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[Lisa Maria Messina](#), [Kristel Miller](#), [Nola Hewitt-Dundas](#)

Institutions: [Queen's University Belfast](#), [Ulster University](#)

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USO Imprinting and Market Entry Timing: Exploring the Influence of University Ecosystems

Lisa Messina, Kristel Miller , and Nola Hewitt-Dundas

Abstract—University spin-offs (USOs) have attracted increasing attention due to being an important source of innovation, university income, and job creation. To support their creation and growth, universities have developed university ecosystems of diverse actors. However, existing research has found mixed results on the effectiveness of these support mechanisms. In particular, there is a lack of research illustrating the impact premarket support mechanisms can have on premarket USO development and their strategic outcomes such as timing of the USOs' first market entry. The findings identify that both the university environment and ecosystem actors leave lasting positive and negative imprints upon USO founders. USO founders who had positive engagement with university ecosystem actors and perceived their university environment as supportive, developed entrepreneurial skills, and market knowledge earlier in the USO formation process. This resulted in greater market readiness and, consequently, contributed to an early first market entry. Conversely, USO founders who perceived barriers within their university environment and had negative experiences with ecosystem stakeholders developed more cautious and risk-averse behavior, contributing to a late market entry. This article contributes new knowledge into the antecedents of USO market entry timing through the novel lens of imprinting.

Index Terms—Ecosystems, imprinting, market entry timing, technology transfer, university spin-off (USO), university support mechanisms.

I. INTRODUCTION

THE role of business incubators and technology transfer offices (TTOs) in supporting the development of university spin-offs (USOs) is widely recognized [1]–[3]. However, in recent years, there has been increasing acknowledgement of the importance of developing a wider university ecosystem to help support USO development [4], [5]. A university ecosystem can be defined as a “set of university-affiliated organizational entities that are connected by directly supporting TT activities” [4, p. 5]. Entities comprise of not only TTOs, incubators, and science parks, but can refer to specific actors such as industry, government, surrogate entrepreneurs, and the university environment

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Lisa Messina and Nola Hewitt-Dundas are with the Queen's University Belfast, BT95EE Belfast, U.K. (e-mail: l.messina@qub.ac.uk; Nm.Hewitt@qub.ac.uk).

Kristel Miller is with the Ulster University, BT370QB Belfast, U.K. (e-mail: K.miller@ulster.ac.uk).

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[4], [5]. Prior research has found mixed results on the role of university ecosystem entities during firm formation [4], [6], [7], resulting in the need for further exploration. Furthermore, little is known about how university ecosystem engagement can influence critically important strategic outcomes, such as the timing of USO first market entry after foundation. Entry timing is a critical strategic decision for any organization whose “windows of opportunity” [8, p. 191] are time-limited before competitors emerge [9]. This is particularly important in competitive and dynamic high-technology industries, like those of USOs, where opportunities should be pursued sooner rather than later to enhance firm performance and sustainability [10]. However, the factors that influence the organizational emergence process and subsequent market entry timing, have seldom been investigated [11].

Market entry timing is more than a strategic decision and is contingent on firms having sufficient resources and capabilities in place to successfully enter the market [12], [13]. It is known that USO teams often lack entrepreneurial skills, market knowledge and resources [4], [10], [14], therefore they rely heavily on entities within their university ecosystem to successfully progress from the research phase to market entry [13], [15]. Prior studies on USOs have often focused on the motivations, challenges, and outcomes of USO development [16], [17]; yet, with few exceptions, studies have paid insufficient attention to the milestones of venture emergence from idea to market-entry, and in particular, to the determinants of its timing [11], [18]. Furthermore, even among the rare exceptions examining the time dimension in USOs and highlighting a positive correlation with external support engagement (e.g., [8], [18]), Markman *et al.* [18, p. 1073] identify the need for research that “further explicate[s] the roles that various participants play in the technology commercialization ecosystem.” In particular, they stress the need for further theoretical exploration of how different actors can help to reduce commercialization time. We attempt to enhance this line of investigation and address the gaps in previous research by employing the strategy of “theory borrowing” [19] from the fields of psychology and entrepreneurship by adopting imprinting theory.

Imprinting theory contends that prior experiences and critical events can influence individual and organizational outcomes [20]. Studies have found that the past experiences of founders, decisions made early on in venture formation [21], and environmental conditions [22], can all significantly influence a new venture's development path [21]–[24]. We suggest that this process is even more prominent in the context of USOs, where academic entrepreneurs possess complex technological

knowledge often at the expense of entrepreneurial and/or industry knowledge [10], [25], [26]. Consequently, we suggest that the university environment and external support mechanisms play a potentially important imprinting role influencing founders' pre-entry behavior and decision-making processes [4], [21], [27], and critically, USO market entry timing. Thus, the aim of this article is to answer the following research question: *RQ: How do premarket support mechanisms imprint upon USO development and influence the timing of their first market entry?*

To explore this, we take a processual perspective of USO formation to investigate the microlevel imprinting effect of university ecosystem entities, during various stages of Italian USO formation. The findings reveal that both the university environment and specific university ecosystem actors such as the TTO, incubator, industry, and surrogate entrepreneurs leave lasting imprints upon USOs' development at different stages influencing premarket entry. This imprinting was both positive and negative. Positive engagement with university ecosystem actors and a supportive environment helped USO founders develop entrepreneurial skills and market knowledge, resulting in greater market readiness at foundation and early first market entry. Conversely, USO founders who perceived barriers within their university environment and had negative experiences with university ecosystem stakeholders, resulted in more cautious and risk-averse behavior, identified as delaying their market entry.

This article makes three key contributions. First, we provide novel insights into the use of imprinting theory to understand the microlevel antecedents of USOs' first market entry timing. Second, we extend knowledge on the enduring impact of the university environment and the role individual actors play (such as the TTO, incubator, surrogate entrepreneurs and industry) during USO formation. In particular, we stress the time implications of their engagement, which are critical in the context of high-technology industries featuring increasingly short windows of opportunity. Third, this article illustrates the importance of considering the imprinting effect of the holistic university ecosystem within which USOs are developed, from as early as the research phase, as a key determinant of market entry timing.

II. THEORETICAL DEVELOPMENT

USOs are new companies formed by university faculty members, staff members, or students to commercialize academic research outputs [1] and are increasingly recognized as a valuable source of university revenue [25]. USOs share a number of similarities with high technology-based ventures, such as operating in conditions of high market uncertainty and dynamism [28], [29]. However, USOs also have unique contextual characteristics that make them more liable to failure [16], [29]. For example, USO founders can be subjected to conflicting interests, such as the "publish or perish" nature of academic culture and the profit-maximizing strive of entrepreneurship [2], [25]. This can limit the time and effort devoted to USO development, hindering timely progression [30], [31]. Additional obstacles associated with the academic origin of USOs pertain to founders' limited industry and entrepreneurial experience [26], limited networks [4], and poor business skills [10], [16]. These factors have been found

to be reliable predictors of future firm activity and outcomes [16], [25], and have been identified to cause substantial time-lags between USO research generation and its industry application [8]. Lazear [32] argues that successful entrepreneurs need to possess a variety of skills; however, academic entrepreneurs often have unbalanced skill sets, i.e., high-level technical skills but weaker business skills, resulting in longer time-lags to market [8] and higher chances of failure. Therefore, universities have introduced different mechanisms of support.

In many universities, the establishment of a TTO and/or incubator signals the institution's commitment to science commercialization activities [4], [25]. TTOs represent intermediary entities between university researchers and external entities, such as companies and investors [26], [33]. The particular aim of TTOs is to protect and manage the IP generated within universities, to establish industry partnerships, and to provide initial commercialization advice to academics [34], [35]. Whereas incubators represent facilities that provide academic founders with office space, equipment, mentoring assistance, networking support and, at times, even capital during USO foundation [6], [30]. Incubators aim to support early-stage ventures to the point where they become viable entities [35]. Substantial research has been devoted to examining TTOs and incubators in supporting USO formation, however studies report mixed findings [6], [25]. For example, prior research identifies that incubators and TTOs generate positive USO performance effects by helping academics develop entrepreneurial capabilities, access external resources [17], and assess the commercial viability of the opportunity [13]. Others have raised questions around the effectiveness of incubators [6] and TTOs (e.g., [7], [26]). Litan *et al.* [36] identify the lengthy bureaucracy of TTOs as a "bottleneck," rather than facilitator, of innovation. Furthermore, Clayton *et al.* [37] argue that the sheer breadth of support offered by incubators renders it difficult to assess their performance effects without considering the type of support provided. Consequently more research is needed to provide fine-grained knowledge on the effectiveness of different support mechanisms.

University ecosystems also comprise of government agencies who often provide proof of concept funding for early stage USOs and market parties such as surrogate entrepreneurs, industrial partners and investors [4]. These entities have been found to help USO founders overcome their skill gaps [38] by being included in the founding team of the venture. Huynh *et al.* [14] contend that by including academics and non-academics in founding teams, USOs are able to effectively integrate technical and business knowledge, resulting in positive performance outcomes [38] such as early market entry [8]. However, limited research has examined how surrogate entrepreneurs and industrial partners influence the behavior and decisions of academic founders during formation.

Furthermore, it should be acknowledged that beyond formal support systems, such as incubators, TTOs, government agencies, market agencies, university links with industry and investors [4], USOs can benefit from informal support mechanisms, which constitute an additional important component of the university ecosystems within which academic entrepreneurs operate [4]. Informal support systems include the

encouragement provided by academic colleagues, the university department and the academic environment as a whole, and have been found to influence technology commercialization behavior [39]. Muller [8] found that informal support mechanisms encourage founders in the timely identification and pursuit of the entrepreneurial opportunity, whereas formal support mechanisms significantly reduce formation costs. Ultimately, prior research agrees that a combination of formal and informal support mechanisms can assist USO formation, potentially reducing USO development time [8] through faster opportunity recognition, complementary capability development and facilitating market access [3], [25]. However, Wright *et al.* [40] and Rothaermel and Thursby [41] caution that, while support mechanisms increase the probability of USO survival, they are time-consuming and may increase, rather than decrease the time-lags between research generation and industry application. Consequently, the interrelationship between entrepreneurial support and the time dimension in USOs remains ambiguous, warranting further empirical exploration.

Research has argued that early market entrants have a higher chance of success in highly uncertain and dynamic environments, like high-technology industries [10]. Furthermore, early entrants display greater readiness to commit resources in conditions of uncertainty and rapid change, while late entrants tend to be more cautious and gradually learn from emerging information [42]. Yet, little is known about how the processes and interactions within university ecosystems can shape USO behavior and trajectories at different stages of development and how this may influence first market entry [18]. While limited insights can be gained from existing literature on USO market entry timing (e.g., [8], [18]), it is widely acknowledged within the entrepreneurship field that founding conditions play a significant role in the future development of new ventures [20], [23], [43]. Borrowing from entrepreneurship and psychology, we employ imprinting theory to cast new light on the influence of ecosystem actors and environments on USOs' first market entry timing.

A. Premarket Entry Imprinting

The concept of imprinting can be traced back to Stinchcombe [20], who suggested that the environmental conditions and events during firm formation determined the firm's organizational form and future trajectory. Since then, a vast amount of literature has explored the imprinting effects prior experiences can have on venture development [22]. The process of imprinting is said to involve two key roles: the imprinted and the imprinter [44]. The term "imprinted" refers to the "focal entity or actor that is subject to imprinting" [35, p. 293], and is normally the unit of analysis within research studies. Conversely, an "imprinter" or "source of imprint" [21] is the unit which enacts its influence over the imprinted, and it can take the form of the wider environment (e.g., the university environment), individuals and/or groups (such as the industry, surrogate entrepreneurs), and organizations (i.e., TTO, incubators).

The imprinting process has associated with both positive and negative effects [21], [24], where an experience can lead to changing behaviors, mindset, and strategic actions at both a

conscious and subconscious level, influencing organizational forms [24]. Furthermore, imprinting has been found to have an enduring effect on the organization [45] due to path-dependency based on vested interests and structural inertia, making it difficult for organizations to subsequently adapt and change [20], [22], [44]. For example, Pieper *et al.*'s [46] study on family firms found that founders' rules and values were imprinted upon the organization and passed on throughout subsequent generations, leading to the persistence of a multifamily organizational form. Lippmann *et al.* [47] suggested that imprinting persists over time due to collective memories. Similarly, Bryant [24] highlighted the importance of managing, and even designing, imprinting systems that facilitate the formation of collective memories, viewed as advantageous to entrepreneurial ventures. How these processes take place, however, is poorly understood. To contribute to our understanding of the imprinting process, it is important to identify its key elements.

Marquis and Tilcsik [22] synthesized research on imprinting theory across different disciplines, and identified that it consists of three essential elements. The first element is *sensitive periods*, which refers to different stages during new venture formation, or times of turbulent change where a firm is more susceptible to environmental influence. The second element is *stamp of the environment*, where the firm internalizes and encapsulates elements of its environment. Carroll and Hannan [48] draw upon Stinchcombe's [20] original work to argue that organizations will structure themselves to fit the environment they are exposed to during formation. The third element is *persistence*, reflecting that prior experiences embed themselves in organizational forms and are difficult to change due to path dependencies, organizational inertia, and institutionalization [21], [22].

Increasing attention is being devoted to the importance of imprinting in entrepreneurship, with scholars finding that imprints from market actors increase the entrepreneurial proclivity of founders [45] and determine new venture structure, culture and routines [24]. Others suggest that imprinting can determine an organization's fate, growth and survival [44], [45]. Furthermore, imprinting theory enables the consideration of how different contextual factors influence entrepreneurial behaviors and firm formation. For example, Micelotta *et al.* [49] explored how gender can imprint upon entrepreneurial behavior. Dufays and Huybrechts [50] find that diversity in team composition imprints upon organizations and can lead to hybrid organizational forms. Others have explored how founders' perceived social identity shapes their new venture [51]. However, few studies examine imprinting in the academic entrepreneurship context, except for recent studies by Ciuchta [52] and Hahn *et al.* [53] who show the applicability and usefulness of imprinting to understand academic and spin-off behavior. Indeed, Ciuchta's [52] study of multigenerational spin-offs originating from USOs identifies that founder experiences during first generation USO formation imprint upon future spin-offs from the focal firm. Conversely, Hahn *et al.* [53] find that academic scientists' career imprint developed through ingrained behaviors of collaborative research can positively influence their engagement in open innovation within startups. However, this change in academics behavior can only take place if the academics depart from their scientific

logic, that is to advance knowledge in a noncommercial manner, and embrace business practices such as strategic planning. How imprinting can support academics to maximize the benefits of their career imprint and minimize its drawbacks, as well as to increase the timeliness of their first market entry is poorly understood.

Existing imprinting research has highlighted the key role of the social and environmental factors in shaping entrepreneurial decisions [25]. In a USO context, this could include the academic environment and the university's approach toward science commercialization, which can influence the norms and behaviors of academic founders, and the support they receive during commercialization activities [4], [54]. Studies have found that the university context can direct the design of entrepreneurial ventures and influence the long-term motivation and entrepreneurial intent of academics, thus influencing their ability to recognize and exploit entrepreneurial opportunities [55]. Interestingly, Tilcsik [56] identifies that perceptions of an environment, as opposed to the environment per se, act as the main source of imprinting. Building on these insights, from a conceptual perspective, we suggest that the environmental conditions and ecosystem support that USOs are exposed to during prefoundation and premarket entry influence future USO development and, critically, the timing of first market entry. In particular, we suggest that the imprinting process leads to the absorption of new knowledge, experiences, and behaviors that affect the cognitive schema and mental models of academic founders, determining their strategic actions and, ultimately USOs' trajectory and timing of first market entry.

III. METHODOLOGY

A. Research Design

To capture the complexity of imprinting and how it influences USO outcomes, a qualitative, interpretivist approach was adopted. Qualitative research is appropriate for contexts where there is a goal to interpret meaning from actions and experiences [57]. Italy was selected as the context for this study for several reasons. First, similarly to other European countries such as the U.K., France, Spain, and Italy has devoted increasing efforts to promoting and supporting the research commercialization efforts of its universities.¹ For example, most Italian universities have developed university ecosystems and introduced incentives for scientists to participate in science commercialization activities [58]. Second, exploring the Italian context responds to calls for studies to explore USOs in Continental European countries, where the entrepreneurial and innovation ecosystems are notably less developed than in the U.K. and the U.S. [59], [40].

A case study approach was adopted to generate rich insights into USO development [60]. We followed a theory-based

sampling strategy to find manifestations of the theoretical phenomenon of interest, to examine its nature and extend existing knowledge [61]. A purposeful sampling method was used to identify cases which meet the required conditions, i.e., USOs that have successfully commercialized and entered the market. A semi-structured interview approach was employed, targeting multiple USOs originating from two Italian universities which are research-intensive and world-leading in STEM subjects. Both universities rank in the top 50 globally [62]² and are among the most proficient institutions nationally in the creation of USOs [63]. This strategy ensured that the USOs faced similar macroenvironmental conditions within a clearly defined institutional and geographic context to allow for comparison and subsequent theory development.

1) *Data Collection*: To ensure validity and reliability, both primary and secondary data were collected to triangulate data sources, map critical imprinting points, and allow for rich description that generates in-depth insights into a real-world phenomenon [64]. First, semi-structured interviews were conducted with a senior management representative of the TTO and the university incubator in each respective university, to gain an overarching understanding of USO development in Italy. Second, a compilation of target USO respondents for each institution was developed using the "Spin-off Italia" database and official university and company websites. 103 USO respondents were identified and contacted to determine their suitability for the study. Suitability criteria included the respondent's involvement in USO formation from its earliest stages and the USO having successfully entered the market after foundation. 22 semi-structured interviews were performed with USOs respondents. Given the renowned ambiguity surrounding "appropriate sample size" in qualitative research [65], and given the challenge of estimating data saturation, we followed Marshall *et al.*'s [66] recommendation to set a numerical guideline based on sample sizes of previous comparable studies. Given this study's focus on USO prefoundation behavior, we referred to Vohora *et al.*'s [13] study on USO formation, which examined nine U.K.-based USOs. Our article aimed to explore both early and late entrant USOs; therefore, we aimed to interview nine USOs from each category. Contact and persuasion efforts were ceased once the minimum number was reached. Semi-structured interviews were conducted with the USO founders. Furthermore, TTO and incubator manager, agency representatives and investors who operate across the two universities were also interviewed to capture the university ecosystem's perspective on USO formation and development, and to enhanced reliability [65]. Details of interview respondents are provided in Tables I and II.

A critical incident interview technique [67] was used to identify key "imprinting points" and corresponding actions. The interview questions covered topics such as the ecosystem support available to and accessed by academics during their commercialization activities, pre- and post-USO foundation; the

¹According to the NETVAL (2018) report on Technology Transfer activities in Italy, Italian universities have increased their investment in university Intellectual Property protection by 128.52% compared to 2004. Furthermore, technology licensing agreements between external market parties and universities have increased by 292% since 2004, and 80% of USOs presently active in Italy were created over the last decade.

²QS World University Rankings was used as a reference as, first, it places most of its weight on academic reputation and, second, it represents the most widely read source for university rankings (Alexa Data, 2019).

TABLE I
ENTREPRENEURIAL ECOSYSTEM RESPONDENT

Category	Interview Respondent	University	Position
TTOs	TTO 1	University 1	Head of TTO
	TTO 2	University 2	Head of TTO
Incubators	Incubator 1	University 1	General Director of Incubator
	Incubator 2	University 2	CTO of Incubator
Trade Agencies	Market Agency 1 - National	Both	External Relations Manager
	Market Agency 2 - International	Both	Business Developer - Italy
	Market Agency 3 - International	Both	Head of Sponsorships and Partnerships
	Market Agency 4 - International; based in Italy.	Both	Deputy Consul General and Deputy Director of Trade & Investment
Providers of Finance	Business Angel	Both	Private Investor
	Assistant to Business Angel		
	Industrial Partner 1	Both	Director of Industrial Partner 1
	Industrial Partner 2	Both	Director of Industrial Partner 2

types of actors USOs collaborate with during USO development; the challenges and antecedents of USO development; narratives of critical experiences, events and/or interactions during USO evolution, from the research phase to the moment of market entry, the timing of market entry and the evolution of the USO from research phase to market entry. Interviews lasted between 40 and 90 min. Detailed field notes were taken during and after the interview process [68]. Interview recordings were transcribed and translated verbatim. This process resulted in 363 pages of interview data.

2) *Data Analysis*: Data analysis involved an iterative process where emergent themes from the empirical data were interpreted in the light of existing literature and informed the direction of subsequent collection through the identification of new questions [68]. First, a process of open coding or “first-cycle coding” [69] was performed. Second, a process of pattern searching was followed which resulted in the identification of second-order themes emerging from the open codes [69]. These second-order themes were aligned with the theoretical perspective of imprinting [20], through the identification of pivotal interactions and experiences, three key “sensitive periods” were identified [21], [22] which constituted the overarching themes, or dimensions [70]. These were the research phase, the idea conception phase, and the pre-entry phase. Finally, a process of within and cross-case analysis [69] was conducted to identify similarities and differences across USO categories. This involved categorizing USOs into two groups based on their market entry timing. There is a lack of empirical studies examining the timing of first market entry [9], [11], therefore literature does not have an agreed timeframe for early or late market entry. This is due to market entry earliness being subjective, depending on the type of sector and competitiveness of the market. However, high technology sectors are acknowledged to have short life cycles, particularly in highly competitive markets

[71]. Therefore, early entrants were those who had entered the market within six months, which reflected the university TTOs’ metrics to capture earliness to market. Imprinting experiences in each sensitive period were then compared across USOs of the same category and, subsequently, across USO categories. Table III illustrates the structuring and ordering of the data, including informant-derived first-order categories, second-order themes and aggregate dimensions.

IV. FINDINGS

Analysis of the data revealed that all case USOs went through three “sensitive periods” during formation, where critical incidents at each stage led to positive or negative imprinting which influenced the USOs’ trajectory and subsequent market entry strategies. These sensitive periods included the Research Phase, the Idea Conception Phase, and Pre-Entry Phase. Fig. 1 illustrates the findings to highlight the differences between early and late entrants’ imprinting experiences, emphasizing key sources of imprinting during each phase and whether the imprinting experience was holistically regarded as positive or negative. These findings will now be discussed.

A. Research Phase

The research phase reflects the period of time in which founders were actively engaged in academic research activities, but had not yet pursued commercialization activities. This phase was identified as being very influential in directing future entrepreneurial actions, highlighting that imprinting often takes place at the subconscious level. The majority of founders reported that they were not initially interested in pursuing an entrepreneurial path; however, the wider academic environment, which had limited job opportunities for young academics, was identified as being a subconscious source of imprinting which

TABLE II
USO INTERVIEW RESPONDENTS

USO	Uni.	Field	Technology	Interview Participant	Academic Founder(s) Background	Found.Year	Market Entry
EAR1	Uni1	Electronics and ICT	Diagnostic device for industrial processes.	CEO/Co-founder	Purely academic background; team of senior academics and PhD students/post-doctoral staff.	2014	< 6 months
EAR2	Uni1	Chemistry	Custom-made solutions for surface coatings.	CEO/Co-founder	Purely academic background; team of senior academics and PhD students/post-doctoral staff.	2012	< 6 months
EAR3	Uni1	Energy	Technology for the remote supply of energy.	CEO/Co-founder	Purely academic background; team of senior academics and PhD students/post-doctoral staff.	2009	< 6 months
EAR4	Uni1	Mechanics	Robots for Industrial automation in the pharmaceutical industry.	CEO/Co-founder	Purely academic background; team of senior academics and PhD students/post-doctoral staff.	2014	< 6 months
EAR5	Uni1	Energy	Consulting services in the field of renewable energy and power electronics.	CEO/Co-founder	Purely academic background; team of senior academics and PhD students/post-doctoral staff.	2006	< 6 months
EAR6	Uni1	Mathematics	Custom-made solutions and software in a wide range of industries.	CEO/Co-founder	Purely academic background; team of senior academics.	2010	< 6 months
EAR7	Uni1	Aerospace engineering	Algorithm for the millimetric measurement and monitoring of geophysical phenomena	CEO/Co-founder	Purely academic background; team of senior academics and one PhD student.	2000	< 6 months
EAR8	Uni1	Electronics	Technology for X-ray and Gamma-ray applications.	CEO/Co-founder	Purely academic background; team of senior academics and recent PhD graduates.	2009	< 6 months
EAR9	Uni2	Energy	Storage systems for renewable energy.	CTO/Co-founder	Purely academic background; team of senior academics and PhD students/post-doctoral staff.	2005	< 6 months
EAR10	Uni2	Electronics	Innovative software for the resolution of modelling problems.	President/Co-founder	Purely academic background; one senior academic and two recent PhD graduates.	2007	< 6 months
EAR11	Uni2	ICT	Technology aimed at efficient energy consumption.	CEO/Co-founder	Purely academic background; team of recent PhD graduates.	2011	< 6 months
LAT1	Uni1	Nuclear engineering	Algorithm and model development for the performance of industrial systems.	CEO/Co-founder	Purely academic background; team of senior academics and PhD students/post-doctoral staff.	2012	> 6 months
LAT2	Uni1	Mechanics	Technology for the conversion of traditional vehicles into hybrid or electric vehicles.	Founding member (no ownership)	Purely academic background; team of senior academics.	2012	> 6 months
LAT3	Uni1	Geomatics	Custom-made solutions using Geomatic technologies.	1.CEO/Co-founder; 2.Co-founder /Researcher.	Purely academic background; team of recent PhD graduates/post-doctoral staff.	2012	> 6 months
LAT4	Uni1	Mechanics	Robots for Industrial automation and bin picking.	CEO/Co-founder	Purely academic background; team of senior academics and PhD students/post-doctoral staff.	2006	> 6 months
LAT5	Uni1	Electronics and ICT	Technology for the characterisation of MEMS sensors.	1.President/Co-founder; 2.CEO/Co-founder	Purely academic background; team of senior academics and recent PhD graduates.	2014	> 6 months
LAT6	Uni1	Biomedical engineering	Diagnostic device for respiratory pathologies.	CEO/Co-founder/R&D Director	Purely academic background; team of recent PhD graduates.	2010	> 6 months
LAT7	Uni1	Electronics	Innovative e-Bike motor.	Co-founder/Marketing Manager	Purely academic background; team of senior academics, PhD students and recent PhD graduates.	2013	> 6 months
LAT8	Uni1	Energy	Custom-made solutions in the field of energy efficiency.	Co-founder	Purely academic background; team of senior academics.	2013	> 6 months
LAT9	Uni2	Fire engineering	Custom-made numerical solutions in the fields of fire engineering and thermal science.	CEO/Co-founder	Purely academic background; team of senior academics.	2007	> 6 months
LAT10	Uni2	Aerospace engineering	Custom-made technologies for aerial surveillance.	President/Co-founder	Purely academic background; team of senior academics.	2005	> 6 months
LAT11	Uni2	Electronics	Intelligent LED lighting bulbs.	1.CEO/Co-founder; 2.Scientific Advisor/Co-founder	Purely academic background; team of senior academics.	2013	> 6 months

TABLE III
CASE DATA SUMMARY

<i>Early Entrant USOs</i>	Research Phases		<i>Late Entrant USOs</i>
First Order Codes	Second Order Codes	Second Order Codes	First Order Codes
The lack of career opportunities within the academic environment motivated founders to create a USO as an alternative career path (positive) . The knowledge-driven orientation of the academic environment contributed to academics adopting a research-driven attitude to work, generating knowledge for knowledge accumulation instead of its commercialisation (negative) . The academic and commercial environments largely viewed as separate worlds (negative) ; academics gain limited exposure to business experience and, therefore, develop limited business-related skills (negative) . Pressure to deliver state-of-the-art research outputs caused academics to focus on being innovative and world-leading (positive) .	Academic Environment	Academic Environment	The lack of career opportunities within the academic environment motivated founders to create a USO as an alternative career path (positive) . The knowledge-driven orientation of the academic environment contributed to academics adopting a research-driven attitude to work, generating knowledge for knowledge accumulation instead of its commercialisation (negative) . The academic and commercial environments largely viewed as separate worlds (negative) ; academics gain limited exposure to business experience and, therefore, develop limited business-related skills (negative) .
Academics' technology transfer experience and market engagement caused a shift in mind-set from purely research-driven to market-driven (positive) . Market-driven research generated outputs that addressed market gaps and led to the recognition of entrepreneurial opportunities (positive) . Constant engagement with market parties through TT increased academics' confidence in entrepreneurial opportunities (positive) .	Technology Transfer Experience	Technology Transfer Experience	Dominance of research-driven outputs resulted in technologies being transferred with limited market demand (negative) ; TT partners often regarded technologies as premature and/or underdeveloped for the market (negative) . TT engagement generated initial ideas to commercialise the research (positive) .
University department supported and encouraged academics to engage in science commercialisation by creating a favourable environment (positive) .	University Department	University Department	Pressure on behalf of the department for academics to behave as 'pure academics' resulted in academics manifesting limited interest in the commercial environment and aversion to research commercialisation. This was regarded as having a long-lasting influence on their behaviour throughout formation (negative) .
<i>Early Entrant USOs</i>	Business Idea Conception		<i>Late Entrant USOs</i>
First Order Codes:	Second Order Codes:	Second Order Codes:	First Order Codes:
Potential clients approached the research group requesting their technology, thus signalling a market gap (positive) . Potential clients gave academics encouragement and confidence in the attractiveness of the opportunity (positive) . Potential clients transferred market-specific knowledge to the research group and helped academics frame the opportunity (positive) . Potential clients supported academics in recognising the market value in their proposition (positive) .	Clients/Potential Clients	Business plan competitions	Positive results in regional, national and/or international business plan competitions resulted in encouragement and greater confidence on behalf of academics in their business opportunity (positive) . Feedback received from business plan competitions helped academics identify the valuable aspects in their proposed market offering (positive) .
The incubator helped give academic founders more direction and provided a clear sequence of steps to follow to reach foundation and market entry (positive) . The TTO required all founding teams to develop a business plan and forecast sales figures as a bureaucratic requirement of the university to approve USOs. This provided greater clarity to founders and inspired their growth ambitions (positive) . Incubator and TTO use helped founders develop business skills and better business planning thanks to the involvement of TT experts, market mentors and advisors (positive) . Positive feedback on behalf of the TTO and incubator resulted in academic founders feeling more encouraged and confident about the opportunity (positive) . Support received from the TTO and the incubator helped founders frame the opportunity in the light of existing market offerings and identify the value-added aspects of their technology (positive) .	Incubator and TTO	Technology Transfer Experience	Technology transfer parties signalled that demand was low and that the market was not ready for the technology yet, resulting in more cautious behaviour (negative) . Engagement with market parties during technology transfer enabled academic founders to gain market-specific knowledge and understand the marketplace better (positive) . Technology transfer engagement enabled founders to identify a market gap, resulting in their opportunity identification (positive) .
Industrial partner helped founders identify the opportunity by scanning the market (positive) . Involvement of industrial partner supported founders in framing the business opportunity more clearly and shaping their offering according to the opportunity (positive) . The business experience of the industrial partner, combined with founders technological know-how, generated synergies (positive) and contributed to the founding team being more proactive and confident (positive) .	Industrial Partner	Industrial partner	Negative feedback and disinterest on behalf of industrial partners involved the founding team resulted in discouragement and perceptions of low market demand/unattractiveness of opportunity (negative) .
Involvement of a surrogate entrepreneur in the founding team resulted in the transfer of commercial skills and market awareness (positive) . Merging of technical and business skills created founding teams with technical excellence that had the ability to effectively sell market solutions (positive) . Surrogate entrepreneurs guided academic founders toward successful opportunity exploitation by providing them with clear direction and teaching them 'appropriate entrepreneurial behaviour' (positive) . The involvement of surrogate entrepreneurs helped founders develop a USO with a business model that would be appropriate to its market opportunity (positive) .	Surrogate Entrepreneur	TTO	By forcing founders to develop a business plan, the TTO provided greater clarity to USO founders about the opportunity (positive) ; however, founders perceived forecasting sales figures as an experience that pressurised them to overestimate growth outcomes, increasing their caution and risk-aversion (negative) .
		University	The university was perceived to be neutral or disinterested toward the creation of USOs and science commercialisation, thus providing little encouragement to founders (negative) .

TABLE III
CONTINUED

<i>Early Entrant USOs</i>	Pre-Entry		<i>Late Entrant USOs</i>
First Order Codes	Second Order Codes	Second Order Codes	First Order Codes
Potential clients taught academic founders how to plan for opportunity pursuit and effectively present their offering as a market parties (positive) . The identification and involvement of clients during pre-foundation perpetuated confidence in the opportunity and encouraged founders to persevere through formation (positive) . Potential clients highlighted the need to maintain a clear separation between the USO, a private profit-making firm, and the parent university, a public knowledge-driven institution, when approaching market parties (positive) .	Clients/potential clients	Academic environment	An unsupportive environment perpetuated founders tendency to behave extremely cautiously when approaching potential clients (negative) . Limited exposure to market parties resulted in founders developing limited business skills and largely focusing on firm survival and sustainability, rather than growth (negative) .
The incubator helped founders identify the required steps and approach the appropriate people to ensure a clear path to market, giving founders greater direction and purpose (positive) . The incubator placed emphasis on USO growth, as opposed to mere survival, leading founders to also embrace this focus (positive) .	Incubator	Industrial partners	The involvement of industrial partners helped founders gain greater structure and direction toward market entry (positive) . Engagement with industrial partners often did not generate positive, synergistic results, as the interests of USO and industrial partner were not aligned and the two parties, therefore, did not work well together (negative) . Industrial partners discouraged and undermined USOs, and often caused delays due to the industrial partners not prioritising their relationship with the USOs who, in turn, heavily relied on them for support and guidance (negative) .
Industrial partner involvement was a significant source of encouragement and confidence (positive) , and also alleviated founders' risk-perceptions by acting as USO's first client and providing financial support (positive) . The industrial partner was provided guidance and teaching to USO founders, by transferring business skills, commercial awareness and providing continuous mentoring support (positive) . Industrial partner involvement, largely motivated by prospects of financial gain, drove founders to proactively search for ways to take the offering to market and maximise firm growth (positive) . The industrial partner acted as a critic of the 'academic way of doing things', emphasising the limitations and non-commercial ways of the academic environment, and led founders to adopt a more market-driven approach (positive) . e involvement of an industrial partner gave USOs credibility in the eyes of market parties and provided access to the partner's market channels and contacts, accelerating entry (positive) .	Industrial Partner	Incubator	The incubator regarded as inadequate, expensive and useless in its support to USOs (negative) . The incubator was highlighted as employing a one-size-fits-all approach to USO support, and was largely regarded as inadequate by USOs that did not fit its mould (negative) .
The surrogate entrepreneur emphasised the need to separate the USO from parent university to increase its credibility as a private company (positive) , and their involvement gave USO founders a greater market-driven orientation (positive) . The surrogate entrepreneur combined technical knowledge with market knowledge, helping founders rapidly position and take their offering to the market (positive) . The surrogate entrepreneur gave founders a more structured approach and clear direction, as well as placing more emphasis on firm growth than mere survival (positive) . The involvement of surrogate entrepreneurs provided USO founders with access to pools of commercial knowledge and market contacts, such as investors (positive) .	Surrogate Entrepreneur	University	The university provided USOs with added credibility from a technological and innovation perspective, due to the scientific reputation of the university (positive) . The university damaged the credibility of the USO in the eyes of market parties, due to the firm's association with a public institution, which are notoriously complex and bureaucratic in Italy. This was regarded as an additional obstacle by founders and caused delays to market entry (negative) .
The USO's association with its parent university provided the firm with added credibility in the eyes of market parties, due to the high esteem of the parent university and its scientific reputation (positive) . Continuous collaboration with the parent university and, particularly, the research group and its lab, provided technical support during the critical final stages of technology launch onto the market (positive) . A supportive university environment provided founders with further confidence and reassurance in the pursuit of an entrepreneurial opportunity, and even encouraged the involvement of industrial partners (positive) .	University	Holistic ecosystem	The holistic ecosystem caused delays and challenges through lengthy and complex bureaucracy, unfulfilled agreements (such as delayed funding provisions, product orders placed with substantial delays, etc), which caused substantial discouragement and further caution on behalf of USO founders (negative) .

influenced the pursuit of USO formation for both early and late market entrants. Indeed, both sets of founders were motivated by the same activation trigger.

There were no jobs in academia in Italy. Essentially that was the main driver behind the creation of the firm. I mean, had we been in an environment where Italian universities [...] offered more opportunities for young researchers, perhaps we wouldn't have thought about creating a spin-off. (USO Founder, Case LAT3).

A second source of imprinting during the research phase was the parent university's commitment to and support of technology transfer (TT). As shown in Table III, both universities had early and late market entrants. Despite USO founders in both

universities being exposed to the same university-wide processes and support mechanisms for TT, the findings revealed that early and late entrant founders had different perceptions and experiences, resulting in different imprinting effects. For example, late entrants perceived their academic environment as unsupportive of TT and as prioritizing pure research. The pressure for scientific advancement, publication and securing research funding was particularly strong at the departmental-level. The founder of Case LAT6, a biotech USO developing diagnostic respiratory devices, stated that their categorization and departmental expectation to be "pure academic researchers" was a key determinant of their slow and gradual progression through formation. This categorization influenced the amount of time

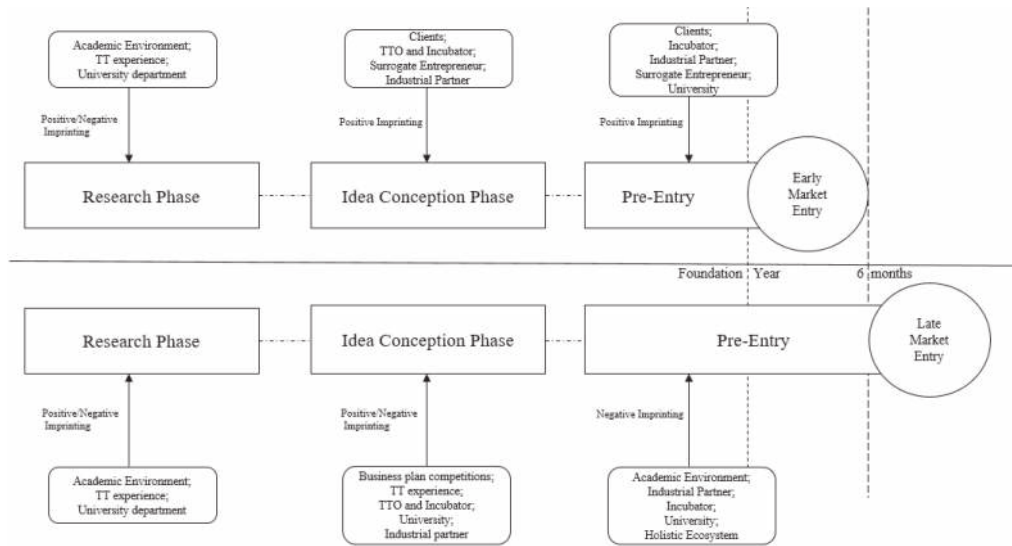


Fig. 1. Prefoundation imprinting in early and late entrant USOs.

they spent on developing their USO, as they did not deem it to be a legitimate activity. Therefore, their perception of the academic environment negatively shaped their entrepreneurial behavior, leading to cautious and risk-averse behavior throughout USO formation. In contrast, early entrants reported a supportive university and departmental environment. They acknowledged that, at the beginning of USO formation, it was challenging to balance research, teaching and exploratory TT; however, their experience of their institutional and departmental support for TT were highlighted as being positive.

It was evident from the interviews that USO founders' early technology transfer experiences had a long-lasting impact on their entrepreneurial behavior. A negative experience with a university ecosystem entity at the research phase significantly influenced subsequent USO development. For example, several late entrants reported that, during TT activities in the early research phase, external partners' concerns regarding either the attractiveness of the technology (e.g., LAT4) or its premature state (e.g., LAT7) led progress to stall. For example, Case LAT4, a USO marketing three-dimensional facial-recognition technology, engaged with an external company that told the founders that "this kind of commercial activity is basically over, there was no market for it." These negative experiences led to cautious behavior until enough market evidence was collected to identify a viable opportunity. Consequently, perceiving high risks in relation to technology transfer resulted in the prioritization of other academic activities, and in founders limiting their engagement with the TTO.

All early entrants, conversely, highlighted an on-going engagement with the TTO and external market parties during the research phase. This engagement stemmed from their positive perception of their universities' support mechanisms, resulting in more openness to imprinting. In particular, early entrant founders reported that close engagement with the TTO positively imprinted upon them, making them realize the importance of market knowledge to complement academic expertise. This

resulted in more market-driven research activities that targeted existing market gaps, and encouraged engagement with external organizations. The TTO also encouraged the founders to develop entrepreneurial and business management skills alongside their research activities, which proved useful in subsequent stages of USO development.

A key difference between early and late entrants was that the majority of early entrant founders were constantly engaging with external ecosystem stakeholders from the outset. These interactions subconsciously imprinted upon early entrants. For example, Case EAR1, a USO marketing optical fiber sensor technology, identified that working with large companies for over 15 years helped them understand their potential markets and how their research could have market value. All early entrants reported that engagement with market experts, potential clients and customers during the research phase led to the accumulation of market knowledge. This market knowledge aided the refinement of ideas, led to market validation and consequently improved their confidence in the attractiveness of the business opportunity. Case EAR1 illustrates this: "We had received a request from a huge multinational company to develop sensors for their industrial plants[...]. We developed it as university researchers[...]. We just adapted it a little. [...] So these are companies that basically showed us that there was an interest in this kind of thing in the market, beyond just research."

It is important to note that early entrants' experiences with these external actors were identified as positive, in contrast to late market entrants who identified their interactions with external entities as negative, rendering them less open to imprinting. The next sections will illustrate how this posture consequently affected imprinting in later phases. Early entrants' positive interactions and engagement with external entities cumulatively contributed to shifting their focus from the academic notion of knowledge generation to the market notion of knowledge exploitation from as early as the research phase. This made them more susceptible to imprinting in later phases.

B. Business Idea Conception

The stage at which founders identified their entrepreneurial opportunity and consciously decided to create a USO was considered a sensitive period [21]. During this stage, early entrants' positive engagement with a variety of ecosystem players was found to support their transition from the research phase to business idea conception. In particular, early entrant USOs reported that the TTO, the university environment and, to a lesser extent, the incubator were key sources of imprinting.

For example, to initiate the USO formation process, the TTO required all founders to develop a business plan detailing the business opportunity and its planned pursuit. Early entrants reported their initial apprehension regarding the development of a business plan, due to their expert knowledge already indicating a market need for this technology. It was only after engaging with the process that early entrant founders recognized its benefits. Among the benefits achieved through this process were the ability to evaluate market gaps, greater clarity of direction, better framing of the opportunity, and a targeted action plan with clearer paths to market. Therefore, the TTO was a positive imprinter through its TT processes. The TTO was also identified by early entrants as driving their growth ambitions by setting ambitious performance targets.

A perceived supportive university environment was found to continue to enhance the confidence of early entrant founders. In particular, department-level acceptance of TT activities led early entrant founders to deem TT to be a legitimate part of their professional responsibilities. Combined with the imprinting effect of the TTO, this encouraged founders to spend time engaging with and involving surrogate entrepreneurs and industrial partners extensively in USO formation. Surrogate entrepreneurs and industrial partners, in turn, emerged as critical imprinters during the later pre-entry phase of early entrant USOs. Late entrant USOs, in contrast, engaged with university ecosystem entities to a lesser extent during the business idea conception phase; ecosystem entities were viewed in a negative light due to founders' negative experiences of engagement during the research phase. Most late entrant founders perceived their departmental environment to be largely disinterested and neutral toward USO formation. Case LAT9, for example, highlighted that the university department had a "*confused relationship with spin-offs [as] on the one hand it views them in a positive light, on the other hand it's suspicious of them, because it fears that spin-offs might [steal] research contracts or resources from it.*"

During idea conception, late entrant USOs reported that they primarily engaged with the TTO to fulfill the bureaucratic requirements involved in the formation process. Instead of being motivated by the ambitious targets set by the TTO, as was the case for early entrants, late entrants viewed them in a negative light, feeling under pressure to overestimate their growth ambitions and forecasted sales figures. This generated a sense of uncertainty and fear of not meeting performance expectations, which added caution to their behavior throughout formation. The difference in perceptions of TTO support among early and late entrants, despite the same mechanisms being place, is interesting to note. Late entrant USOs had very limited engagement with

and consequential imprinting from other ecosystem parties such as the incubator, surrogate entrepreneurs, industrial partners, and investors. Critically, in the rare instances where interactions occurred, they often resulted in founders feeling discouraged and/or less committed to the venture.

We approached an investment fund at that time, and their comments were to the effect of "Well, the idea doesn't sound good... it's not flashy enough". [...] And that was a first important knock-back... We didn't agree [with their opinion], but we hadn't really thought about the marketing side of things. (USO Founder, Case LAT11).

In sum, during the business idea conception phase, early entrant USOs engaged with a wide variety of ecosystem players and these interactions generated long-lasting commitment, encouragement, and confidence among USO founders. Conversely, late entrant USOs reported much more limited and sporadic engagement with ecosystem players. Their perceptions of the university environment and negative engagement with external entities in the research phase appeared to have had a lasting influence over both their openness to engage with entities and their commitment to the entrepreneurial opportunity, leading to more cautious behavior. This limited their skill development compared to early entrants and, ultimately, slowed down their progression through formation and influenced their market entry timing.

C. Pre-Entry

Pre-entry is a sensitive period that began during prefoundation, after the opportunity had been identified and framed, and ended when the firm entered the market for the first time, post-foundation. In both early and late entrant USOs, this sensitive period was the longest and most influential in terms of the timing of market entry. Four university ecosystem players emerged as being influential imprinters in the context of early entrant USOs: the incubator; surrogate entrepreneurs; industrial partners; and the parent university. The incubator was perceived as a positive source of knowledge and helped with skill development. Indeed, thanks to the incubator's support, early entrant founders recognized their value proposition and developed the entrepreneurial skills needed to rapidly introduce it into the market.

The incubator was really very important for us, particularly in terms of giving us business skills and support, helping us perform market analyses, approaching clients, understanding the market... (USO Founder, Case EAR11).

The majority of early entrants identified positive imprinting from the involvement of surrogate entrepreneurs and/or industrial partners during USO formation. It was identified that surrogate entrepreneurs acted as mentors, where they helped alleviate concerns and perceived uncertainty about the entrepreneurial process by sharing their knowledge and past experiences, both positive and negative. By sharing entrepreneurial and industry experience, surrogate entrepreneurs enabled founders to become more conscious of the target market, of their value proposition and, critically, of how to effectively sell it to potential clients. As a result, founders manifested greater confidence when approaching potential clients. This pattern

was particularly influential when surrogate entrepreneurs and industrial partners possessed both business skills and a technical understanding of the USO's offering, and were able to integrate the two.

[By having] *an engineering background, combined with his professional experience, [the surrogate entrepreneur] was completely aware of what our offering was capable of achieving. Therefore, he was able to sell it to market parties that did not come from a technical background. We followed his lead, basically.* (USO Founder, Case EAR6).

The findings, however, revealed that positive imprinting could only be realized when all parties' were open and responsive to the relationship. The mere presence of a surrogate entrepreneur and/or an industrial partner was not sufficient; both parties had to be committed to the relationship by actively collaborating and combining their skillsets. This was particularly evident in cases EAR4 and EAR5, where the industrial partner recognized the shortcomings in academic entrepreneurs' business skills and embraced the role of teaching academics how to frame their business *"with an industry ethic, [where] the key objective is to generate turnover [...] and to sell a solution to the client's problems"* (USO Founder, Case EAR5). Where founders were open to learning from the industrial partner and devoted efforts to doing so (as was the case with early entrants), this resulted in positive imprints on the USOs. Furthermore, industrial partners often acted as USOs' first clients after foundation. This provided founders with reassurance regarding the firm's early survival and greater legitimacy when approaching other potential clients. For example, Case EAR8 stated that, among the reasons behind the involvement of an industrial partner during formation *"was that [they] would commission work from us, meaning particular developments, product parts, and so on. This allowed us to begin the activity very quickly, and importantly, it gave us a track-record of clients."* This was particularly important as most academic founders of both early and late market firm categories reported that, due to their academic background, their instinctive tendency would have been to be cautious and risk-averse. Therefore, by engaging with and being open to industrial partners and surrogate entrepreneurs, a positive imprint was embedded which changed founders mind-set and behaviors, ultimately contributing to an earlier market entry.

A final important source of imprinting identified by early entrant USOs during pre-entry was the parent university. Affiliation to their parent university was perceived by early entrants as adding status and credibility, where university affiliation signaled to market parties that the USO marketed state-of-the-art reliable and innovative offerings, as *"everyone expects that anyone associated with [this university] will always come up with amazing and new innovative ideas"* (USO Founder, Case EAR1). The added credibility was reported to facilitate early market entry because it provided a stamp on the USO, which signaled to market parties that the USO was reliable. Furthermore, it gave early entrant USO founders more confidence to speak to key industry players and potential customers. *"By being affiliated with the university, we eliminated the reputational barrier the spin-off might have encountered otherwise... You know, I would call people saying "Good morning, I am calling from [name of*

USO] from [name of university]", and their reaction would be "Oh! Help! This must be serious!" (USO Founder, Case EAR2). The affiliation was identified as being critical during early entrant USOs' pre-entry phase and accelerated their progression to market, a pattern that did not emerge among late entrant USOs.

Late entrant USOs identified three sources of imprinting during pre-entry: industrial partners, the university, and the wider academic environment; and the university ecosystem as a whole. Many late entrants highlighted challenges and obstacles during pre-entry which caused the founders to feel discouraged and to perceive higher risks than reported by early entrants, which appeared to slow their market entry. For example, similar to early entrants, the majority of late entrant USOs engaged with industrial partners during pre-entry. However, unlike early entrants, late entrant USOs identified their industrial partners as unhelpful, disinterested, and uncommitted to the venture. For example, Case LAT10 and Case LAT5 reported that their industrial partners had made promises, such as the provision of financial support, market access and commissions that were not subsequently kept, creating further challenges for the USOs and increasing their time-to-market.

[The industrial partner] was meant to order some products from us straight away [upon foundation]. But we received the order with a 10-month delay. During those 10 months, the person that we were hoping to hire, a highly specialised guy, was hired by another company. So we weren't able to hire anybody, and this created a loss of momentum for the spin-off. Effectively, we were only able to enter the market with this product after 10 months (USO Founder, Case LAT10). Such a pattern emphasizes the need for synergy and fit among the involved parties for imprinting to happen, and not their mere involvement. Late entrants' perceptions of and experiences with ecosystem entities, where external entities behaved in a disinterested and uncommitted manner, resulted in the USOs and external parties not being able to fruitfully cooperate and to realize the added value of combining their tangible and intangible assets. The interviews revealed that late entrants' negative experiences and lack of synergy with ecosystem entities during each phases cumulatively increased their caution, risk aversion and closure to future imprinting.

Similar to early entrants, late entrants also identified the university and the wider academic environment as a source of imprinting during pre-entry, but this was not positive. Late entrants perceived their affiliation as having slowed down their progress, leading them to hide their nature as USOs from market parties. Indeed, late entrants reported that market parties erroneously viewed USOs' university affiliation as signaling the involvement of a public institution, which in the Italian context is notoriously complex and bureaucratic. This was suggested to drive many potential clients and investors away from late entrant USOs, thus slowing down market entry. Case LAT3 identified, *"Spin-offs of any university had huge warning signs associated with them, because they viewed you [the USO] as working for a public institution... so firms wanted to have nothing to do with you. [...]"*. While the university affiliation also potentially presented a risk for early entrants, the findings revealed that the positive synergistic involvement of surrogate entrepreneurs

and industrial partners from the outset enabled founders to learn how to make the distinction between the firm and the university very clear and, in some instances, to use it to their benefit when reaching out to market parties. As a result, the founders were able to benefit from the university's scientific credibility, while reducing its market-related risks.

A final source of imprinting among late entrant USOs was the university ecosystem as a whole. This was frequently emphasized by late entrant founders as providing inadequate or limited support. Incubators and the funding infrastructure for early stage companies were emphasized as being a source of frustrations and delays. Several founders labeled the incubator as being "useless" and "expensive," and as employing a one-size-fits-all approach to support. According to the founders, such an approach did not complement their existing skill-sets, nor did it address their weaknesses.

The support the incubator provided... it was completely useless and a waste of time. The vast majority of the firms that were incubated there developed software, or applications. We were making actual things, so we needed a different type of support that they couldn't provide. Manufacturing support, logistical support, storage space... And on top of that, it was outrageously expensive. (USO Founder, Case LAT6).

In sum, the pre-entry stage emerged as being the most influential sensitive period in relation to USOs' market entry timing. Early entrant USOs continued to engage with ecosystem players extensively and benefited substantially from these interactions. However, it was evident that a condition of positive imprinting was that the interactions and relationships were of a collaborative and synergistic nature, whereby all parties involved manifested commitment and openness to the engagement. Conversely, late entrant USOs also engaged with ecosystem entities during pre-entry, despite their negative experiences in the earlier phases. However, they were unable to establish synergistic collaborations and, therefore, faced several obstacles which contributed to a delayed market entry.

V. DISCUSSION

Over the last decade, the important role USOs play in transferring academic research to markets, generating university income, regional innovation and employment has been acknowledged [13], [25]. Prior research has sought to explain the process of USO development, focusing on issues such as the characteristics of the founders and founding team [10], [16] and how different support mechanisms such as TTOs and incubators can contribute to USO development [6], [25], [26]. However, Good *et al.* [4] argue that prior research takes an atomistic view of technology transfer support and identifies the need to look at the holistic impact of the university ecosystem. This is particularly important for high technology USOs, who often operate within short industry life cycles, requiring early market entry to increase their chances of success [71]. We build on prior USO research and identify how imprinting theory can generate new insights. We do this by taking a microlevel perspective of the process of USO formation to explore the role of university ecosystem engagement in influencing the timing

of a USO's first market entry. From the findings, we identify three sensitive periods, namely the research phase, idea conception, and premarket entry, which constitute important phases during USOs' prefoundation development. During each phase, university ecosystem imprinters were identified to play a positive or negative role in shaping USO founders' strategic decision making, risk perceptions, and market readiness (see Fig. 1).

The findings provide new insights on the role played by individual ecosystem entities as important imprinters throughout USO formation. For example, extending prior research [26], [33], the findings identify the key imprinting role TTOs, incubators, surrogate entrepreneurs, and industrial partners had for all USOs (either positive or negative) at different stages (see Fig. 1) for early and late market entrants. Whilst these actors have been found to play a vital role in USO development in prior literature [6], [7], [14], they have not been linked to market entry timing. TTOs, for example, were identified by early entrants as having helped ingrain the need for market research [54] from as early as the research phase, helped with skills development and connected them with other important entities. Incubators were also perceived as important imprinters by early entrants, providing strategic support in translating research outputs into attractive market offerings during pre-entry. Surrogate entrepreneurs and industrial partners were identified as instrumental in instilling entrepreneurial proclivity within early entrant founders. Ultimately, these interactions influenced founders' future decisions and actions [21], [53] by not only developing their skills but through altering their cognitive frames, shifting from a largely conservative and survival-focused mind-set, to a growth-driven orientation. These positive imprinting experiences, however, were not identified among late entrant USOs, who engaged with ecosystem entities to a lesser extent. Despite being in the same university environment as early entrants, late entrants emphasized the university environment, the TTO, the incubator, surrogate entrepreneurs, and industrial partners as negatively influencing their USO development. This was due to negative comments which generated discouragement, heightened uncertainty and caution which had a long lasting impact, leading to delays in their USO development.

While the individual imprinting role of each entity emerged as important, extending prior research on the value of certain support mechanisms and entities [4], [53], what appeared to be even more critical was their holistic imprinting effect on USO development [4]. The ecosystem interactions maintained by early entrant USOs throughout the different stages of formation holistically benefited them by positively imprinting entrepreneurial behaviors and encouraging the academic founders, helping to alleviate resource challenges and facilitating the acquisition of market knowledge. The opposite pattern emerged among late entrant USOs, whose holistic engagement with the ecosystem perpetuated founders' risk-aversion and uncertainty about the entrepreneurial opportunity. In particular, the findings indicated that founders' perceptions, experiences, and interactions with the university ecosystem as a whole, as opposed to the support provided per se, emerged as influential. Indeed, the support provided by the university ecosystem appeared to remain consistent for all USOs within the same institution; yet, founders of each

USO category reported very different imprinting experiences with the same types of actors. These findings are in line with Tilcsik's [56] arguments and would help explain the mixed findings reported by prior research [4], [6], [7]. Furthermore, they highlight the need to monitor interactions with and perceptions of the university ecosystem to ensure synergistic and positive experiences from as early as the research phase.

Critical to the divergence in ecosystem perceptions was late entrants' tendency to be less receptive and open to university ecosystem interactions and therefore imprinting, compared to early entrant USOs. Indeed, positive experiences in the research phase impacted USOs' openness to receiving support at later phases of development, and the extent to which founders actively or passively pursued USO development [54]. This is consistent with existing arguments that positive imprinting is an active, rather than passive process of transmission between two or more committed parties [21], [24]. Hahn *et al.* [53] stress that individuals need to be receptive and open for social interactions to "stamp" an influence over future actions and trigger cognitive changes. In particular, scientists need to possess the right mind-set to abandon their academic "career imprint" and create an organizational culture that is conducive to entrepreneurship [72]. Our findings illustrate how this can be achieved through positive imprinting. This extends research by Hahn *et al.* [53], who highlight the importance of having a reference point to benchmark "appropriate behavior." For example, if the academic founders use their academic peers as the key reference point for appropriate behavior, as was the case for late entrants, they are likely to reinforce their shared academic norms and cognition and are, therefore, unlikely to embrace an entrepreneurial and risk-taking mind-set. Conversely, if the academic founders use their market peers as a new reference point for appropriate behavior, as was the case in early entrant USOs, they are more likely to accept and successfully emulate entrepreneurial behavior. Consequently, our findings provide important insights into how academic founders can overcome their "career imprint" [53] and become receptive to entrepreneurial imprinting on behalf of university ecosystem stakeholders.

Overall, the findings extend prior research on USO support mechanisms [14], [52] and identify that through receptivity and openness to ecosystem imprinting, USOs learn to manage the risks and uncertainty associated with an early market entry in a dynamic technological market. In particular, we provide empirical evidence identifying that USOs will achieve market readiness earlier if they have positive early interactions with university ecosystem entities, which cumulatively will lead them to be open to future ecosystem engagement and imprints [43]. It is widely recognized that subconscious memory [24] and organizational inertia can cause rigidities that can be difficult to change [73]. Therefore, it is important that USO founders are exposed to a supportive university environment and positive ecosystem interactions from their research phase; but also accept these new partners as appropriate reference points for new behavioral development. Collectively, these factors will enhance the effectiveness of USO development and earliness to market. These findings are important as, first, they contribute to explaining why some academic founders embrace

the norms of entrepreneurship while others continue to prioritize their scientific achievements [1], [25], [28]. Second, they highlight that the mind-set of academic founders during formation is as important as the quality of support provided by the ecosystem.

VII. CONTRIBUTIONS AND CONCLUSION

Our findings provide new insights into how imprints from university ecosystems can play a role in influencing the timing of USO market entry. Overall, our article makes several contributions to theory development. First, we extended literature on USO market entry timing by identifying its determinants through the novel lens of imprinting theory. To date, there is a lack of research on the microlevel influences of USO market entry timing [8], [18], [43]; therefore, our article helps to extend knowledge on how positive imprinting from university ecosystem actors and a supportive university environment can lead to earlier market entry. Additionally, we provided new insights into the application of imprinting theory in a USO context by identifying the role that different university ecosystem actors play at key "sensitive periods" in helping USO founders to manage risk and uncertainty throughout formation, resulting in greater market readiness at foundation and earlier market entry.

Second, we contributed to the literature on university ecosystems by identifying the enduring impact that the university environment and individual ecosystem actors (such as the TTO, incubator, surrogate entrepreneurs and industry) can have on USO founders' decision making, motivation and market readiness. Through this, we provided new insights into the market entry timing implications of university ecosystem support. Understanding the determinants of market entry timing is critical in the context of high-technology industries which have increasingly short windows of opportunity [43] and life cycles [71]. Furthermore, in line with Ellis *et al.* [45, p. 66], who suggests that "*founders imprint the culture, knowledge, and strategies to which they are initially exposed onto their organizations,*" we drew attention to the influence positive and negative imprints university ecosystem actors can have on USO founders from as early as the research phase. Through this, we contributed to explaining the existing conflicting findings on the firm-level outcomes of different university support mechanisms [6], [7] by illustrating that USO founders may be less receptive or "open" to ecosystem support due to prior experiences which consequently influence future imprinting. We illustrated that early entrants' greater openness to engagement with university ecosystem actors due to positive experiences at the research phase compared to late entrants contributed to the early entrants' positive imprinting and, subsequently, earlier market entry.

Third, the article contributes to academic entrepreneurship literature and, in particular, it extends knowledge on the importance of enhancing their market and industry skill development to improve USO firm-level outcomes [8], [14]. The findings support and extend existing research by suggesting that the intervention of industry-experienced individuals, such as industrial partners or surrogate entrepreneurs, help to generate favorable firm-level outcomes [38], particularly early market entry. These

time advantages stem from the learning curve effects associated with the external partners' prior experience which, when combined with technological knowledge, shorten time-to-market [43]. A condition for the achievement of these advantages was the ability and willingness of academics to abandon their "career imprint" by shifting their benchmark of appropriate behavior to these market parties [53]. We also build on prior research contending that academic founders often do not have access to the right types of networks for technology commercialization [2]. Our articles illustrate that positive engagement with university ecosystem entities at different phases of USO formation can help USOs to overcome many challenges related to knowledge and resource scarcity.

Finally, this article concurs with Good *et al.* [4] and extends knowledge on the importance of taking a holistic university ecosystem approach to understand how to enhance USO development. Whilst understanding the role of individual ecosystem stakeholders as imprinting sources is important [4], [53] what emerged as more important is their holistic imprinting effect during prefoundation [4]. Our findings provide new insights into the need to monitor USO interactions with the university ecosystem as a whole, and to ensure these interactions are holistically positive. This, ultimately, should help early entrant USOs to cumulatively develop market knowledge and entrepreneurial skills, capabilities, and resources that contribute to the development of clearer paths to market, greater market readiness at foundation, and more confidence to enter the market early.

VIII. LIMITATIONS AND AREAS FOR FUTURE RESEARCH

Despite the important insights gained through the novel application of imprinting to explore USOs' ecosystem engagement and market entry timing, this research has several limitations. First, we adopted a qualitative methodology to gain rich insights into the complex interactions and imprinting effects of the university environment and ecosystem stakeholders on USOs. Whilst imprinting theory recognizes the role of individual characteristics such as prior knowledge, background, relationships and career experiences [22], it was out of the scope of our article to explore all these factors in depth. While the academic founders all had similar characteristics in terms of academic background and career experiences (see Table II), future research should adopt a quantitative approach to test relationships between individual, environmental and ecosystem sources of imprinting during USO formation and their influence on strategic outcomes such as speed. This may help identify stronger USO founding teams who possess a multitude of experiences, skills, and capabilities. Second, whilst this research identified changes to USO founders' cognitive framing and mental models as a result of positive imprinting experiences, future research could explore how different types of imprinters lead to different types of capability development and learning which influence USO development. Third, our research explored USO development from the research phase to market entry, which was useful to identify the influence of premarket entry support; however, future research should take a longitudinal approach to identify how imprinting experiences influence post market entry growth and survival.

Fourth, the study focuses on an individual country context, Italy. While Italy shares many similarities with other European countries, particularly Continental European countries such as Spain, future research should increase the external validity of the findings by conducting comparative analyses involving other European country contexts. Finally, first market entry timing bears important implications for firms' achievement of first mover advantages, particularly in high-technology industries. While it was beyond the scope of this article to capture the competitive dynamics of USOs' target markets, future research should examine how market entry timing influences USOs' competitive positioning and achievement of first mover advantages.

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Lisa Messina received the B.Sc. degree in international business with French, the M.Sc. degree in international business, and the Ph.D. degree in management from Queen's University, Belfast, U.K., in 2012, 2014, and 2019, respectively.

She is a Lecturer in Management with Queen's University. Her research interests include the fields of international and academic entrepreneurship, technology transfer and innovation, social and human capital. In particular, she is interested in understanding the dynamic processes involved in the formation of new ventures and how they affect their future trajectory.

Kristel Miller received the B.Sc. degree in business and computers, the M.Sc. degree in business and information innovation and the Ph.D. degree in innovation management from Ulster University, Belfast, U.K., in 2005, 2006, and 2012, respectively.

She is a Senior Lecturer in Strategy with Ulster University. Her research focuses on the areas of business model innovation, SME innovation, university–industry knowledge transfer and technology commercialization. She has presented her work in various international conferences and published in internationally recognized journals. Furthermore, she works with local organizations to help them develop their innovation capabilities.

Nola Hewitt-Dundas received the B.Sc. degree in geography and the Ph.D. degree in economic geography from Queens University, Belfast, U.K., in 1991 and 1995, respectively.

She is currently a Professor of Innovation Management and Policy and Pro-Vice-Chancellor (AHSS) at Queen's University. She is a Senior Research Fellow with the U.K. Enterprise Research Centre. She has extensive consultancy experience, having advised the NI Assembly, NESTA, HEFCE, Forfas Ireland, InterTradeIreland, the EU and World Bank. Her research focuses on the dynamics of entrepreneurial and innovation ecosystems, technology transfer and evaluation of intervention to support university commercialization efforts.

Dr. Hewitt-Dundas is a member of the Assessment Panel for REF2021 and an Elected Council Member of the U.K. Chartered Association of Business Schools.