The dynamics of entrepreneurial networking logics: evidence from United Kingdom high-tech start-ups

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Abstract

Purpose – This study aims to explore how entrepreneurial firms' networking logics may change under different types of perceived uncertainty. The arrival of new knowledge from the entrepreneurial firm's network may alter the perceived technology and market uncertainty that in turn determines how the firm adopts or combines the two opposing logics of causation and effectuation. Focusing on the roles of external advisors recruited by the firms, the study probes the details of the cyclical process and the mechanism through which networking logics are altered.

Design/methodology/approach – In this study the authors conducted a 3-year longitudinal multiple case study of 12 United Kingdom (UK) high-tech start-ups from prefounding to A-round funding with 54 semistructured interviews and meeting observations.

Findings – The knowledge of external advisors with distinct experience often reshapes the entrepreneurial firm's perceptions of uncertainty, leading to logics change in network development. The authors identify two types of knowledge brought by external advisors and discover how these can influence three networking logic pathways under different levels of technology and market uncertainty.

Originality/value – The study is one of the first to map the paths of changing logics along with different types of uncertainty in the context of entrepreneurial network development. The study unpacks one of the key mechanisms of networking logic changes: the knowledge and expertise of those advisors recruited by the entrepreneurial firms. The process model of changing logics contributes to the effectuation literature and entrepreneurial network research.

Keywords Advisor, Effectuation, Entrepreneurial network, Knowledge, Logic change, Uncertainty

Paper type Research paper

Introduction

The effectuation literature has suggested that causal and effectual logics are extreme points on a continuum in a firm's decision-making (Sarasvathy, 2001; Chandler *et al.*, 2011; Reymen *et al.*, 2015; Smolka *et al.*, 2018). In the context of entrepreneurial network development, these two seemingly competing logics have received lots of research attention in the past two decades (c.f., Hoang and Antoncic, 2003; Kerr and Coviello, 2019; van Burg *et al.*, 2022). According to "causal logic", entrepreneurial networking is a goal-directed process during which entrepreneurs search for and pursue predefined networking targets to acquire knowledge and resources (Hallen and Eisenhardt, 2012; Vissa, 2012). In contrast, "effectual logic" argues that when there is great perceived uncertainty, desired ties cannot be identified in advance and networking outcomes cannot be predicted. Hence, entrepreneurial firms engage in a "broad search" and ongoing social interactions that may fuel the emergence of new objectives (Huang and Pearce, 2015; Engel *et al.*, 2017). More recently, the related empirical work has provided evidence that decision-makers may change and balance between the two logics under certain circumstances such as the arrival of new advisors into their networks (e.g. Kerr and Coviello, 2019; Alsos *et al.*, 2020). Accordingly, the literature has suggested a "guided" approach, i.e. the coexistence of the two logics guided by a strategic direction (Engel *et al.*, 2017; Smolka *et al.*, 2018).

In the context of entrepreneurial network development, scholars have paid attention to the causes of the changing and intermingling of logics in the network development process (Grégoire and Cherchem, 2020). Among these studies, Engel *et al.* (2017) provided a dynamic conceptual framework for understanding entrepreneurial networking logics. Taking the perspective that networking is the consequence of the cognitive perceptions of entrepreneurs, they model perceived uncertainty as the critical boundary condition determining the choice between the two extreme logics in forming network ties. What is critically important for this research is these authors' modeling of the feedback loops – the networking logics may give rise to events that have the possibility of changing the entrepreneurs' evaluation of uncertainty and hence lead to logic change. However, this is a conceptual paper in which the authors neither provide empirical evidence nor detail the process of logic change. As a result, the black box of the changing logics is still packed.

To address this research gap, this study focuses on one of the key mechanisms through which the networking logics change: different kinds of knowledge provided by external advisors. When a new advisor arrives and engages with the firm, the event brings new information and knowledge, and sometimes this event reduces the entrepreneurial firm's perceived uncertainty, but at other times uncertainty is increased. For instance, a network event may bring forth new knowledge that challenges the entrepreneur's original thinking, leading to a realization that there is greater uncertainty. In sum, network events may increase or decrease perceived uncertainty; thus, networking logics may change.

This study explores the following question: *How does the arrival of the knowledge provided by external advisors change an entrepreneurial firm's perception of uncertainty and corresponding networking logic?* Drawing upon a longitudinal case study of 12 UK high-tech start-ups, this study identifies two types of knowledge brought by external advisors which may reshape the entrepreneurial firm's perceptions of technology and market uncertainty, leading to three networking logic pathways.

This study contributes to the effectuation literature and entrepreneurial network research. First, it is one of the first to map the paths of the networking logic change. Moreover, it studies the change along with different kinds of uncertainty – technology and market uncertainty. Prior studies (e.g. Sarasvathy, 2001; Huang and Pearce, 2015; Engel *et al.*, 2017; Murdock and Varnes, 2018; Alsos *et al.*, 2020) did not differentiate uncertainties. This study emphasizes that uncertainty is not a single dimensional variable, and that changing perceptions of uncertainty may lead to different networking logics and pathways. Second, the study

develops a process model of entrepreneurial networking logic change. The model reveals one important mechanism through which networking logics are built and altered, thereby providing a more nuanced understanding of the process of logic change. The study also sheds new light on how knowledge and expertise offered by external advisors can assist in firm development (Dushnitsky and Matusik, 2019).

Literature review
Entrepreneurial network studies
To position this study, the section starts by reviewing the entrepreneurial network literature to provide a context for this work on how cognitive logics regarding network formation may change over time. The literature provides a link to why studying the cognitive processes of entrepreneurial firms can assist in a better understanding of networking behaviors.

In the past couple of decades, an interest in networks has permeated entrepreneurship research. Extending the literature review by Hoang and Antoncic (2003) and Slotte–Kock and Coviello (2010) identified two research streams on network processes. The first stream positions the network as an independent variable. Theoretical arguments include the importance of a cohesive network (Coleman, 1988), the idea of structural holes (Burt, 1992) and the value of strong versus weak ties (Granovetter, 1973). Correspondingly, research in the entrepreneurial network has examined the impact of network structures, such as density (e.g. Larson and Starr, 1993), structural hole (e.g. Hite and Hesterly, 2001) and tie strength (e.g. Elfring and Hulsink, 2007; Jack *et al.*, 2004; Jack, 2010) on entrepreneurial process and outcomes.

This study contributes to the second stream of research, where network is positioned as a dependent variable [1]. In a recent review of entrepreneurial network literature, Kerr and Coviello (2019) summarized the microfoundations of the mechanisms – agency, opportunity and cognitive inertia – through which a network develops. They commented that while the effectuation literature has addressed the first two mechanisms, less attention has been directed to understanding the cognitive inertia. This study focuses on cognition and aims to contribute to this research field by studying an important mechanism through which networking logics are altered – the arrival of knowledge provided by external advisors, thereby providing a more nuanced understanding of how the logic changes in network development of entrepreneurial firms. This study will contribute to this literature more deeply.

Three types of networking logics
As reviewed earlier, causation and effectuation are two competing logics of decision making. They have been well studied in many contexts, such as business opportunity identification (e.g. Sarasvathy, 2001; Welter *et al.*, 2016) and network development (e.g. Elfring and Hulsink, 2007; Engel *et al.*, 2017). This study focuses on the context of entrepreneurial network development.

Recent empirical research has explored the contexts that influence the coexistence of causal and effectual logics (Reymen *et al.*, 2015; Villani *et al.*, 2018; Frese *et al.*, 2020). The literature suggests that the coexistence of the two logics tends to be guided by a strategic direction coupled with a long-term orientation consisting of short-term experiments. Smolka *et al.* (2018) suggest that the "planning effectuator" logic may be optimal, and firms can take advantage of opportunities that arise due to unexpected events while still focusing on a long-term goal. This paper uses *"guided logic"* to label this hybrid logic. This concept extends the work of Engel *et al.* (2017), which posits that networking is a choice between the two logics. Table 1 summarizes the three types of networking logics.

	Causal networking	Effectual networking	Guided networking
Theoretical underpinning	A "discovery" theory of entrepreneurship (Kirzner, 1997; Shane, 2003)	A "creation" theory of entrepreneurship (Alvarez and Barney, 2007; Alvarez et al., 2013; Miller, 2007)	A "hybrid" decision-making logic; causal and effectual logics may exist in tandem (Sarasvathy, 2001; Dew et al., 2009)
Goal/means	Goal-oriented, i.e. Defining the final objective up front (Chandler et al., 2011)	Mean-oriented, i.e. unspecified possible (near-term) future (Welter et al., 2016); goals are not available and tend to emerge in the process of interaction with network actors (Engel et al., 2017)	A combination of both causal and effectual logic, i.e. the planning effectuator approach (Reymen et al., 2015; Smolka et al., 2018)
Underlying logic in the networking behavior	Narrow (search scope) directed at specific predetermined targets, i.e. focused on meeting the 'right' people and reaching them efficiently (Engel et al., 2017)	Broad (search scope), directed at generating unexpected contingencies, i.e. focused on meeting new people or discovering new facets in existing ties (Engel et al., 2017)	Search may be both broad and narrow depending on tasks at hand
	"Cognition-precedes-action" search heuristics (Cyert and March, 1963; Gavetti and Rivkin, 2007)	"Action-precedes-cognition" search heuristics (Sarasvathy, 2001; Elfring and Hulsink, 2007)	Guided by a strategic direction (often medium or longer-term), couple long term objectives with short-term experiments (Smolka et al., 2018)
Outcome	Measured outcomes against preset goals, securing needed resources and progressing toward given venture goals (Engel et al., 2017)	Serendipitous outcomes involving resources, ideas or both, which result in new or modified ventures goals (Engel et al., 2017)	A combination of measured and serendipitous outcomes, e.g. (firms) can take advantage of opportunities that arise due to unexpected events while still focusing on a long-term goal (Zheng and Mai, 2013)

Table 1.
Three types of entrepreneurial networking logics

Different types of uncertainties and firm networking logics
Uncertainty can be defined as the unquantifiable probabilities associated with alternative states (Knight, 1921). Early-stage firms are confronted by uncertainty because entrepreneurs cannot predict the impacts of their own decisions and actions (Milliken, 1987; McKelvie et al., 2011). Although the literature has recognized that uncertainty is a critical contextual factor that influences entrepreneurial network development (Sarasvathy, 2001; Alvarez and Barney, 2005; Engel et al., 2017; Chen et al., 2021), more research is needed concerning different types of uncertainty.

All start-ups face a landscape of decisions with different types and levels of uncertainties that may change over time. Two types of uncertainties – technology and market uncertainty – lie at the core of high-tech entrepreneurial activities (Atuahene-Gima and Li, 2004). This framing has been well recognized in the literature for providing an excellent summary of the complexity entrepreneurial firms face (Teece, 1986). Intuitively, it suggests that entrepreneurial firms may adopt different networking logics under different kinds of uncertainty.

Dynamics of entrepreneurial networking logics
Engel *et al.* (2017) built a conceptual model that highlights the influences of uncertainty on the choice of entrepreneurial networking logics. Critically, they point to the need to examine the process by which a network forms and evolves and highlight the impacts of the arrival of new ties. However, this conceptual paper does not provide empirical evidence nor map the process of logic change. Following this line of reasoning, this study examines how the events of new advisors joining in the firm may change an entrepreneurial firm's perception of uncertainty and trigger a networking logic change.

An early-stage start-up's network is primarily composed of direct ties between the entrepreneur and a few external advisors, such as technology transfer officers (TTOs), professional advisors, angel investors and venture capitalists (Hansen, 1995; Aldrich, 1999; Steier and Greenwood, 2000). These advisors bring their know-how and know-who. The arrival of a new advisor can be considered an "event" because it triggers a sequence of actions (Vissa, 2012; Engel *et al.*, 2017). Events are considered the natural units of social processes (Van de Ven and Engleman, 2004).

Research method and data
Research approach
The authors identified 12 early-stage high-tech start-ups in the UK and examined their advisors and entrepreneurial networking activities over 38 months. Entrepreneurial networks are egocentric and comprised of direct ties between the firms (as represented by their founders) and key external advisors (Hansen, 1995).

Adopting a process research approaches (Langley, 1999), the authors traced the events of new advisors' arrivals and the consequent changes in the entrepreneurial networking logics. The multiple case study design enabled us to analyze both within-case and cross-case variations (Yin, 1989), and the longitudinal multiple cases approach helps examine the process both vertically and horizontally. Hence, the study's internal and external validity are increased (Pettigrew, 1990; Van de Ven and Poole, 2005).

Context and case selection
We used purposeful sampling to select cases that facilitate theoretical inferences (Eisenhardt and Graebner, 2007). Twelve cases were selected based on three criteria. First, all ventures operated in high-tech sectors and were founded in a similar institutional environment. In this period, early-stage high-tech ventures were often endowed with valuable patents or intellectual property (IP) and found commercializing the technology challenging. This complex and demanding task requires identifying and integrating a diverse array of in-depth knowledge and raising a large sum of capital to fund research, product development and tests within a short time. Meanwhile, there was significant funding gaps and limited institutional support in the UK (Hopkins *et al.*, 2013). Second, the founders were academics, scientists or individuals with little serious commercial and entrepreneurial experience; thus, they typically needed help to create and build the venture, which provided ample opportunities to observe the role of external advisors in shaping entrepreneurial network building. Third, all firms were at an early development stage (i.e. from inception to achieving A-Round commercial funding) that helps trace the development of a group of similar ventures in real-time.

Data collection
The authors adopted a snowballing strategy for data collection. The data collection included two stages. During the first six-month, the authors attended various events to gain insights into the industry and build networks for future data collection. The authors were able to

identify three individuals actively involved in the process who held different institutional roles: a university TTO, a venture capitalist and an independent advisor. The authors asked them to list the companies they had been involved with in the past or were currently working with, along with the dates they were engaged. The authors identified 12 companies with which the three advisors were closely involved. The authors then contacted the founder or Chief Executive Officer (CEO) of each firm to explain the aims of our research project, secured their collaboration and interviewed them.

This research focuses on three stages from prefounding to A-round funding. At T0, the founders generate innovative ideas, often based on their scientific research in academic institutions. The start-ups are often incorporated at the end of T0 or the beginning of T1. At T1, the main challenge is feasibility studies that convert academic research outputs into an initial business model. This stage is primarily funded by government agencies, often up to £250,000. At T2, the main task is to achieve A-round commercial funding, which can reach up to £5 million and can come from various sources, including informal investors or business angels, venture capital (VC) funds or an early initial public offering (IPO) on the London alternative investment market (AIM).

Primary data were collected using multiple data sources. The first author interviewed multiple informants in all 12 companies, including founders and/or current Chief Executive Officers (CEOs) and at least two external advisors identified by the founders or CEOs. A semistructured interview protocol was used. Interviews typically began by collecting background information about the interviewees, followed by the questions exploring: (a) How did the firms' networks develop over time, and what was the logic behind that development? and (b) How did the firms perceive the uncertainties in their environments as they evolve? Interviews typically lasted 60–120 min, and any outstanding issues were clarified in follow-up telephone interviews.

To add further depth to the investigation, the authors became more fully immersed in two case companies to perform participant observations. The first author sat in on board meetings and accompanied executives as they delivered presentations to city brokers and potential investors and at informal social or networking occasions. Also, the second author traced the behavior and thinking processes of key actors to increase our depth of understanding, thus developing close relationships with these two firms (even serving on one board for a period). In total, the authors had conducted 54 semistructured interviews and meeting observations, resulting in 82 h of recordings that were then transcribed. Other data sources included confidential corporate documents (e.g. board papers, historical accounts and financing round) from sources including company websites, Fame and Perfect Fillings Databases. Table 2 describes the 12 sample companies.

Data analysis strategy
The authors used narrative extensively (Langley, 1999) to create a "thick" description for each (Lincoln and Guba, 1985) before conducting within- and cross-case analyses (Yin, 1989; Eisenhardt and Graebner, 2007). The data were coded and recoded several times. Case descriptions were cross-checked by key informants. As in most qualitative research, the data analysis involved a highly iterative process (Miles and Huberman, 1994). The analysis was conducted in three steps in Table 3.

Following the process research strategy (Van de Ven and Poole, 2005), the authors focused on the key "network events" (i.e. the arrival and involvement of new advisors in the network) and collected data of the three characteristics of the advisors: the knowledge they brought, their perspectives (logics) and the timing of their arrival. Second, we traced each advisor's involvement at T0, T1 and T2. Third, we map the perceived uncertainty and firms' networking logic at each stage. Our interview suggests that the perceived technology

Company	Industry	Year of legal formation	University spinout?	A-round funding achieved?	No. of board directors (By Dec 2006)	No. of exec. Directors (By Dec 2006)	No. of FT employees (By Dec 2006)
AIR	Medical devices	2001	N	N	5	1	6
AOX	Life science	2005	Y	N	6	2	1
AUV	Life science	1996	Y	Y	4	2	12
BLUE	Software engineering	2005	Y	N	4	1	0
CAP	Life science	2002	Y	Y	8	3	7
CYTO	Life science	2005	Y	N	5	1	1
ID	Medical devices	2001	Y	Y	7	4	9
MED	Life science	1999	Y	N	6	4	35
NOVA	Life science	2004	Y	N	9	3	12
PHONO	Physical science	2004	Y	N	6	3	0
PHY	Life science	2002	N	Y	8	3	4
PROX	Life science	2003	Y	Y	5	2	11

Table 2.
Summary of case descriptions

Steps	Tasks	Key findings
1	Identify external advisors and classifying different types of advisors by knowledge, logics and institutional affiliation	Table 4
2	Trace advisors' involvement at different stages of venture development (T0, T1, T2), i.e. coding architectural events vs functional events	Table 5
3	Map firms' perceived uncertainty and networking logics at each stage, and examine the pathways of logic change from T0 to T1 and T1 to T2	Table 6, Figure 1 and Table A2

Table 3.
Stages of data analysis

uncertainty often relates to Research and Development (R&D) progress, while the perceived market uncertainty relates to the understanding and specificity of customers and their needs in the target market. Following Reymen *et al.* (2015), we investigated whether a firm's networking logic changed and the connections that might exist between the events, the perceived uncertainty and the evolution of networking logics.

We identified 115 advisors, which gave rise to 228 events. Some advisors were engaged with multiple firms. We closely examined the knowledge bases of these advisors in three steps. First, we created a personal file for each advisor, including their education, career background, institutional affiliations and previous and current directorships. Following the literature on functional diversity (Boeker and Wiltbank, 2005), we classified their "functional knowledge": (1) science and technology; (2) business development, marketing and sales; or (3) corporate finance, accounting and legal matters. In the cases of advisors with more than one domain knowledge, we coded their expertise according to the knowledge they used in their involvement with our case ventures.

The authors then coded the logic types of our advisors according to their knowledge bases. We coded advisors with effectual logics as those who had entrepreneurial experience and coded advisors with causal logics as those who had functional experience and/or training in traditional management techniques. We checked this coding carefully by inspecting the

actions of our advisors, specifically by tracing how they framed a problem and hence how they sought or responded to network ties.

The data suggest that the two types of advisors' knowledge attributes were congruent with their observed logics. Those with causal logics only possessed functional knowledge in a particular domain (e.g. technology development) and in a specific venture development stage (e.g. proof of concept and scaling) and so we labeled these advisors *functionalists*. In contrast, those with effectual logics had a broader entrepreneurial knowledge and knowledge base, including functional knowledge, because they started their careers in a functional domain before becoming entrepreneurs. We labeled these advisors *architects*. We observed that architects appeared to have in-depth knowledge concerning the underlying principles of building an entrepreneurial firm, including its process and required components, and we refer to this as *entrepreneurial knowledge*. An important component of entrepreneurial knowledge is the knowledge about networking, including what type of people to connect with (expertise/ know-what) and the relevant connections (know-who). In comparison, functionalists often lack such knowledge. Table 4 summarizes these connections.

Findings
Network events and logics
Two types of network events emerged from the data: *functional events* (i.e. the presence of a functional advisor with causal logic associated with narrow-based expertise) and *architectural events* (i.e. the presence of an architectural advisor with effectual logic associated with broad-based expertise).

The study traced the network events over time in each company. The results are shown in Table 5. The table shows that there were more functional events (177) than architectural events (51) in the initial stages. As the firms developed, the presence of both types of events increased in number and frequency. In general, the range of both functional and entrepreneurial knowledge grew over time.

This study identified the firms' networking logics drawing upon primary interview data concerning the logics and the perceived technology and market uncertainties. Then the firms'

	Functionalists	Architects		
Advisor's knowledge domain	*Functional knowledge* within a venture development stage and often within a particular knowledge domain (e.g. science and technology, business development, marketing and sales and finance, accounting and legal matters)	*Functional knowledge and Entrepreneurial knowledge.* The latter refers to an in-depth understanding of the underlying principle of building an entrepreneurial firm, its process and required components, including expertise/know-what and know-who		
Advisor's logics	Causal logics derived from functional experience and learned traditional management techniques (e.g. MBA)	Effectual logics derived from a track record of entrepreneurial experience		
Advisor's institutional affiliation	Count	%	Count	%
Venture capitalist	3	3	4	25
Tech. transfer officer	7	7	0	0
Academics	31	31	0	0
Prof. advisors	21	21	4	25
Gov. agent	5	5	1	6
Ind. advisor	32	32	7	44
Total	99	100	16	100

Table 4.
Knowledge, logics and attributes of advisors

Company	T0				T1				T2				Achieving A round funding?
	Arch. events*	Fun. events**	Sub-total	Knowledge type***	Arch. events	Fun. events	Sub-total	Knowledge type	Arch. Events	Fun. events	Sub-total	Knowledge type	
AIR	0	2	2	T	1	7	8	T,F,E	2	13	15	T,B,F,E	N
AOX	0	2	2	T	1	3	4	T,E	5	3	8	T,F,E	N
AUV	0	1	1	T	0	4	4	T	3	3	6	T,B,F,E	Y
BLUE	0	2	2	T	2	3	5	T,F,E	3	3	6	T,B,F,E	N
CAP	0	3	3	T	1	6	7	T,F,E	1	12	13	T,B,F,E	Y
CYTO	0	1	1	T	0	1	1	T	1	4	5	T,E	N
ID	0	2	2	T	1	2	3	T,E	3	12	15	T,B,F,E	Y
MED	0	3	3	T	0	9	9	T,B	1	9	10	T,B,E	N
NOVA	0	3	3	T	1	6	7	T,F,E	5	15	20	T,B,F,E	N
PHONO	0	2	2	T	1	4	5	T,B,E	1	3	4	T,B,F,E	N
PHY	0	1	1	T	6	8	14	T,B,F,E	8	10	18	T,B,F,E	Y
PROX	0	1	1	T	1	4	5	T,F,E	3	10	13	T,B,F,E	Y
TOTAL	0	23	23		15	57	72		36	97	133		

Note(s): Total events = 228
* Total architectural events = 51
** Total functional events = 177
***T: Science and technology development
B: Business development, marketing and sales
F: Corporate finance, accounting and legal matters
E: Entrepreneurial knowledge

networking logics was mapped along the dimensions of technology and market uncertainty for each of the three periods (T0, T1 and T2) based on both primary and secondary data [2].

The result shows that in three firms (AUV, CYTO and MED), the networking logic did not change, nor did the perceptions of technology and market uncertainty. However, in the remaining nine firms, there was significant change in the logics and the corresponding perceptions of technology and market uncertainty. These changes led us to identify the connections that might exist between the events, the evolution of the networks and the perceived uncertainty. Table 6 shows the networking logics of each firm in each period and the implied logic change pathway, as well as the entry of architectural events. Three pathways of networking logic change emerged. These pathways are shown in Figure 1 [3].

Company	Networking logic change pathway	Timing of architectural events
CAP	C-G-G (path A)	Early
PHY	C-G-G (path A)	Early
PROX	C-G-G (path A)	Early
AIR	E-G-G (path B)	Early
AOX	E-G-G (path B)	Early
BLUE	E-G-G (path B)	Early
ID	E-G-G (path B)	Early
NOVA	E-G-G (path B)	Early
PHONO	E-G-G (path B)	Early
AUV	Remains C (path C)	Late
CYTO	Remains C (path C)	Late
MED	Remains C (path C)	Late

Note(s): C: Causal logic
E: Effectual logic
G: Guided logic

Table 6.
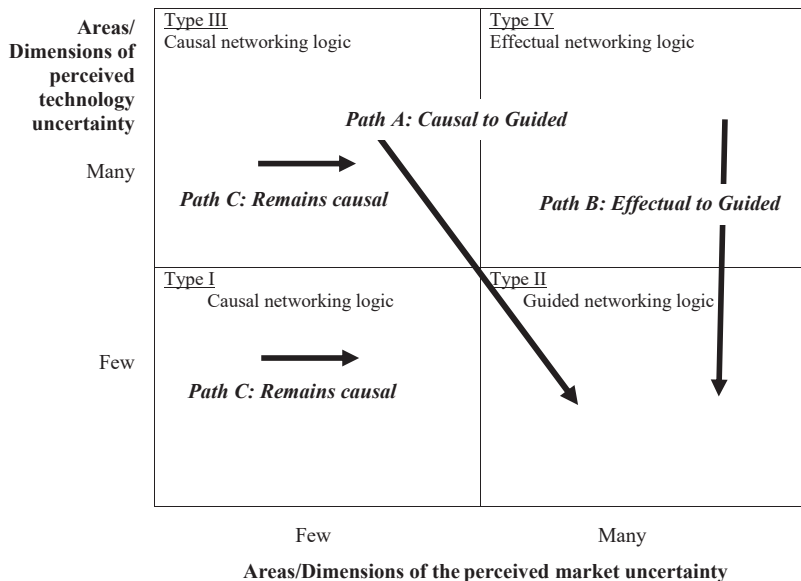Data summary on pathways of networking logic change and the timing of architectural events

Figure 1.
Data mapping on networking logics change under uncertainties

Three pathways of networking logic change

Path A: Causal to guided. Three sample firms (CAP, PHY, and PROX) followed this path. All firms started in the Type III category (low market and high technology uncertainty). At T0, the founders primarily focused on the science behind the original ideas but gave little attention to identifying potential target markets for the technology. Initial networking was limited and followed a causal logic; the few functionalists who joined were either TTOs or family and friends. Thus, applications for initial funding were rarely successful. For instance, PHY's initial networking logic was causal based. The founders had a clear predesigned business model, which consisted of commercializing traditional Chinese medicine in Western markets for known unmet needs. To achieve this goal, their initial network building was focused.

As ventures grew, the firms adopted a guided logic as they moved to the Type II context (low technology and high market uncertainty). The data suggest that this trajectory was often triggered by the early entry (at T0 or early in T1) of an architect who possessed entrepreneurial knowledge and an effectual logic. In most cases, architects actively sought start-ups with potential; in some cases, founding teams actively searched for advisors within their existing networks. After joining start-ups, architects brought not only their ability to help identify potential market opportunities and their vision of the future state of the business, but also their own effectual logic to guide the start-ups to build partnerships and keep an open mind. As a result, networking became more effectual coupled with a medium/long-term goal.

For instance, in the case of PHY, with the entry of an architect at T1, founders started to think more broadly about the application of their technology and shaped their business model and funding strategy accordingly. Consequently, the perceived market uncertainty increased. At the same time, the architect brought in other functional advisors with technological expertise advancing their research and development program, which reduced the perceived technology uncertainty. At T2, after a round of failed private placements, the firm decided to prepare for an AIM IPO to raise desperately needed funds. With the architect's guidance, the firm's networking became more effectual in the sense that the firm broadened the search scope to generate more opportunities rather than directing focus at specific predetermined targets. Consequently, more architects and functionalists joined, which spurred further active partnering activities in the UK, Europe, the United States (US) and Asia.

In the case of PROX, the spinout was founded to keep the existing research team working on the provision of contract services and proprietary R&D on neurodegenerative disorders, as the renowned leading scientist was about to retire. The initial networking followed a causal logic and was structured as a narrow search with a specific goal in mind. At T1, the reputation of the renowned scientist attracted the attention of an early VC fund, which introduced an architect from the US. With his guidance, the business model was refocused on preclinical development and early clinical trials of novel drug candidates in the field of neurodegenerative disease. To become a fully-fledged biotech start-up, the firm broadened its potential target market. Networking became effectual and led to partnerships across scientific and industry communities in the UK and the US. At T2, the architect helped set a medium-term goal – to prepare for an IPO – and its network continued to expand, including collaborators in the industry, finance and technology communities.

In summary, the findings suggest that the early entry of architects tended to trigger Path A, whereby firms started from a causal logic and then moved to a guided logic oriented by a strategic direction coupled with short-term experiments.

Path B: Effectual to guided. Six firms followed this path. While three firms' networks (AIR, ID, and NOVA) had become relatively large and heterogeneous by the end of our study period, the other three firms' networks (AOX, BLUE, and PHONO) remained small and less diverse. This suggests that this path could be associated with varied outcomes.

Unlike the firms on Path A, initially, all firms appeared to consider both market and technology uncertainty to be high (Type IV) and adopted effectual logic in finding different

opportunities to apply their technology. Except for one firm (AIR), all the firms' founders were academic scientists, and they often considered themselves "non-traditional academics". Their networking was means-driven and effectual, while their visions for commercializing the technology were vague. All firms tended to have an "unspecified possible (near term) future" (Welter *et al.*, 2016) and goals were not available and tended to emerge in the process of interaction with network actors (Engel *et al.*, 2017). Over time, the entry of architects at T1 in all firms in this path moved the networking pattern from an effectual to a guided approach. Similar to Path A, the arrival of architects triggered changes.

For instance, in the case of ID, funding cuts at the founders' research institute led the founders to various research grant agencies (including National Health Service, Medical Research Council, and Wellcome Trust) before they attempted to persuade an industry partner to sponsor the research project. ID took more than four years to reach beyond the existing networks of its two founders.

At T1, the firm decided to commercialize its technology via a spinout rather than licensing, and it had been suggested that an IPO was a preferred route for raising funding to accept VC money. Given this direction, an architect was introduced by TTO, and he helped reshape their business model, and their networking became more guided in identifying knowledge gaps and filling those gaps. At T2, with a specific target market in mind, their networking became more guided. Finally, they received the endorsements of two of the world's leading dental schools in New York and California and signed a partnership agreement with one of the world's largest manufacturers and distributors in the field. At the same time, more functionalists and architects joined the firm as they prepared for a potential IPO.

In the case of NOVA, at T0, the founding scientist mainly focused on science, and her effectual networking led her to TTOs, who helped her draft the initial business plan and applied for a proof-of-concept funding scheme. The entry of an architect at T1 helped to evaluate the firm's potential target markets and develop a robust business model. The networking also became guided.

As the venture grew to T2, the founder considered the technology uncertainty reduced while the market uncertainty increased. As a result, the start-up proactively sought potential deals with industry partners, investors, clinical trial partners and so on with a medium/long-term goal in mind. In the case of AIR, a functionalist introduced an architect who helped shape the business plan with a clear focus on routes to market. Subsequently, the networking became guided and was expanded to potential users (over 800 medical practitioners) and distributors, government and grant agencies (e.g. Wellcome Trust and Department of Health) and potential investors.

In all sample firms, founders proactively attended conferences and exhibitions to engage potential customers, distributors and research collaborators, and they initiated meetings and roadshows to entice potential investors. Almost all founders reported that networking had taken up a considerable part of their time and energy. This is a distinctive feature of guided networking. On the one hand, the firms' networking was guided by a clear goal and consisted of "searching and selecting contacts, clients and partners based upon pre-defined plans" (Reymen *et al.*, 2015, p. 362). On the other hand, their networking approach became more effectual in the sense that they "cast a wide net, and start[ed] interacting with potential stakeholders in an ongoing process of negotiating and renegotiating the design of an emergent venture" (Engel *et al.*, 2017, p. 43).

In summary, driven by entrepreneurial firms' strong desires to explore the potential market opportunities for their technologies, initial networking practices exhibited an open, flexible approach, although without a clear strategic goal (i.e. an effectual logic). With the entry of architects, a clearer business plan was shaped. Subsequently, these firms' networking became more focused but remained effectual (i.e. a guided logic). Thus, their network expanded gradually to include diverse ties across more knowledge domains.

Path C: Remains causal. Three firms (AUV, CYTO, and MED) remained causal in their approach. All three firms started by having a clear goal of providing contract research services using technology developed in universities. For instance, at T0, the founder of AUV believed that "science was easy," and the networking was limited and causally based. At T1, as AUV started seeking to develop its IP alongside contract research work, its networking became more active but remained causal. At T2, an architect was introduced by functionalists but with little success; we found no evidence of the firm adopting effectual logic.

Conversely, both CYTO and MED started from and remained in Type III and managed to expand their networks. For instance, MED's networking was causal and mainly relied on its network of functionalists with a wealth of industry experience. The network expanded to include a range of partners, including large pharma and small biotech companies. In the case of CYTO, their networking activities remained focused on a predefined goal – developing the technology platform for diagnosing different types of cancers.

Interestingly, all firms failed to switch their business model from a contract research organization (CRO) to a full-fledged biotech development company, which does not indicate failure by any means. Although AUV was acquired in 2006, CYTO had received nearly £4 million in grants to further their research in 2015 and MED had become a leading CRO in its specialized area by 2018.

Discussion

The findings suggest a process model of entrepreneurial networking logic change, as shown in Figure 2. The model explains how entrepreneurial firms' perceptions of market and technology uncertainty (high or low) lead to different networking logics (effectual, causal or guided), which in turn lead to events that bring new knowledge that may change the original perceptions. In particular, it shows that network events may challenge their perceptions and increase or decrease the perceived uncertainty. In this case, "time" becomes a moderating factor (i.e. early interventions are more likely to lead to change than late ones).
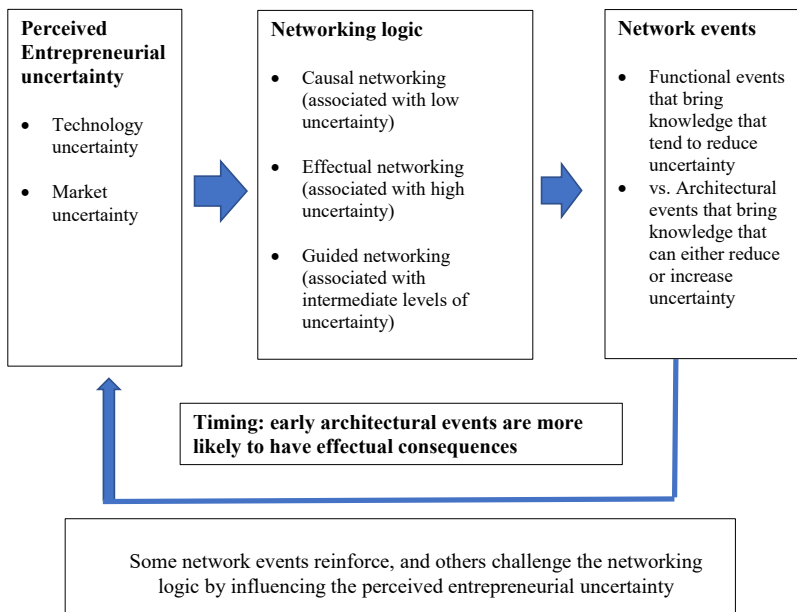

Figure 2.
A process model of networking logic change in high-tech start-ups

In our study, levels and changes in market uncertainty level appeared to be a key driving force for changes in logic. We found that when firms believe that they face relatively low market uncertainty, they tend to adopt a causal logic since they have little difficulty in framing the problem. As a result, they may approach advisors with specialized expertise (e.g. IP lawyers) to help them solve a particular problem/task at hand. When firms believe market uncertainty is high, they tend to adopt an effectual or guided logic; they may engage in a broad search and adopt an open, flexible networking approach in seeking advisors who can help identify a potential market and frame the problem to be solved.

This study suggests that the arrival of *architect advisors* typically gives rise to architectural *events* that trigger changes in the networking logic. Firms with an effectual logic are likely to draw their network more widely for advisors and increase the likelihood of architectural events. As firms grow, some may remain on the causal path, and some may change and adopt a guided logic.

Conclusion

Theoretical contributions

This study contributes to the effectuation literature and entrepreneurial network research in several ways. First, the model depicts a refined process of entrepreneurial networking logic changes under uncertainty. While the literature suggests that entrepreneurial networking tends to follow an effectual logic under uncertainty, the research on how these networking logics are constructed and how they vary under different types of uncertainty is very limited (Alsos *et al.*, 2020; Engel *et al.*, 2017). The model proposed in this study reveals the dynamic relationship between networking logics and perceived technology and market uncertainty. Moreover, while previous studies have recognized the advantages of combining causal and effectual logics (e.g. Smolka *et al.*, 2018), they did not probe further into the conditions that determine when a causal, effectual and guided logic may be preferred. This study shows that a guided logic is likely to be adopted at a later stage and is often triggered by architect advisors' engagement with the firm. Therefore, it sheds new light on the entrepreneurial network research by revealing how firms shift among the three networking logics (casual, effectual and guided) under two types of uncertainty (technology and market).

Moreover, this study unpacks one of the key mechanisms of networking logic changes under uncertainty: the knowledge and expertise of those advisors recruited by the entrepreneurial firms. The model highlights that what matters in changing networking logic is both the knowledge content and the timing of the knowledge flow into the firm. The knowledge brought in by advisors with entrepreneurial experience will help the venture adopt an effectual logic and broaden its networking scope. The inclusion of timing in this model adds to the entrepreneurial network literature, where timing is often overlooked (e.g. Larson and Starr, 1993; Hite and Hesterly, 2001; Maurer and Ebers, 2006). Hence, this study contributes to the literature on the role of advisors by highlighting how their different types of knowledge may influence the firm development differently (Neumeyer *et al.*, 2019; Chikweche and Bressan, 2022; Longva, 2021). Our focus on the triggers for changing logics contributes further to the wider literature on network development reviewed by Kerr and Coviello (2019). This study provides a missing link to understanding the processes that drive the logic change behind network development patterns.

Practical implications

This study offers important empirical implications for entrepreneurs. First, it suggests that entrepreneurs should appreciate that different types of networking logics may be required depending on the different types and levels of uncertainty as a firm evolves. Since high-tech

entrepreneurs are likely to have a strong causation-based logic (probably because of their scientific training; Villani *et al.*, 2018) they may find it challenging to adopt an effectual or guided logic in networking in a highly uncertain market.

Second, entrepreneurial firms must "find" advisors with different types of insights and thus networking logics (Fern *et al.*, 2012; Gruber *et al.*, 2013). To this end, this study helps entrepreneurial firms ascertain how different types of advisors, based on their knowledge and experience, may be of help. In particular, the early entry of architectural advisors seems to be critically beneficial in reducing uncertainty.

Third, the findings suggest that entrepreneurs need to be open-minded to benefit from advisors. In some of the cases, the late entry of architects was related to entrepreneurs' unwillingness to listen, which caused the firm to reject effectual logic. This insight echoes the view that network inertia constrains network change (Gulati, 1995; Kim *et al.*, 2006), and it answers the call for more studies on "inertia" in network development (Kerr and Coviello, 2019).

Limitations and future research directions

The findings are based on a small sample of UK high-tech firms. Future research may extend the process model to other entrepreneurial contexts. Moreover, since this study is focused on the early stage of venture development from prefounding to A-round funding, it did not study the other types of important events, such as the success of raising major funds and the loss of pilot customers. Future studies may collect data with a longer span of company development, based on which they may be able to identify new mechanisms of networking logic change.

In addition, two of the 12 sample firms appear to have been successful (in terms of survival and being sold). Future studies may investigate the effects of the networking logic change on firm performance. Another fruitful research direction is to study why some entrepreneurial firms are more likely to overcome networking inertia than others. Overall, the process model proposed in this study calls for future studies to discover the antecedents and outcomes of networking logic change.

Notes

1. This stream is also commonly found in the industrial marketing literature, where the studies emphasize interactions that create dyadic interactions within the business network, including external players such as customers (Håkansson and Snehota, 1995; Ritter *et al.*, 2004; Coviello and Joseph, 2012).

2. A sample of coding for logic is available in Table A1 for the concern over paper length.

3. A detailed description is available in Table A2.

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Appendix 1

	Examples from our cases
Causal networking	In the case of PHY, the founders had a pre-defined business model from the outset. To achieve this goal, their initial networking building was narrow and focused. As the founder mentioned, "*Our business is in identifying proven Chinese botanical drug treatments which meets unmet (known) medical needs in the West and in undertaking the purification, characterization, clinical trials and formulation required to make them acceptable to regulatory authorities in the west . . . so we tried very hard and finalized a deal with Chinese ministry of health from Bill's (co-founder) contacts.*"
Effectual networking	In the case of ID, funding cuts at the founders' research institute led them to various research grant agencies and industry partners without a clear pre-defined goal. As the founder said, "*If you like, the drive to the commercialize came out of the frustration, that we couldn't do the research with conventional funding . . . .So what I did was to persuade the industry...If you are looking for characteristics, it's called bloody mindless.*"
Guided networking	In the case of NOVA, the entry of the architect helped to evaluate their potential target markets and develop a more robust business model. As the founder said, "*with MG's advice, we brought in external advisors, including accountants, patent attorney, marketing research firm – they put together a very comprehensive package which we will not be able to do ourselves. . . it expanded the (target) market size 5-fold from what it is now.*"

Table A1.
Examples of coding
three networking
logics

Appendix 2

Table A2.
Example descriptions of mapping entrepreneurial networking logic changes

Case company/network path	T0		T1		T2	
	Ent. uncertainty	Networking logic	Ent. uncertainty	Networking logic	Ent. uncertainty	Networking logic
PHY (Path A)	Type III (T+M−)	Causal networking – Developed initial business model, i.e. commercializing traditional Chinese medicine in the western markets. Initial networking building were limited and driven by the pre-defined goal.	Type II (T−M+)	Guided networking - With the entry of architects, the networking became more "effectual" coupled with "a medium-term goal", e.g. actively seeking connections beyond the existing networks through cold calling and attending events with an aim to achieve a private placement.	Type II (T−M+)	Guided networking - With a round of failed private placement, the firm intended to go to AIM IPO to raised desperately needed funds. More architects and functionalists join which spurt further active partnering activities in UK, Europe, US and Asia.
PROX (Path A)	Type III (T+M−)	Causal networking - The spinout was founded to keep the research team working on providing contract services and proprietary R&D on neurodegenerative disorders while the renowned leading scientist was about to retire. Initial networking was narrow and driven by the pre-defined goal.	Type II (T−M+)	Guided networking - The reputation of the renowned scientist attracted the attention of an early VC fund, who introduced an architect from US. The business model was re-focused on pre-clinical development and early clinical trials of novel drug candidates in the field of neurodegenerative disease. Networking became effectual and led to partnership across scientific and industry communities in both UK and US	Type II (T−M+)	Guided networking - In preparation for an IPO, its network continued to expand and include partners in industry, finance and technology community.

(continued)

Case company/ network path	T0		T1		T2	
	Ent. uncertainty	Networking logic	Ent. uncertainty	Networking logic	Ent. uncertainty	Networking logic
ID (Path B)	Type IV (T+M+)	Effectual networking - Initially networking was mainly motivated to seek any funding to do research without specific goals. Founders' proactive networking led to an industry project which allowed them to develop their IP	Type II (T−M+)	Guided networking - TTO brought in their institutional logics which helped the firm to decide on a spinout route. The entry of an architect helped reshape their business model and their networking became more "effectual" in identifying and filling knowledge gaps.	Type II (T−M+)	Guided networking - With a specific target market in mind, their networking become more "effectual", leading to the endorsements of two of the world's leading dental schools in New York and California. They signed a partnership agreement with one of the world's largest manufacturers and distributors of bearings and seals.
NOVA (Path B)	Type IV (T+M+)	Effectual networking - The founding scientist mainly focused on science. Her "effectual" networking led her to TTOs, who helped her draft the initial business plan and apply for proof-of-concept funding scheme. However, the application was rejected since "too close to the market".	Type II (T−M+)	Guided networking – TTO introduced an architect. The target markets were revaluated, and a new business model was developed. Network building became more "guided".	Type II (T−M+)	Guided networking - With redefined markets and business models, networking became more "guided", e.g. seeking potential deals with industry partners, investors, clinical trial partners with a long-term goal in mind.

Table A2.

Table A2.

Case company/ network path	T0		T1		T2
	Ent. uncertainty	Networking logic	Ent. uncertainty	Networking logic	Ent. uncertainty	Networking logic
AUV (Path C)	Type I (T−M−)	Causal networking - The origin of the firm was doing contract work based on the university lab. Network building was limited.	Type I (T−M−)	Causal networking - After spinout, they were struggling with the hybrid model (carrying out contract work and developing their own IP). Remained limited networking driven by a pre-defined goal.	Type I (T−M−)	Causal networking - The late entry of architects found it hard to reshape the firm strategy and networking. Subsequently, the architect advised another company to acquire the venture to develop their technology further.
CYTO (Path C)	Type III (T+M−)	Causal networking - Impressed by the potential of technology for cervical cancer, the founder negotiated a licensing deal with Cancer Research Technology to develop this technology into other types of cancer. Networking activities was limited and driven by the pre-defined goal.	Type III (T+M−)	Causal networking - networking activities remain in clinical trials and development and the pre-defined focus.	Type III (T+M−)	Causal networking - with the entry of an architect, the company started to explore commercial development slowly, though the networking remained on the pre-defined goals.

Note(s): T: Technology uncertainty
M: Market uncertainty
+: High uncertainty
−: Low uncertainty