified major energy companies (public and non-public) who invested into solar PV industry and collated M&A and JV data directly from these companies. In this way, we create a sample of 149 M&A and JV deals between 1997 and 2016.

In order to collect data on control variable, prior top management industry experience, we use a combination of data sources including the commercially available Capital IQ and Corptech databases, company annual reports and LinkedIn to identify the names and detailed career histories of personnel who have served in top management roles at a time of entry. We select seniority level - executive board of directors, chair and founders. For each executive director, we identify the number of years during which the director has had a prior experience in energy sector at any seniority level in sales, business development, commerce, operation and general management, for those director who studied electronics and went to work in electronics, semiconductor sector after graduation, we start the experience year count immediately after their graduation; because any of these experiences in energy or semiconductor sectors aids to experience necessary to commercialise, nourish and scale a new dominant technology.

4.3 METHODS

4.3.1 Key Variables

Independent variable: Life cycle phase. Our theoretical framework distinguishes between evolution phase, or the period in an industry's history from the time of the industry category's commercialization to industry shakeout followed by the emergence of a dominant design, which triggers the onset of industry maturity (Agarwal & Bayus, 2002; Utterback, 1994); and the mature phase, the subsequent years.

We test entry time advantage both to a new industry and at times of environmental uncertainty based on the sample from energy sector. We review how energy companies reposition to a new and uncertain solar photovoltaic (PV) industry. Despite, its prominence in economic, political and environmental terms, the industry's cosmic growth, technological evolution, price decline, shakeout and 'dominant technology' emergence in 2011 provides a distinct data sample at unique time, see Figure 1.

In the study we analyze entry survival for entries made in years 1997-2011 (industry evolution stage when dominant technology is not emerged) and years 2012-2016 (matured industry when dominant technology is identified). Different solar PV technologies competed till 2008 without consensus on the future dominant design/ technology (Furr & Kapoor, 2018, Ardani & Margolis, 2011; Peters, Schmidt, Wiederkehr, & Schneider, 2011; Bradford, 2006; Chopra, Paulson, & Dutta, 2004). An unity in opinion on the future dominant technology started to emerge in 2008, with a view that crystalline silicon leads a price-performance advantage among all competing technologies (Barron, 2008; Shahan, 2013; Furr & Kapoor, 2018). A solar PV industry shakeout began in 2010 (Furr, 2018) during which a Crystalline silicon (cSi) emerged as a dominant technology. Separately, we analyzed production volumes by solar PV technology type and witnessed that multi-crystalline silicon module, clearly emerged as a dominant technology in year 2011, see Figure 2

Firm-level independent variable: The length of the prior industry experience of executive management - the length of 'managers' experiential knowledge in the same sector expressed in tenure – number of prior experience years in the energy sector. Based on the example on an industry analysed in this study, the energy sector—comprised of players who produce energy derived from fossil fuels (oil and gas) and renewable energy (solar, wind, hydro, and other renewable energy sources) — top executives from oil, gas and alternative energy companies possess prior experience in the energy industry which they bring to their entry into a fast-paced technological industry, solar photovoltaics (PV). Therefore, the management human capital (foundation of dynamic managerial capabilities), which facilitates top executives' ability to commercialise and nourish a new dominant technology, is available to the newly acquired firm or venture in the solar PV industry. This dynamic managerial capability is a capability needed to successfully enter the industry at its maturity stage so as to commercialise and nourish a dominant technology and lead strategic change demanded by fast-paced technological industries. In the current dataset—top executives from oil, gas and alternative energy companies possess prior experience in the energy sector which they bring along to a fast-paced technological industry, solar photovoltaics (PV) energy industry at a time of entry. Therefore, this dataset assures that top management holds a prior industry experience in the same industry. The remaining part is to measure a length of managers' experiential knowledge in the energy industry. We measure the length of 'managers' prior market experiential knowledge following Wright et al (2014) and Helfat & Martin (2014) – by measuring each entrants' executive management' (Vice President, Chief Executive Officer or executive board member) tenure in the energy sector for each entrant).

Dependent Variable - Entry failure. For each firm-year observation, our dependent variable, failure, was coded as 0 if the firm exited the market within four years after the establishment of the dominant design, and as 1 otherwise. There should be a clear separation between performance measures at different phases of ILC. The firms that enter industry during the evolution phase of life cycle phase have their advantage lasted only until the dominant design is emerged (Dowell & Swaminathan, 2006), thus until the industry enters the mature phase; the reason we measure the survival rate as firms ability to survive beyond the establishment of the dominant design, allocating two years post establishment of the dominant design as a sufficient time frame to test it.

4.3.2 Methods of analysis

We test Hypothesis 1 and 2 using a logistic regression.

Analysis and findings

4.3.3 ***Results***

Out of the dataset of 149 transaction: 81 or 51% happened at the evolution stage of an ILC, whilst remaining 68 transactions at the maturity stage of an ILC. The regression results are presented in Figures 3-4. When we look at the Entry exit predictor (Figure 3), negative 'length of prior experience' (Figure 3:B=-0.081) predicts a higher exit rates with the increasing length of the prior industry experience. Entry at the maturity stage of an ILC was significantly predicted to be a success (Figure 3: B=2.236). Odd ratio (Figure 1: Odds ratio = 9.352) display that the entry at the maturity stage highly (Figure 3: B=2.236) predict entry survival (success) in the current dataset, a data set comprised of transactions when entrants possessed a prior industry experience of executive management prior to its entry. Therefore, the model predicts a high entry success rate to the maturity stage of ILC in the setting when entrants' personnel possesses a prior industry experience, with entry survival rates nine times (Figure 1: Odds ratio = 9.352) higher than during entry to the evolution stage of an ILC.

The graphical presentation of the entry failure in correlation to the prior executive management industry experience for entries to the evolution and maturity stages of an ILC are represented in Figure 4, where Y = 0 (firm exits the acquisition). Results are remarkable. Firstly, $y<0.5$ represents high mortality for all entries to evolution stage of ILC. Mortality rate correlates further with a higher length of the prior industry experience at this stage of ILC. Secondly, $y \geq 0.5$ represents low mortality for entries to maturity stage of ILC, when the length of prior executive management experience is less than twenty three years.

Therefore, the hypothesis 1A and 1B are supported by the results of this study- and thus based on the evidence from the energy sector the length of prior industry experience of executive management available to entrants at time of entry i.) correlates to lower mortality rates at the maturity phase of an industry lifecycle, if it is less than twenty one year of experience; and ii.) correlates to higher mortality rates at the evolution phase of an industry lifecycle.

Hypothesis 2 is not supported by the empirical results in this study, because the relationship between the length of prior industry experience of top management and the survival of new entrants at maturity stage resemble a linear trajectory, rather than an invert U shape; - thus the results of this study herald that any length of prior experience in the same industry, even very short earlier acquaintance with the industry by the executive team has a favorable impact on entry survival at maturity stage of an ILC.

[Section is being finalized.]

5 Robustness Checks

We conducted a number of robustness checks. We re-do our analyses, using alternative estimation methods, alternative dependent, control and independent variables. We use an OLS/fractional logit and Mixed-effects model to test H1 & H2 in terms of estimation methods. Overall, our results remain consistent using these alternative model specifications.

6 Discussion

Despite the acknowledgement in the academic literature that firms should possess distinct capabilities to succeed at different stages of an ILC (Lee, 2009), no scholarly enquiry addressed what capabilities compliment an entry at the maturity stage of an ILC. Moreover, we know little on which capabilities support firms at their entry to the maturity stage of ILC, and whether these capabilities may have a negative effect on other stages of the ILC. We addressed this inquiry using a unique data set complied from the energy industry during the evolution and maturity stages of solar photovoltaic (PV) industry. Indeed, the uncertain solar PV energy industry which moved from the growing to the mature stage of an ILC in 2011 presented us a recent and relevant opportunity to analyze these relationships in the view of a new sector entry both generally and in a light of an environmental uncertainty. Overall, our results show that, while prior industry experience of top management (DMC) do not assist in entry during the evolution stage, more so, the length of prior industry experience available to entrants at a time of entry correlates to post-entry mortality rates, these capabilities are important to succeed in market entry during the maturity stage of an ILC.

6.1 Contribution to theory

Maturity stage of an ILC is triggered by the emergence of a dominant design in technological industries. Thus, in this study, we argue that a capability to rapidly commercialize the dominant technology is of a highest importance to entrants survival at the early maturity stage of an ILC. It is accepted that technology commercialization (TC) speed is dictated from the knowledge derived from internal and external firm specific competences attained from human resources and capabilities (Teece, 1986; Teece, 1997), we argue that dynamic management capability – prior executive management industry experience – is one of the core capabilities to succeed at the maturity stage of an ILC. This is a first study of its kind proving this bond – DMC and entry success at the maturity stage of an ILC.

Thus, as a first contribution, our study empirically documents that DMC expressed in the length of prior industry experience of executive management correlates to entry survival at the maturity stage of ILC. Which can be explained not only because DMC dictates i. technology commercialization (TC) speed, but ii. New technology nourishment, and iii. Facilitates to reach economies of scale - all inevitable to entry survival and success at the maturity stage of an ILC. Whilst, technology commercialization is a key milestones an entrant must successfully accomplish to survive when dominant technology is identified (Moeen & Agarwal, 2017; Moeen, Agarwal, Shah, 2020), the existence of capabilities to commercialize technology immediately after dominant set is identified—when an industry enters a mature phase—predetermines firms' ability to scale it (Klepper, 1997), and thus generate higher sales volumes at lower costs, translating to profits, necessary for entrant to survive. Concurrently, dynamic capabilities are core enablers to effectively fine-tune business models (BM) (Teece, 2018). The longer the prior industry experience of executive, the more time she/he had to fine-tune BM (Leih, Linden & Teece, 2015) whilst establishing the route to a customer and building relationships with a distributor network and intentionally intervene into product development processes (Salvato, 2009) whilst learning how to nourish the technology and – all manifesting in his/her age benefit to entry at the maturity phase of an ILC.

A second theoretical contribution concerns our findings that the effect of DMC on the survival of new entrants at maturity stage resembles a linear trajectory, rather than an invert U shape; - thus the results of this study herald that any length of prior experience in the same industry, even very short earlier acquaintance with the industry by the executive team has a favorable impact on entry survival at maturity stage of an ILC. More specifically, regardless of the starting point in years of the prior industry experience, the length of prior industry experience – 25 years of prior industry experience - during which it plays a favorable impact on entry at the maturity stage of an ILC, but ceases to add value if the prior industry experience is longer. This age gap during which the prior executive experience plays a beneficial role may be explained by the adaptability – rigidity puzzle (Kapoor, R. & Klueter, T., 2015). Prior executive management experience - DMC support adaptability (Kapoor & Klueter, 2o15; Eggers & Kaplan, 2009; Rothaermel, 2001; Tripsas, 1997), necessary to commercial the new technology. However, rigidity starts to overtake the adaptability as the experiences ages, when development attempts necessary to commercialize the technology and research efforts necessary to nourish it gets overshadowed by previous habits and old technology knowledge.

Finally, our study highlights a destructive effect DMC play on entry at the evolution stage ILC. The negative effects the dynamic management capabilities on new market entry 'just' started to gain some attention – a highlight of a study by Ener (2019) who concluded that beyond a narrow threshold, greater prior experience in the top executive team was associated with a greater likelihood of failed entry attempts on an example of biotechnology industry. His study did not split entrants to the ILC stage they entered into to determine the ILC stage at which the prior experience on new market entry had hindering effect on. Our study is first on its own to empirically detect the distractive effect DMC play on a new market entry at the evolution stage of an ILC.

6.2 Limitation and implications for future research

Whilst the study confirms that DMC play an important role on the entry survival at the early maturity stage of ILC, the question arises on the time effect they play a favorable role on entry, thus: How long DMC benefit organization after the dominant technology had been emerged, commercialized and scaled? Whilst this study presents an evidence that the DMC facilitate tasks such as new technology commercialization and its expansion on scale upon entry to the maturity stage of an ILC, we did not examine their effect on the long-term adaptability[4] (Kapoor & Kluetter, 2015) necessary to long-term survival in uncertain industries. Despite a proven stream of research on the complimentary aspect of DMC to support adaptability, many scholars reserve to the conclusion that even with an access to necessary complimentary assets, like DMC capabilities, firms still faced great difficulties in managing technological change (Cooper & Schendel, 1976; Rosenbloom, 2000; Taylor & Helfat, 2009; Tripsas & Gavetti, 2000) and lengthier prior industry experience of top management generally impeding adaptability to a changing environment (Ener, 2o19).

There is a possibility of a time window during maturity phase of ILC starting with the emergence of a dominant set at which the DMC facilitates its commercialization and expansion on scale, but DMC effect on entry success may be losing its strength as the industry progresses. There is an avenue to rerun the study in 5-10 years' time to include a longer time spam to determine a window of opportunity (Lee, K.& Malerba, F. 2017; Suarez, 2015; Christensen, 1998) at which the DMC play a favorable effect during the maturity stage of ILC.

We reserve an opinion that the window of opportunity at which the DMC play a favourable effect during the maturity stage of ILC needs to be examined in two separate settings: new and uncertain industry, because they deviate on industry structure followed after the new dominant technology had

[4] Entrant ability to leverage its specialized assets, like DMC, that are necessary to commercialize the new technology – also known as entrants adaptability (Kapoor & Klueter, 2o15; Eggers & Kaplan, 2009; Rothaermel, 2001; Tripsas, 1997).

been commercialised and scaled, when uncertain industry may move in cycles, thus demanding adaptability.

6.3 Managerial implications

In addition to theory enrichment, this study offers several implications for practice. Importantly, to survive, and consequently succeed in entry to both a new and uncertain industry, entrants must possess internal capabilities necessary to execute specific tasks which are dictated by the industry characteristics prevailing at a particular stage of an ILC, - they must possess different and relevant capabilities to succeed in entry to distinct stages of an ILC (Lee, 2009). The maturity phase of an ILC is triggered by the emergence of dominant design (Utterback & Abernathy, 1975; Suarez & Utterback, 1995). In the present study, then, 'dominant design/ also set or technology' is viewed as that which unveils new information about the capabilities needed to capture income streams available in the new industry (Argyres, 2016).

Whilst entrant must possess capabilities to invent and innovate a new technology and business models to succeed in entry at the evolution stage of ILC, capabilities needed to commercialise a newly acquired dominant technology particularly if these capabilities support its nourishment and its expansion to economies of scale, are imperative to entry survival at the maturity stage of ILC.The dynamic management capability expressed in the length of the previous experiences of internally based executive management in distribution and product development processes in the same sector is necessary to accomplish these tasks. This industry specific, tacit knowledge and sector experience takes years to develop (Nonaka and Takeuchi, 1995). Thus in this study we argue that the length of executive management prior industry experience available to firms at a time of entry to maturity stage of ILC positively correlates to their ability to commercialise, nourish and scale a newly acquired dominant technology in the same sector. We confirm it through quantitative data analysis.

During the same time the results of the quantitative analysis display a hindering effect these capabilities play on the entry survival during the evolution stage of an ILC and confirm that the length of prior industry experience available to entrants at time of entry to evolution stage of ILC correlates to post-entry mortality rates.

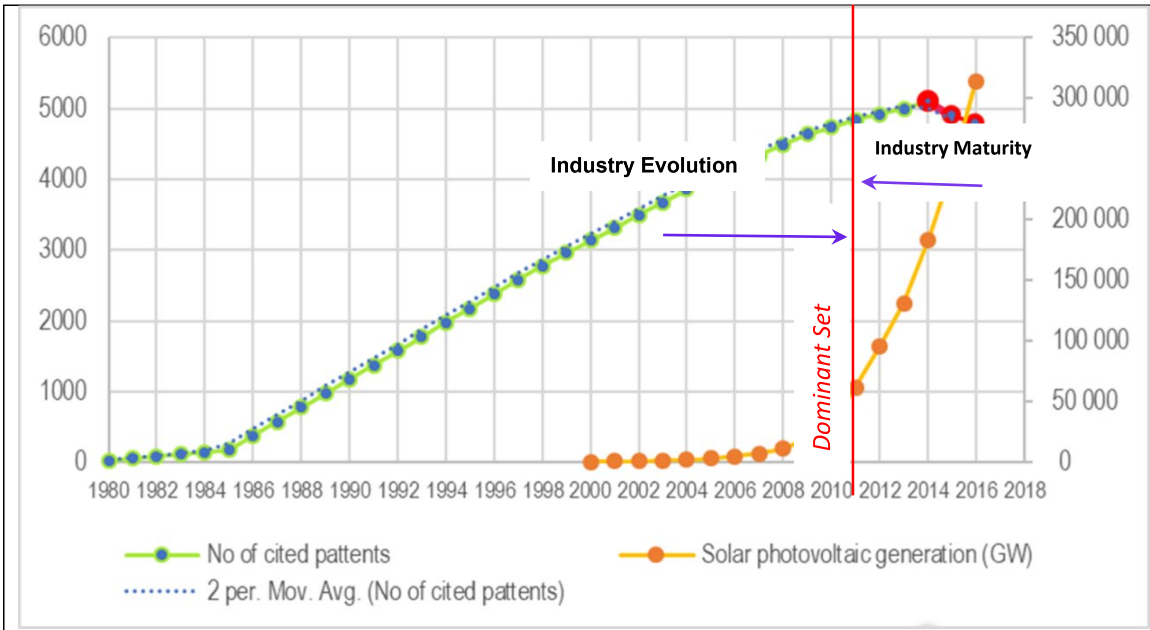
It order to be efficient in entry timing decision making the firms have to assess their capabilities and understand at which stage of ILC they will drive their acquisitions to a glory or downfall. This study is the first of its kind which caters an empirical evidence that entrants rich with dynamic management capabilities – in the form of an executive personnel who have a prior industry experience – have higher chances to succeed in their new product market entry strategy to both new and uncertain industry when they enter during the maturity stage of ILC, if that amount of experience totals less than twenty-one years. Antithetically, the length of prior industry experience of executive management available to entrants at a time of entry to evolution stage of an ILC corelates to mortality rates, thus DMC are incompatible to the entry success at the evolution stage of ILC.

7 Conclusion

This study caught an academic curiosity and investigation after the direct involvement in managing M&A's and JVs in energy in sector. It was evident from the observation that many oil & gas firms failed in their entry attempts to the renewable energy industry at its evolution stage of ILC; but succeed in their entry during the maturity stage. We examined this phenomenon from the the management human capital perspective, and argue that the prior executive management industry experience influences managers' ability to effectively lead entry into new product markets in the industry they have a previous experience in –important to successfully commercialise and nourish the newly acquired dominant technology, the task scholars have viewed as an important indicator of dynamic managerial capabilities (Helfat and Martin, 2015). Through quantitative data analysis, we reveal that the effect of dynamic managerial capabilities (expressed in the length of prior industry experience of executive management) on entry survival at various stages of ILC is asymmetrical: Whilst they do not assist in entry during the evolution stage of an ILC, more so, the length of prior executive management industry experience available to entrants at time of entry does correlate to higher post-entry mortality rates the evolution stage of an ILC, they are important to succeed in market entry during the maturity stage of an ILC until he length of prior executive management industry experience of executive management available to entrants at time of entry ceases to be beneficial to entry survival at the maturity stage of ILC if that amount of experience totals more than twenty-one years.

Figures

Figure 1



Caption: Solar PV industry development. Identification of the industry maturity stage

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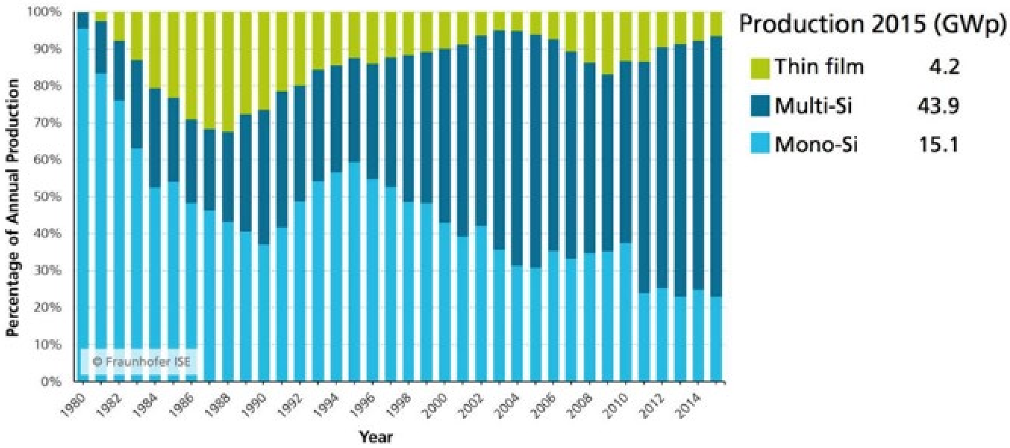
Figure 2



Caption: Annual production by PV technology type – Evolution of 'Dominant design': multi-crystalline silicon module

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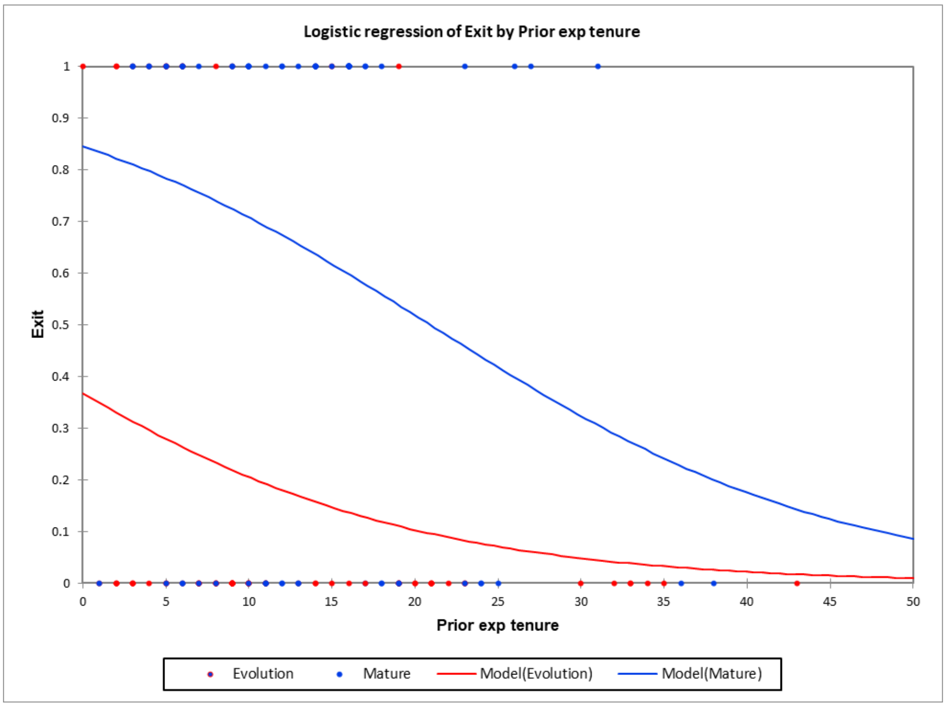
Figure 3

Model predictor parameters (Variable - Exit):

Source	Value (B)	Standard error	Wald Chi-Square	Pr > Chi²	Wald Lower bound (95%)	Wald Upper bound (95%)	Odds ratio
Intercept	-0.542	0.386	1.972	0.160	-1.298	0.214	
Length of Prior industry exp	-0.081	0.028	8.159	0.004	-0.137	-0.025	0.922
Industry phase-Evolution	0.000	0.000					
Industry phase-Mature	2.236	0.416	28.889	< 0.0001	1.420	3.051	9.352

Figure 4



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