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Resource configurations among digital academic spin-offs: finding the technology-market fit

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Abstract

Purpose – Managing resources is crucial for firms to gain competitive advantages and succeed, particularly for startups with limited resources. It is important to understand how digital startups in general and digital academic spin-offs (ASOs) in particular may orchestrate their resources to optimize value. This paper integrates the resource-based perspective with digital entrepreneurship to analyze the resource configurations leading to success of digital ASOs.

Design/methodology/approach – The paper adopts an inductive approach and applies qualitative comparative analysis (QCA) on a longitudinal dataset of digital ASOs to identify the resource configurations for a successful outcome.

Findings – The authors' paper identifies two main paths to success among digital ASOs, consisting of five distinct resource configurations. The first path is termed "market exploiters" that operate in favorable market conditions where specific technological resources and research collaboration resources are lacking. The second path involves "technology explorers" that combines both technological and commercial resources to achieve success.

Research limitations/implications – By outlining distinct pathways to the success of digital ASOs, this paper contributes to the digital academic entrepreneurship literature and the resource-based view of entrepreneurial firms. The paper also suggests implications for policymakers and managers in managing resources for the success of digital ventures.

Originality/value – By exploring the resource configurations leading to the success of ASOs commercializing digital technologies, the paper shows that favorable market conditions and complementary resource configurations can be alternative pathways to success.

Keywords Technology, Small firm/new venture strategy, Entrepreneurship, Resource-based theory

Paper type Research paper

1. Introduction

Digital technologies have emerged as a crucial catalyst for entrepreneurial opportunities, giving rise to digital startups that yield substantial market and societal impacts (Audretsch *et al.*, 2020; Nambisan, 2017; Sahut *et al.*, 2019). Successful examples include Google, which provides search and Internet-based services, AirBnB and Uber, which offer sharing ownership models, Amazon, which dominates the e-commerce space and Tesla, which relies on digital technology for its automobiles (Sahut *et al.*, 2019). These digital startups have the potential to create not only economic benefits but also contribute to sustainability efforts (George *et al.*, 2020).

Managing resources is crucial for firms to gain competitive advantages and succeed, particularly for startups with limited resources (Zaheer *et al.*, 2019). In the context of digital markets, digital startups may gain many opportunities but also face high uncertainty due to the complex digital attributes such as openness, modifiability, generativity and integration (Troise *et al.*, 2022; Nambisan, 2017). To navigate challenges and reap opportunities of digital technologies, entrepreneurs may need to find new ways of managing resources and capabilities (Troise *et al.*, 2022; Chen and Tian, 2022). Entrepreneurs in digital businesses may not only need to acquire but also to combine various resources to generate unique capabilities

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and optimize value for success (Sirmon *et al.*, 2007). Despite the recognition of resource configurations and environment uncertainty in the resource-based view, there is still a significant lack of research on how startups should combine resources in the context of digital markets. Chen and Tian (2022) and Amit and Han (2017) have strongly stressed the significant need to examine how digital contexts influence the resource configurations for value creation.

This paper focuses on the context of academic spin-offs (ASOs), which are high-technology, new ventures established to commercialize research results from universities or research institutes (Rasmussen, 2011). ASOs are at the forefront of introducing new technologies and inventions, making them crucial for initial changes in technological trajectories and markets. Google is a successful ASO that has led to technological change and market disruption (Mathisen and Rasmussen, 2022). Digital businesses also shift the motivations of ASO's founders toward market knowledge and financial gains (Galati *et al.*, 2020). However, the extant research provides limited knowledge on how digital ASOs effectively make use of resources to survive and grow in digital contexts (Rippa and Secundo, 2019). Additionally, conventional linear models and variable-based approaches might limit the exploration of resource configurations on the outcomes. The predefined assumptions of linear regression models (e.g. homogeneity linearity little or no between-variable multicollinearity and normality of the error term) may fail to account for the combinatory effects of resources.

To address these theoretical and methodological gaps, we integrate a resource-based perspective with the entrepreneurship literature to develop a novel configurational approach for the research question: *What are the resource configurations leading to success among digital ASOs?* The configurational approach is based on the idea that causal relations are better understood in terms of set-theoretic relations rather than correlation (Fiss, 2011). By using fuzzy-set qualitative comparative analysis (QCA), we identify resource configurations for success of digital ASOs. QCA "balances the choice between simplicity and complexity by beginning with a relatively small number of dimensions previously identified in existing research and then examining the interactions between these subcomponents" (Ault and Spicer, 2022, p. 4).

Our study uses a longitudinal dataset covering ASOs established in Norway from 1999 to 2011. We identified 49 digital ASOs and traced their development over a 10 year period after establishment. Using QCA, we identified five different resource configurations that lead to success, representing two main routes. The first path to success involves "market exploiters," digital ASOs operating in favorable market conditions when technological resources and research knowledge resources are absent. The second path involves "technology explorers," digital ASOs that strategically combine different technological and commercial resources to achieve success. Our approach provides a nuanced understanding of the role of resource configurations in the success of digital ASOs, shedding light on the importance of context-specific factors in achieving entrepreneurial success.

Our study contributes to the resource-based view and entrepreneurship literature by providing an understanding of necessary resource configurations for success of digital ASOs. By distinguishing between market exploiter and technology explorer types of ASOs, we clarify the heterogeneities of resource needs for digital ASOs. Finally, our findings have practical implications for policymakers, investors and managers who wish to support and promote digital entrepreneurship.

2. Conceptual framework

2.1 The resource-based view perspective and startup's performance

The resource-based view has highlighted the direct relationship between resources and firm performance (Barney, 1991) by describing strategies of resource structuring, resource bundling and resource leveraging (Chen and Tian, 2022). Firm resources are tangible and intangible assets that enable firms to gain efficiency and effectiveness, such as physical assets, capabilities, knowledge, technologies, financial resources, partnership and networks (Barney, 1991). These resources are attributed to mobility, scarcity, imperfect imitability and non-substitutability (Barney, 1991). Under resource scarcity, firms compete not only on how to sell their products and services but also on how to acquire and combine resources. Resource scarcity may induce higher costs and lower affordability for firms and therefore require imperfect trade-offs related to the resources that firms can acquire (Zahra, 2021). The strategic management of resources determines how firms may exploit their resource advantages in efficient, effective and valuable manners.

Managing resources is a core business activity in entrepreneurship (Chen and Tian, 2022). The long-established resource-based view has been closely integrated into entrepreneurship research (Alvarez and Busenitz, 2001; Chandler and Hanks, 1994; Wiklund and Shepherd, 2003; Kellermanns *et al.*, 2016; Druilhe and Garnsey, 2004). During entrepreneurial processes of exploring and exploiting market opportunities and coordinating various inputs to generate outputs, the strategic management of resources is vital for the establishment and growth of startups (Westhead and Wright, 2013). In their early stages, startups may encounter challenges such as higher uncertainty, liability of newness, limited resources and entrepreneur's insufficient experiences and competencies. As a type of startups, ASOs face similar attributes and needs such as a lack of financial resources or partnership resources (Mathisen and Rasmussen, 2019). However, ASOs also have several unique attributes and needs compared to non-academic startups. For instance, by originating from academic institutions, ASOs tend to have advantages in technological resources and collaboration with universities but often lack market knowledge and business capabilities (Druilhe and Garnsey, 2004; Barney *et al.*, 2001). Moreover, ASOs tend to find it challenging to acquire venture capital (Wright *et al.*, 2012), but this finding seems related to particular industries and investment stages (Mathisen and Rasmussen, 2019).

2.1.1 Firm resources. Newness liabilities necessitate startups and ASOs to have access to diverse types of resources such as financial resources (Van Geenhuizen and Soetanto, 2009; Powers and McDougall, 2005; Wright *et al.*, 2012), partnership resources (Das and Teng, 2000; Eisenhardt and Schoonhoven, 1996), technological resources (Mustar *et al.*, 2006; Westhead and Wright, 2013; Wright *et al.*, 2012) and research knowledge resources (Belderbos *et al.*, 2004; Inzelt, 2004).

2.1.1.1 Financial resources. Financial resources refer to the amount of financial capital the firm can access either by generating it through its activities or securing external funding such as bank loans, governmental grants and external equity investments (Chitsaz *et al.*, 2017). Lack of financial resources hinders the development of startups because it delays investment progression and commercialization activities (Van Geenhuizen and Soetanto, 2009). Although parent organizations may be supportive in the early stages, the venture development and commercialization phase require additional sources of financial resources. Financial resources from investors besides public research grants boost the performance of new firms (Parker *et al.*, 2010).

Financial resources can also assist firms to acquire other necessary resources and capabilities. However, academic discussions about the effects of financial resources on firm performance remain divided. Several studies have emphasized that financial resources may boost firm performance by providing small firms with more affordability for fundamental research, business development and commercialization activities (Wiklund, 1999). However, others have argued that financial resources, for example, late-stage venture capital, may have negative impacts on a firm's innovation performance (Dai *et al.*, 2022) and therefore not provide firms with sustainable competitive advantages (Paeleman and Vanacker, 2015). These oppositions can perhaps be explained by context differences and the combinatory effects of other resources with financial resources.

2.1.1.2 Strategic partnership resources. Strategic partnerships can be an essential resource to build a firm's capabilities and get access to other necessary resources for less investment and commitment and in less munificent environments (Harrison *et al.*, 1991; Sirmon *et al.*, 2007). Firms seek strategic partnerships fitting internal characteristics and external environment to accumulate, share and exchange valuable resources which firms cannot afford or obtain directly in the market (Das and Teng, 2000). Additional resources such as tacit knowledge and technological capabilities are usually accumulated through strategic partnerships (Sirmon *et al.*, 2007).

Strategic partnerships with other firms are especially crucial for startups because these firms may need more resources, networks and market access to commercialize products, secure market shares and sustain survival (Homfeldt *et al.*, 2019; Stuart *et al.*, 1999). For instance, to commercialize innovations, ASOs need two interactive, interdependent types of knowledge: technological knowledge and market knowledge. Technological knowledge is beneficial to explore more technological and R&D opportunities, while market knowledge is used to understand customer needs and market conditions (Nerkar and Roberts, 2004). Startups based on research projects are likely to search for new knowledge (Grimpe and Sofka, 2016) and introduce to markets advanced technologies and radical innovations (Henry *et al.*, 2020; Hockerts and Wüstenhagen, 2010) that may be associated with higher risks of market ambiguity (Ndonzuau *et al.*, 2002).

Strategic partnerships may be particularly important to ASOs which often lack market knowledge related to for example value propositions, target customers and distribution channels (Bruneel *et al.*, 2020). There often exists a gap between science and markets in commercializing scientific knowledge. Thus, strategic partnerships with other firms or potential clients are essential for ASOs to acquire market knowledge, market access, necessary resources and industrial expertise (Bruneel *et al.*, 2020; Gilbert and Campbell, 2015; Nerkar and Roberts, 2004). Without industrial insights, knowledge produced by academics in universities or research institutes may be too theoretical to commercialize in the market (Spencer *et al.*, 2005). Hence, strategic partnerships provide startups with resources and competitive advantages to enhance performance but also reinforce the startups' solutions to societal challenges (Cacciolatti *et al.*, 2020; Chesbrough and Bogers, 2014).

2.1.1.3 Technological resources. Technological resources include intellectual properties and licenses (Westhead and Wright, 2013) and also tacit technological knowledge (Sirmon *et al.*, 2007). Technological resources, such as patented technologies, can help technology startups secure competitive advantages from inventions and innovations and increase their survival and performance (Helmers and Rogers, 2011; Kato *et al.*, 2022; Mathisen and Rasmussen, 2019). These resources provide startups with signals for financial investments, monopolistic positions, greater freedom and a longer time to commercialize their innovations (Audretsch *et al.*, 2012; Bloom and Van Reenen, 2002; Czarnitzki and Toole, 2011). Technological resources are particularly important to ASOs which often are first-movers to introduce radical innovations and advanced technologies in uncertain new markets so it may take longer to earn positive revenue growth and profitability (Bloom and Van Reenen, 2002; Wright *et al.*, 2012). This will help firms with a higher degree of freedom in their market activities and avoid direct competition when these radical innovations are still new to markets (Helmers and Rogers, 2011).

Technological resources are positively correlated with market value, productivity and incentives for a firm's innovations (Bloom and Van Reenen, 2002). Moreover, technological resources also serve as a signal to the capital market to attract potential investors (Audretsch *et al.*, 2012; Bloom and Van Reenen, 2002; Czarnitzki and Toole, 2011). Firms with a higher number of technological resource applications are found with a higher propensity for venture capital (Hellmann and Puri, 2000). Extant research has found that startups with technological resources have a higher chance to survive and grow (Helmers and Rogers, 2011), lower likelihood of bankruptcy and are more likely to be merged or acquired (Kato *et al.*, 2022).

2.1.1.4 Research knowledge resources. Firms also require research knowledge resources to continuously adapt to emerging market demands and technological changes. This resource can be obtained through collaborations with academic partners, such as research institutes and universities, to jointly search for and share new technical knowledge and costs of research and development (Agarwal *et al.*, 2004; Soetanto and Jack, 2016). Beliaeva *et al.* (2019) suggested that collaborations and joint business activities of diverse actors in the innovation system may result in higher profits for digital ventures.

External networks and partnerships with knowledge-based institutes, universities and research centers help high-technology startups to access resources, absorb and acquire technological knowledge more quickly (Agarwal *et al.*, 2004; Soetanto and Jack, 2016), as well as reduce investment costs of equipment and research (Schwartz and Hornych, 2010). Complementary technological knowledge and research capabilities provided through external research knowledge resources may accelerate processes of opportunity exploration, knowledge transfer and commercialization to enhance the growth and performance of technology startups (Agarwal *et al.*, 2004; Soetanto and Jack, 2016).

Moreover, knowledge spill-overs from research knowledge resources may help technology startups avoid technological inertia and exploit new technological knowledge (Nerkar and Roberts, 2004). Maintaining connections with parent universities may increase the performance of ASOs (Bolzani *et al.*, 2021). Furthermore, Ndonzuau *et al.* (2002) stressed this relationship between ASOs with other universities.

2.2 The interaction between external environments and firm resources

The relationship between internal resources and external environments is complex and multidimensional, and while it has been recognized by the resource-based view, it has been little explored. The relationship between resources and firm performance can be moderated by the external environment, which can also act as an antecedent to resource management. The external environment can determine the type and amount of resources that should be accumulated, developed and bundled. Sirmon *et al.* (2007) have argued that understanding the fit between environmental contingencies and resource configurations can lead to a greater understanding of how resources can be managed to optimize value creation. In other words, considering the external environment in conjunction with internal resources can provide a more comprehensive perspective on how to effectively manage resources for firm success.

Market condition is a crucial external environmental factor that directly determines a firm's competitiveness and performance, particularly for startups that require a range of resources to ensure stable cash flows, market shares and survival (Pelham and Wilson, 1995). Additionally, market-related challenges are regarded as some of the most significant barriers to success for high-technology startups, particularly those less than five years old (Van Geenhuizen and Soetanto, 2009). A market condition can be understood as the level of competition in a market (Porter, 1980; Atuahene-Gima, 1995), the demand for products or services at the time of innovation launch (Lin *et al.*, 2013) and how well the innovation meets consumers' needs and preferences (Roger, 1995). Favorable market conditions, characterized by high demand and low competition, have a positive impact on firm performance (Baden-Fuller and Haefliger, 2013). This is because such conditions reduce the risk of market ambiguity and facilitate the commercialization of radical innovation (Baden-Fuller and Haefliger, 2013). Additionally, growing demand may provide more opportunities for firms in marketplaces, leading to lower competition. Conversely, fluctuations in market demand may increase uncertainty and competition (Sirmon *et al.*, 2007).

Market conditions can moderate the effects between resources and firm performances. A market with high uncertainty due to competitive rivalry or demand fluctuations may require more diverse and intensive types of resources to develop the necessary capabilities for responding to change and uncertainty (Sirmon *et al.*, 2007). Conversely, a favorable market with lower competitive intensity or higher consumer demand may facilitate faster and easier commercialization, requiring fewer resources to generate capabilities. This moderating effect can change, intensify, or moderate the relationship between firm resources and performance over time. Dynamic capability theory has captured this moderating effect by explaining how firms need to reallocate and reconfigure their resources to adapt and respond to changing markets (Eisenhardt and Martin, 2000). Sirmon *et al.* (2007, p. 278) suggested that “because environments vary in their degree of uncertainty and munificence and because these conditions affect the potential value of a firm’s resources and capabilities, value creation based on resource management is at least partly contingent on a firm’s external environment.”

Furthermore, market conditions also act as an antecedent factor that can either facilitate or hinder the accumulation, development and maintenance of resources. For instance, in a crowded market with many competitors, resources may become scarce, making firms compete harder. By contrast, a market with fewer competitors may also be less resource-intensive, reducing competition for resources such as technical knowledge and human resources. Furthermore, a high level of market uncertainty can make it more challenging to evaluate the potential value creation of resources or make available resources less relevant and necessary (Sirmon *et al.*, 2007). Consequently, the external environment can influence the relative value of resources, with some becoming more valuable than others. Miller and Shamsie (1996) compared two external conditions and found that knowledge-based resources are needed in an ambiguous environment, while asset-based resources are more valuable in a certain environment. In a less munificent environment where external resources are not easily acquired, the development and maintenance of internal resources become more critical (Sirmon *et al.*, 2007).

2.3 A resource configuration approach

To create values and maintain competitiveness, a firm must exploit, accumulate, allocate and combine different resources in its environment dynamic (Grant, 1991; Sirmon *et al.*, 2007). Configuring or bundling resources defined as “resources within the firm’s resource portfolio are integrated (i.e. bundled) to create capabilities, with each capability being a unique combination of resources allowing the firm to take specific actions . . .” is one of the core steps in the resource management (Sirmon *et al.*, 2007, p. 281). It concerns not only how each resource contributes, but also how these resources are configured to boost firm performances (see Table 1). Additionally, “the complexity and heterogeneity of markets create multiple opportunities for firms to leverage their idiosyncratic capabilities and create value for customers (Sirmon *et al.*, 2007, p. 284). To fully capture these values and capabilities, firms should know how to make effective choices of their resource bundles in response to external environmental uncertainties (Chitsaz *et al.*, 2017; Borch *et al.*, 1999; Sirmon *et al.*, 2007).

Borch *et al.* (1999) developed a conceptual framework illustrating the connections between various resources, resource configurations, competitive advantages and various firm performances. Different resources with distinct attributes can be formed into various resource configurations that may result in competitive advantages and higher firm performance. Contingency factors such as competition, industry and environment may moderate or intensify the effects of resource configurations on competitive advantage, while firm attributes such as age and size can affect how various resources can be configured.

Claims	Authors (years)
"To ensure sustained firm competitive advantage overtime, entrepreneurs need to combine or orchestrate resources . . ."	Westhead and Wright (2013, p. 46)
"To achieve the different objectives firms may choose various strategies depending on their resource configurations. The effects of the strategies are determined by the characteristics of the resources and how they are combined."	Borch *et al.* (1999, p. 52)
"The value of resources (e.g. knowledge) is not defined solely by supply-demand consideration or actual use but also by its combination with others. This logic works equally well in existing industries where new firms challenge incumbent companies by revising known industry recipes by reconfiguring their resource portfolios"	Zahra (2021, p. 1846)
"The source of competitive advantage is not only the resources but also the configuration of the resources within the firm."	Chitsaz *et al.* (2017, p. 187)
"Creating the most value out of one's existing resources by combining these with others' resources, provided, of course, that this combination results in optimal returns."	Das and Teng (2000, p. 37)

Source(s): Author's own work

Table 1. The importance of resource configurations

Firms which fail to align multiple resources and achieve resource orchestration may be outcompeted in their markets, whereas high-performing firms often successfully combine and orchestrate resources to gain competitive advantages (Wiklund and Shepherd, 2005). A configurational approach has been used as an alternative to identify resource configurations. "The logic of the configurational approach rests on the premise that firms that are able to align certain firm attributes with the characteristics of the environment outperform other firms" (Wiklund and Shepherd, 2005, p. 76). "The configurational approach has been developed to overcome the shortcomings of contingency theory, which focuses primarily on the unidirectional influences of (situational) diversified environments on organizations" (Korunka *et al.*, 2003, p. 25).

Wiklund and Shepherd (2005) studied the configurations of entrepreneurial orientation (i.e. the ability to find and discover new opportunities to differentiate the firms and create advantages), resources (i.e. finance) and firm environment. Their empirical evidence showed that entrepreneurial orientation in combination with minimal financial resources and a non-dynamic environment exhibits superior performance among small firms. Paeleman and Vanacker (2015) found that firms which effectively combine abundant financial resources with constrained human resources are more likely to perform better.

Zahra (2021) showed that the survival of startups is determined by the combined effects of several resources and in sync with their external environment. Furthermore, the external environment may be more volatile and influential to certain types of firms such as ASOs. It is because ASOs often introduce radical innovations and advanced technologies associated with a faster-changing pace, higher market uncertainty, higher complexity, lower market stability and more prone to market volatility. However, the understanding of the market effects on digital startups in general and digital ASOs in particular remains incomplete. Neglecting contextual variables such as external environments and technological attributes leads to biased investigations of firm performances (Zahra, 2021).

Despite the calls for more studies, it still lacks research on resource configurations and external environment in both entrepreneurship and the resource-based view literature. Because most resource-based view studies focus on large firms, more knowledge is needed to show which resource configurations can create competitive advantages for startups. Our paper focuses on the emerging context of digital ASOs to explore how resource configurations are linked to performance.

2.4 The context of ASOs and digital markets

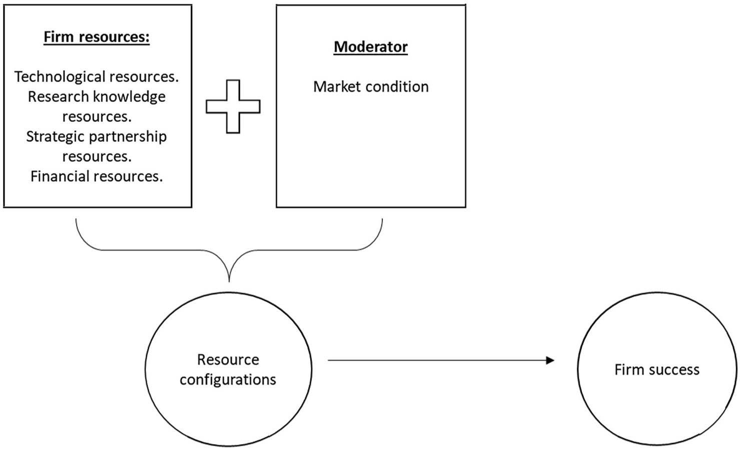
Digital technologies have unique attributes such as openness, editability, re-programmability, generativity and interactivity (Sahut *et al.*, 2019). These digital attributes open both new opportunities and challenges for entrepreneurship and innovation (Sahut *et al.*, 2019). When it comes to opportunities, digital attributes have significantly decreased information disparities and market impediments, while also improving transparency and communication between partners. Such technological emergences have greatly improved the efficiency and efficacy of exchanging, combining and integrating resources (Barua *et al.*, 2004). Unique digital attributes provide firms with more accessible resources, markets and customers globally (Zahra, 2021). For instance, digital platforms can connect digital startups with potential investors worldwide for crowdfunding to overcome financial shortages (Gupta and Bose, 2019; Chandna, 2022).

Digital attributes also create market uncertainty and technical uncertainty and therefore require more novel, innovative resource configurations to overcome those challenges (Chen and Tian, 2022). Digital products tend to be more open, reprogrammable and editable compared to other technological innovations. These digital products and services are likely to continue to evolve and transform after the first versions are introduced (Nambisan, 2017; Sahut *et al.*, 2019). New functions and additional values can be easily developed, added, or rewritten to provide modified versions of digital products and services (Steininger, 2019). Rapid changes in digital products and services increase market uncertainty, unpredictability and more intensive competitiveness (Nambisan *et al.*, 2019). Chen and Tian (2022) have emphasized the significant effects of market uncertainty and technical uncertainty of digital markets on resource orchestration. The authors underscored that in uncertain digital markets, firms need to make use of their resource orchestration capability such as resource structuring, resource bundling and resource leveraging to achieve a higher maturity in digital transformation.

Under the influence of digital attributes, digital entrepreneurship has become more dynamic, diverse and repetitive than traditional entrepreneurship (Nambisan, 2017). The frameworks in traditional innovation and entrepreneurship were grounded upon the underlying assumptions of “stable, fixed, and discreet sets of well-defined boundaries of products and services” (Nambisan, 2017, p. 1032), contrasting to the “porous and fluid boundaries” of digital entrepreneurship (Nambisan, 2017, p. 1032). Hence, the conditions for the success of digital startups may differ from those conditions for other traditional startups, as “the fluid and dynamic processes enabled by digital technologies encourage fast iterations in non-linear paths in the entrepreneurial process” (Zaheer *et al.*, 2019, p. 2). Hence, the successes of digital startups are not determined by predefined entrepreneurial opportunities and predefined value propositions to the same extent as traditional entrepreneurship models (Nambisan, 2017; Sahut *et al.*, 2021).

When it comes to the context of ASOs, technology is a key characteristic of these firms (Mustar *et al.*, 2006). Since many ASOs commercialize digital innovations, it may be expected that digital ASOs require different resource configurations that fit the attributes of their digital markets. These firms may involve in different development paths compared to ASOs based on other technologies. “Many of these resources may not even exist, and if they do, they have to be reconfigured and shaped in major ways. In this process of resource configuration or be reconfigured, these startups make some resources strategically more (less) valuable-a process not always well-recognized in existing resource-based view research” (Zahra, 2021, p. 1846). Despite this significant knowledge need, there is still limited research on resource management of digital ASOs.

We address this gap by exploring the resource configurations shaping the success of digital ASOs. We construct a theoretical framework illustrated in Figure 1. We include key resources such as financial, technological and network resources suggested by Mustar *et al.*



Source(s): Author's own work

Figure 1. Theoretical framework of firm resources, market conditions and firm performance

(2006) and knowledge resources suggested by Das and Teng (2000) and Eisenhardt and Schoonhoven (1996) in the framework. Furthermore, we also include market condition (Autio *et al.*, 2014; Barney, 1991; Sirmon *et al.*, 2007) as a moderator between the resources and firm performances. These four key resources and the market condition provide a premise to form the resource configurations that potentially lead to success of digital ASOs.

3. Method

3.1 Fuzzy-set qualitative comparative analysis

We adopted an inductive, exploratory approach and applied the fuzzy-set QCA method to identify the resource configurations that lead to firm performance among digital ASOs. QCA "allow systematic cross-case comparisons, while at the same time giving justice to within-case complexity" (Rihoux and Ragin, 2009, p. xix). QCA, which is based on Boolean algebra and counterfactual analysis (Ragin, 1998), explores whether single conditions are necessary and sufficient to result in an outcome and which multiple causal configurations can lead to the outcome. Configurations are specific combination sets of factors (i.e. the four internal resources and the external market condition). QCA is particularly appropriate for medium and small-sized samples (Rihoux and Ragin, 2009) and has been widely applied in management studies (Zheng *et al.*, 2021; Del Sarto *et al.*, 2020; Douglas *et al.*, 2020; Torres and Augusto, 2020; Gilbert and Campbell, 2015; Grillitsch *et al.*, 2022).

Social researchers often face a dilemma between the complexity of a social phenomenon and generalities (Ragin, 1998). Variable-oriented, quantitative techniques focus on homogeneous settings to generalize across contexts but have limitations in exploring context complexity. In contrast, case-oriented, qualitative techniques provide a complex understanding of specific settings but with limited generalizability. QCA is considered by Ragin (1998) as a middle path that combines the strengths of both quantitative, variable-oriented and qualitative, case-oriented methods (Zheng *et al.*, 2021; Grillitsch *et al.*, 2022). QCA is a set-theoretic method that systematically recognizes all logically possible configurations (Fiss, 2011; Ragin, 2008). This aspect of QCA may help overcome some limitations of variable-oriented techniques that mainly focus on the marginal effects of single variables on the outcome and therefore potentially face difficulties in "observing event sequences and causal processes" (Ragin, 1998, p. 106f). The logic of QCA rests on an important assumption that the conditions can be interactive and combined in different ways for the same outcome. This situation is called "equifinality" referring to "a system can reach the same final state from different initial conditions and by a variety of different paths" (Katz and Kahn, 1978, p. 30). Hence, QCA can reflect a complex reality where multiple resource configurations can lead to an outcome of digital ASOs. The next section presents the resources and conditions we examine in this study.

3.2 Data and coding

To explore the resource configurations, we developed a dataset of 49 ASOs based on digital technologies. We identified these digital ASOs from a longitudinal database of 373 Norwegian ASOs established on the basis of research from universities and research institutes in Norway between 1999 and 2011. The sample of 49 digital ASOs was identified through a step-wise process as shown in Figure 2.

First, data of 373 Norwegian ASOs was collected through the Research Council of Norway's program aiming to stimulate academic entrepreneurship. The database was constructed using various data sources including news articles written about the firms, published financial statements, corporate announcements from the National Register of Business Enterprises in Norway and patent data from the Norwegian Industrial Property Office and surveys. Then, we relied primarily on the news article data extracted from the A-text/Retriever database covering local and national media in Norway. We found 4,252 news articles written about 295 of the 373 ASOs during the period of 1999–2021. The remaining 78 ASOs were early failures without news articles, so we excluded these firms. Based on the news articles, we extracted information and coded the technology types that the firms invented and commercialized. There were diverse types of technologies such as digital technology, nanotechnology, biotechnology and environmental technology.

Next, based on technology types, we identified 89 digital ASOs. We then coded the specific types of digital ASOs: (1) "software and digital platform", (2) "automation and robotics", (3) "sensor and software" and (4) "3D simulation models". For example, for one company established in 2001 a news articles stated that "the company created an interactive software program that shows parents how to deal with their children's illnesses and injuries"; so we coded this digital technology in the category of "software and digital platform'. For another company established in 2004 a news article stated that "the company invented an advanced algorithm for automation in oil well controls and operation"; so the digital technology was coded as "automation and robotics".

After that, we conducted qualitative coding of the four resource conditions. We re-read the news articles written about the digital ASOs to identify relevant information related to the conditions and performances. All the relevant sentences, numbers, or words in the news articles were noted in relevant categories. The information of financial resources, technological resources, strategic partnership resources and research knowledge resources

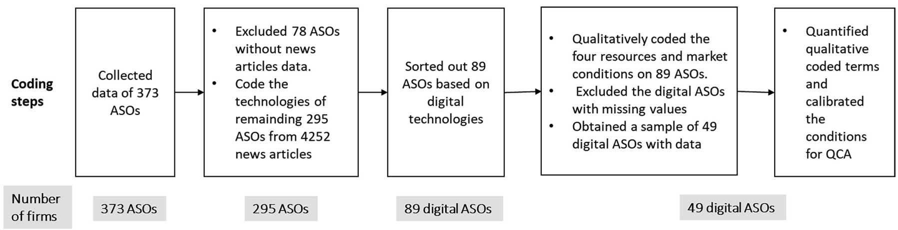


Figure 2.
The coding process

Source(s): Author's own work

could be retrieved quite straightforwardly from the news articles and patent registration data; for example, which types and how much of funding the firms secured; who were the firm’s research partners or client partners and how the partnership contribute to the firm’s activities.

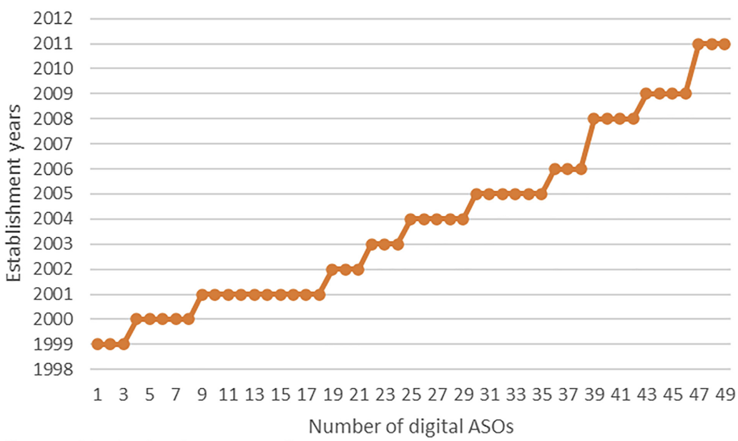
Retrieving information about the market condition from news articles were somewhat more challenging. Some but not all news articles described quite clearly about market conditions in which firms commercialized their products. To mitigate this issue, we used additional survey data. This survey included questions about the innovation and technology (i.e. type, novelty), the market (i.e. market segments, market orientations, customers, competitors) and the social and economic impacts. The firms were asked to evaluate their market conditions, for example, to rate from 1 to 3 the degree of rivalry in the market and to rate from 1 to 5 how adoptable the firm’s innovation is to consumers (i.e. in terms of compatibility, simplicity, trialability and observability). Combining survey data with news article data, we could justify better whether the market condition of an ASO were considered as favorable when the innovation was introduced.

After this coding step, we obtained the final sample of 49 firms with adequate empirical data and excluded 40 firms with missing data. Figures 3 and 4 illustrate a summary of the data sample. Because ASOs are high-technology firms which often are at the forefront of technological advances, these digital ASOs might adopt the digital transformation trend earlier than other firms. Our data showed that ASOs established from 1999 and early 2000s already commercialized digital products and services.

Finally, we quantified these qualitative coded terms of technological resources, strategic partnership resources, research knowledge resources, market condition, funding resources and the performance outcome in a calibration process described in the next section.

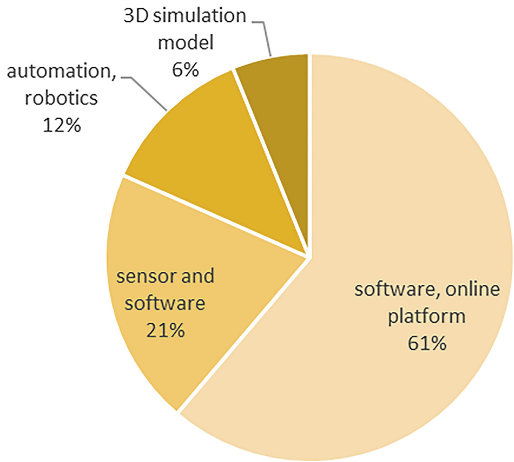
3.3 Measurement and calibration

3.3.1 The four resources and market condition. We coded the conditions “research knowledge resources (RES)”, “strategic partnership resources (PART)”, “market condition (MARK)”, “technological resources (TECH)”, if the given condition is present and 0 if the given condition is absent. For example, if the firm has at least one research partner (i.e. other universities or research institutes), the “research knowledge resources” condition is coded as 1. Otherwise, this condition is coded as 0. In terms of the outcome, the membership score of 1 indicates the



Source(s): Author’s own work

Figure 3.
Digital ASOs and the establishment years



Source(s): Author's own work

Figure 4. The types of digital technologies commercialized by digital ASOs

firm was successful in its first ten years. Moreover, we expected there might be changes in the market conditions and resources of firms over time, so we limited our scope of examining these resources and market conditions within the timeframe of ten years since the establishment.

The "financial resources" condition is in the form of continuous values with specific amounts of financial resources secured during ASOs' establishment and early development. We calibrated this condition by performing a direct calibration process suggested by Ragin (2008) and Gilbert and Campbell (2015) on the fuzzy-set QCA software. The condition calibration is set with the three thresholds of (1) full membership (i.e. fully in); (2) full non-membership (i.e. fully out); and (3) cross-over point, corresponding to the maximum value, minimum value and mean value respectively (Davey *et al.*, 2016). The "financial resources" of digital ASOs varied from 0 to thousand NOK 65,000 (i.e. NOK 65 million) with a mean value is 12,755. According to that, we employed three anchor values of full membership threshold as 65,000, full non-membership as 0 (indicating the firm receiving no financial resources) and cross point as 12,755. The software program transforms continuous values into set values/log odds of membership scores which range from 0 to 1. For example, given three anchor values, the software automatically calibrated a financial resource amount of 50,000 as 0.89 or financial resources amount of 10,000 as 0.34. Table 2 shows the calibrations of the conditions and the outcome.

3.3.2 Firm performance. Given their technological and knowledge capabilities, ASOs are attractive to investors and likely to be acquired by larger industrial firms through trade sales (Clarysse *et al.*, 2013; Cumming and MacIntosh, 2003; Mathisen *et al.*, 2022). Some firms plan exit strategies such as mergers and acquisitions when the businesses are well-performing and profitable in order to scale up their ventures (Kato *et al.*, 2022; Mathisen *et al.*, 2022). In most cases, after successful mergers and acquisitions, the acquired businesses' activities and innovations are likely to be continued under the governance of the buyer firms (Coad *et al.*, 2016). Following Wennberg *et al.* (2010), we consider harvest sales as an indicator of entrepreneurial success, not only as survival or non-survival indicator. Hence, we identify a successful performance as (1) whether the firm is active and profitable; or (2) whether the firm is acquired or merged with another firm and continues to operate and profit from its entrepreneurial innovations after firm sale events. We coded the firm performance as a binary

Table 2. Calibration of conditions and outcome

Conditions/outcome	Label	Description	Calibration
Research knowledge resources	RES	Dichotomous variable, indicating whether the firm has one or more research partners (i.e. universities, research institutes) in addition to its parent organization	No research partner → 0 At least one research partner → 1
Market condition	MARK	Dichotomous variable, indicating whether market conditions are favorable (i.e. high demand, few competitors) when the firm first introduces innovations to the market	Not favorable market condition → 0 Favorable market condition → 1
Strategic partnership resources	PART	Dichotomous variable, indicating whether the firm has one or more partnerships with other firms (i.e. firm client, suppliers)	No partnerships → 0 Partnership with at least one firm → 1
Technological resources	TECH	Dichotomous variable, indicating whether the firm has technological resources	No technological resources → 0 Technological resources → 1
Financial resources	FUND	Continuous variable, indicating the amount of financial resources the firm receives during the first ten years in million NOK	Fully in: 65,000 Crossover: 12,755 Fully out: 0
Outcome: successful performance	OUT	Dichotomous variable, indicating whether the firm is still active or successfully exited in ten years (i.e. acquired by another firm)	Not succeed → 0 Succeed → 1

Source(s): Author's own work

value of equaling 1 if the firm was successful within ten years after establishment and 0 otherwise.

We selected the timespan of ten years since the establishment because the examination of firm performances should be standardized regardless of whether the digital ASOs were born early (e.g. 1999 or early 2000s) or late (e.g. 2010, 2011). For instance, the performance of a digital ASO established in 1999 would be measured from 1999 until 2009, while that of one established in 2011 would be measured until 2021. The timespan of ten years is also appropriate because ASOs are likely to introduce radical innovations that need longer development times to convert their innovations into profitable ventures (Mathisen *et al.*, 2022; Ortín-Ángel and Vendrell-Herrero, 2014).

4. Findings

4.1 Necessary condition analysis

The necessity analysis shows whether any of the conditions can be necessary for the outcome. Following Ragin (2008), we used the consistency threshold of 0.9 to identify conditions considered necessary for the outcome to occur (Rihoux and Ragin, 2009). None of the conditions in this study had a consistency value higher than 0.9 (see Table 3). Hence, the performance of digital startups seems not to be dependent on any individual condition (i.e. financial resources, research knowledge resources, strategic partnership resources, market conditions, or technological resources) but depends on combinations of conditions. We conducted further analyses to explore the configurations of those conditions.

4.2 Sufficient condition analysis

Sufficient condition analysis provides the possible causal configurations required for the outcome to occur. First, we constructed a truth table to find related paths between the

Table 3. Analysis of necessary conditions for the successful performance outcome

Condition	Consistency	Coverage
FUND	0.668	0.898
~FUND	0.332	0.529
RES	0.515	0.750
~RES	0.485	0.708
PART	0.743	0.838
~PART	0.257	0.529
MARK	0.543	0.904
~MARK	0.457	0.592
TECH	0.314	0.917
~TECH	0.685	0.667

Note(s): ~ indicate the absence of the condition. For example**, ~**RES = the absence of research knowledge resources
Source(s): Author's own work

conditions and the outcome. "The truth table elaborates and formalizes one of the key analytic strategies of comparative research—examining cases sharing specific combinations of causal conditions to see if they share the same outcome" (Ragin, 2008, p. 24). Our study examines five conditions; thus, our truth table comprises 32 ($=2^5$) rows or possible causal combinations. By applying cut-off consistency and frequency values, we reduced the rows of the truth table by excluding combinations with no empirical evidence. Following Ragin (2008) benchmark suggestions, we set threshold cut-off values of frequency as 1 and consistency as 0.75.

Next, we run fsQCA 3.0 software based on the Boolean algorithm to simplify and identify causal configurations that lead to the outcome. QCA relies on counterfactual analysis to produce three solutions: a complex solution, a parsimonious solution and an intermediate solution. These three solutions are distinct in terms of limited diversity and logical reminders (non-observable cases). The complex solution does not include logical reminders, in other words, neither easy nor difficult counterfactuals; while the parsimonious solution includes both easy and difficult counterfactuals and intensively uses logical reminders without evaluation of plausibility. The intermediate solution is a more moderate solution that includes only easy counterfactuals and uses logical reminders which are consistent with both theoretical and substantive knowledge.

Following Fiss (2011), Du and Kim (2021), Gilbert and Campbell (2015) and Speldekamp *et al.* (2020), we report both core conditions (denoted by ● if present and ⊗ if absent) and peripheral conditions (denoted by • if present and as ⊗ if absent). Conditions that are not important and related to certain configurations are denoted as blank spaces. This approach of reporting causal core-peripheral conditions (Fiss, 2011) helps distinguish the conditions that appear more important and empirically stronger than the others, as core conditions are defined as "those causal conditions for which the evidence indicates a strong causal relationship with the outcome of interest" (Fiss, 2011, p. 394) and peripheral conditions as "those for which the evidence for a causal relationship with the outcome is weaker" (Fiss, 2011, p. 394). Core conditions are those present in both the parsimonious solution and the intermediate solution, whereas peripheral conditions are those only present in the intermediate solution but not in the parsimonious solution, given that the parsimonious solution requires more difficult counterfactuals.

4.2.1 The conditions for successful performances of digital ASOs. By applying the configurational analysis, we identified seven configurations that possibly lead to a successful outcome (see Table 4). The overall coverage indicates the proportion of the outcome that can

Table 4. Configurations for the successful performance of digital ASOs

	1. RES*PART	2. MARK*~TECH	3. MARK* ~RES	4. PART*TECH	5. FUND* RES*~TECH	6. FUND*~RES* TECH	7. FUND*~PART[*]
Financial resources (FUND)					•	•	●
Research knowledge resources (RES)	●		⊗		•	⊗	
Strategic partnership resources (PART)	●			•			⊗
Market Condition (MARK)		●	•				
Technological resources (TECH)		⊗		•	⊗	•	
Raw coverage	0.372	0.343	0.315	0.257	0.112	0.093	0.070
Unique coverage	0.123	0.027	0.027	0.036	0.044	0.017	0.0432
Consistency	1	0.924	0.917	1	0.940	1	0.751
Solution coverage	0.860						
Solution consistency	0.960						

Note(s): ●, Core present condition; ⊗, core absent condition; •, peripheral present condition; ⊗, peripheral absent condition; blank space, indifferent ("don't care") condition
[*]: Only in parsimonious solution, not in intermediate solution
Source(s): Author's own work

be explained by all configuration solutions. Seven configurations have high solution coverage of 0.867 and solution consistency of 0.958 that meet the criteria given by Ragin (2008) demanding solution coverage and solution consistency must be higher than 0.25 and 0.75, respectively. A solution coverage of 0.867 means that 86.7% of cases are explained by these configuration solutions.

QCA showcases different configuration paths leading to the same outcome as referred to "equifinality". QCA also indicates the degree of empirical evidence in terms of the coverage and consistency values of each configuration path (Gilbert and Campbell, 2015). However, Gilbert and Campbell (2015) also emphasized that a configuration with relatively low empirical evidence (low coverage) does not imply a lack of theoretical importance. Raw coverage is the percentage of cases where the outcome is explained by a certain configuration solution. In other words, the raw coverage value indicates to which degree a configuration is explained by empirical evidence presented as the cases in the dataset. Unique coverage is also the percentage of cases explaining the outcome but exclusively by a certain configuration solution and not covered by other configuration solutions. In our study, all configurations have high consistency values (more than 0.9), except configuration 7 with a relatively lower consistency value of 0.751.

The result reveals that configurations of multiple conditions are required for successful performances. The first configuration RES*PART consists of high raw coverage of 0.371, consistency of 1 and presence in both peripheral condition and core condition. This indicates that combining research knowledge resources and strategic partnership resources can lead to digital ASO's successes.

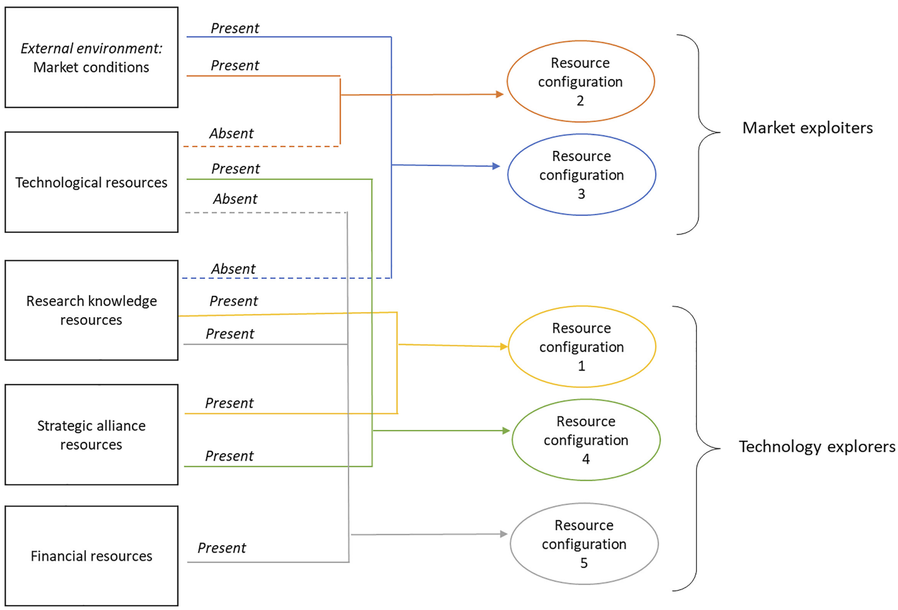
The second configuration MARK*~TECH (raw coverage 0.343, consistency 0.924) indicates that when digital ASOs do not have technological resources, a favorable market condition is required for this type of firm to succeed. This configuration is also present in both peripheral and core conditions. Similar to the second configuration, the third configuration MARK*~RES (raw coverage 0.315, consistency 0.917) implies that in the situation of lacking research knowledge resources, a favorable market condition may also be needed for successful performance. Hence, the market condition that is present in both configurations 2 and 3 appears to be a significant condition for digital ASOs' success when other resources such as technological resources or research knowledge resources are absent.

The fourth configuration PART*TECH (raw coverage 0.257, consistency 1) suggests a combination of strategic partnership resources and technological resources. To succeed, digital ASOs may need to collaborate with industrial partners and, at the same time, patent their innovations. However, this configuration is not present in the core condition but only in the peripheral condition. The fifth configuration FUND*~RES*TECH (raw coverage 0.112, consistency 0.940) shows the combined effect of financial resources and technological resources when lacking research knowledge resources for successful performance. Configurations 6 and 7 consist of low raw coverage (less than 0.10), and in addition, configuration 7 also has low consistency (0.75). Thus, we decided to not report configurations 6 and 7 due to their lack of empirical evidence as shown in the lower raw coverage and consistency values. Compared to other factors such as market conditions and strategic partnership resources, financial resources seem to be a less critical condition for the success of digital ASOs.

5. Discussion

Our study sought to further understand the resource configurations for success of digital ASOs. By applying QCA, we demonstrated that no single condition of "financial resources", "research knowledge resources", "strategic partnership resources", "technological resources", or "market condition" was sufficient for firm success. However, we identified five distinct resource configurations where different combinations of resources were linked to the success of digital ASOs. These resource configurations represent two distinct paths as illustrated in Figure 5. First, many of the successful digital ASOs operate in favorable market conditions combined with an absence of either technological resources or research knowledge resources, as shown in configurations 2 and 3. We term these digital ASOs as “market exploiters” that benefit from pursuing a favorable market opportunity. Second, another group of successful firms follow a path that we label “technology explorers” where they rely on a combination of technological and commercial-related resources. This is evident in configurations 1, 4 and 5 where one condition related to technology (i.e. research knowledge resources or technological resources) is present in combination with one condition related to commercial resources (i.e. strategic partnership resources or financial resources).

The market exploiters consist of two resource configurations that both have an absence of one resource and require the presence of favorable market conditions (i.e. MARK*~TECH and MARK*~RES). The resource configuration MARK*~TECH means that a favorable market condition is a prerequisite when technological resources are absent. The technological resources in the form of patents protect the firms’ rights to exclusively exploit innovations and thereby provide more time to profit from sunk-cost investments, especially when market conditions are uncertain (Bloom and Van Reenen, 2002). This reduces the vulnerability of market uncertainty for startups with limited financial capital. This is especially relevant for digital ASOs which may find even higher market uncertainty attributed to digital technologies (e.g. openness and re-programmability) and often introduce new technologies and radical innovations that require more time for market acceptance. Hence, if digital ASOs do not secure technological resources, a favorable market condition should be present for digital ASOs to commercialize and survive in their early stages. Without technological resources, commercialization in immature markets and risks of innovation imitation from competitors may cause early failures.



Source(s): Author’s own work

Figure 5.
The resource configurations for digital ASOs’ successes

Moreover, a favorable market condition is also crucial for digital ASOs with a lack of research knowledge resources as shown in the resource configuration "MARK*~RES". Digital products and services are likely to be developed and replaced at a faster pace compared to other technologies because digital components can be more easily formed, edited and adjusted. This results in a digital product lifecycle that is less linear, more repeated and without clearly defined starting and ending phases. Additional research knowledge resources through research collaboration with other academic organizations may help digital ASOs better cope with digital uncertainties and adapt to iterative changes in digital markets. Therefore, lacking the research knowledge may require a more favorable market condition to increase market certainty, so digital ASOs can be successful in technology commercialization.

The other group of firms is termed "technology explorers" which belong to three distinct configurations involving combinations of different technological and commercial-related resources. The resource configuration "RES*PART" shows the importance of combining research knowledge resources with strategic partnership resources to simultaneously accumulate technical and market knowledge during the commercialization process. This resource configuration is consistent with Nerkar and Roberts (2004) and Bruneel *et al.* (2020) who showed the complementarity and interdependency between technical knowledge and market knowledge for firm success. Digital ASOs should synergize research knowledge resources and strategic partnership resources to enhance their market exploration ability. On the one hand, startups enter into strategic partnership resources to gain market intelligence and financial resources. Digital ASOs may receive signals of changes in marketplaces through strategic partnership resources. On the other hand, they collaborate with other research institutes to gain technical knowledge and laboratory resources to develop solutions and modify innovations in response to market variations. This searching process of research knowledge and market knowledge through collaboration and partnership may be recurrent, following evolving technological trajectories and market demands. Strategic partnerships and research knowledge may also save costs owing to resource sharing with partners.

Configuration 4 "PART*TECH" shows the significance of strategic partnership resources in combination with technological resources as a formal appropriability mechanism. The tendency of innovation has moved from in-house, closed innovation to more open innovation and collaborative R&D (Chesbrough, 2003), especially in areas relying on digital technologies. Henttonen *et al.* (2016) acknowledged that R&D collaboration with other actors may necessitate various types of innovation protection. Our study affirms that the combination of both strategic partnership resources and technological resources is crucial for entrepreneurial firms, especially for ASOs whose digital innovations may be prone to imitations. The "openness" and "integrability" attributes of digital technologies have rendered the process of multiple-actor collaborations more easily and quickly. Digital entrepreneurship becomes less bounded in terms of spatial proximity and temporal structure. It means that digital ASOs can invite and engage partners from other locations more easily. Moreover, entrepreneurial activities are not limited by timeframes, as digital products and services are editable and reprogrammable after first introductions to the market. Participating in joint R&D may enable knowledge exchange and help digital startups to overcome resource limitations. However, these digital attributes can also incur greater risks of knowledge leakage and technological imitation during entrepreneurial activities. Thus, appropriability mechanisms are particularly important to collaborations and partnerships of digital ASOs, so that the firms can participate in effective, collaborative partnerships but still be able to protect and earn profits from their digital innovations. These boundaries between sharing (e.g. resources, knowledge) and protection (e.g. knowledge, profit) should be balanced and maintained in order for digital startups such as digital ASOs to commercialize and survive, especially in the early development phases.

The financial resources occur in three configurations but only one of these configurations "FUND*RES*~TECH" has relatively good raw coverage (higher than 10%) but still lower coverage compared to configurations 1–4. The lower coverage value means that fewer firms in the dataset rely on this resource configuration for their success. Our empirical result also shows that financial resources are an important but not the only factor for the success of digital ASOs and should be combined with other conditions such as research knowledge resources and absent technological resources. Besides the function of protecting innovation, technological resources can also be essential to attract investors (Kato *et al.*, 2022; Audretsch *et al.*, 2012; Bloom and Van Reenen, 2002). A lack of technological resources may cause a lower possibility of raising venture capital and investments. Moreover, technological resources also provide firms with more time to wait for market maturity before investing in commercialization costs such as marketing (Czarnitzki and Toole, 2011; Bloom and Van Reenen, 2002). Also, technological resources mitigate competitive pressures from competitors since digital ASOs can protect their monopolistic exploitation of their innovation. Our study is aligned with this point of view. We found that when the condition of technological resources is absent, financial resources and research knowledge resources must be combined. The reason may be that without technological resources, firms may have less time for waiting for market certainty and also lack opportunities to attract investments. So, firms may need to gain technological knowledge from research knowledge resources and secure sufficient financial capital from various sources to invest in commercialization activities.

6. Conclusion

6.1 Theoretical contributions

Our study contributes to the intersection of the resource-based perspective and digital entrepreneurship literature in several ways. First, we examine the five resource configurations and distinguish two main paths to success of digital ASOs as "market exploiters" and "technology explorers." Our findings expand the studies of Sirmon *et al.* (2007) and Zahra (2021) by highlighting the role of market conditions in moderating resource management of startups and how resources can be bundled under market conditions. Additionally, we underscore the importance of emergent digital contexts when analyzing the resource needs of ASOs, as also emphasized by Chen and Tian (2022). Due to the unique advantages and disadvantages of digital markets, digital startups and digital ASOs may achieve success through different paths compared to traditional startups. Market certainty emerges as a critical factor in the success of digital ASOs, as demonstrated in the two configurations of "market exploiters." We presume that the significance of digital markets on digital ASO's performance can be attributed to digital attributes such as their fast-changing nature, editability, openness and collaborative potential, which have been highlighted in the existing literature. "Market exploiters" can leverage market certainty, especially in situations where certain technological knowledge by such as technological resources or research collaboration resources are lacking.

Another path to achieving success is by adopting the role of "technology explorers," where the combination of various technological and commercial resources plays a crucial role. In the context of digital ASOs, conventional resources such as strategic partnerships and research collaborations continue to hold significant importance. By leveraging these resources, digital ASOs can simultaneously enhance their technological knowledge and especially market knowledge which ASOs often encounter limitations. This combination of technological and market knowledge can serve as a valuable "recipe" for digital ASOs to thrive in dynamic and rapidly evolving digital markets. Our study enhances Nambisan (2017)'s study by explaining the dynamics of actor collaborations and digital markets where digital products continuously evolve value propositions and actors are involved in new means of communication. As digital markets are more dynamic and digital product lifecycles are shorter, digital companies need to quickly adopt new capabilities and resources (Schiuma *et al.*, 2022). Moreover, our study aligns with the findings of Cavallo *et al.* (2019), which suggest that financial resources, such as venture capital, can have a positive impact on the growth and success of digital ASOs. However, we emphasize that financial resources alone may not be sufficient for the success of digital ASOs. Instead, they need to be effectively combined with other resources, such as research collaboration resources, particularly in cases where technological resources are lacking.

In addition, our study contributes to the field of academic entrepreneurship, which has gradually explored the heterogeneity among ASOs and their resource bases (Mustar *et al.*, 2006). However, there is still limited knowledge regarding the performance implications of resource variations. The significant rise of digital ASOs in recent years has stressed the need for more knowledge about the heterogeneous resources employed by these firms. We show that the importance of the firm's resource base is contingent on the market conditions the ASO is operating in. Prior research has shown the importance of the industry or market context and found that ASOs perform better when operating in less concentrated industries (Nerkar and Roberts, 2004) and using a market exploitation strategy (Soetanto and Jack, 2016). This is consistent with our market exploiters type of digital ASOs that can succeed regardless of some resources absent. In contrast, technology explorers need specific resource configurations connecting the commercial and technological spheres. This means that the lack of favorable market conditions can be compensated by combining technological and business resources. Linking science and business is a fundamental challenge and many ASOs struggle to manage the transition across the institutional boundaries between the academic and commercial worlds (Fini *et al.*, 2019). The technology explorers in our sample can succeed by relying on specific combinations of technological and commercial resources. This adds to the literature on resource complementarity (Hess and Rothaermel, 2011) by illustrating how resources that are complementary (i.e. one technology-related and one business-related) lead to successful outcomes, while none of the successful configurations contains supplementary resources (i.e. only technology-related or only business-related resources).

6.2 Managerial and policy implications

The insights from our study hold significant implications for entrepreneurs, investors and policymakers involved in the digital ecosystem to assess the resource requirements for new digital ventures. Policymakers should consider the diverse resource needs of digital ASOs and ensure that support programs and funding initiatives are designed to address these specific requirements. This may involve providing targeted resources such as research collaboration opportunities, technological infrastructure and access to specialized knowledge or expertise. Digital ASOs operating in better market conditions exhibit less specificity in their resource needs. Conversely, digital ASOs operating in higher market uncertainty require resource combinations that encompass both technological and business resources.

Moreover, our research highlights that financial resources alone are not enough to ensure the success of digital ASOs. This finding suggests that caution should be exercised by investors and public programs when providing funding to digital startups and digital ASOs, ensuring that these ventures have good access to the appropriate combinations of resources necessary for their success. Digital entrepreneurs should carefully consider the configuration of resources needed for success. Financial resources should be complemented with other critical resources such as technological capabilities, research collaborations and strategic partnerships. ASOs should actively seek networking with other organizations, such as research institutions, technology providers and industry associations. These partnerships can help access complementary resources, share knowledge and expertise and enhance the competitive advantage of digital ASOs. Understanding the specific resource combinations that drive success in their particular industry or market context is crucial.

Furthermore, our study underlines the significance of the external environment in shaping the resource needs of digital ASOs. We advocate for increased attention from policymakers to foster favorable digital markets that enable new digital firms to acquire, mobilize and balance their resources effectively. Policymakers should create a favorable regulatory environment that promotes the growth and sustainability of digital ASOs. This includes ensuring flexible regulations that accommodate the fast-changing nature of digital markets and technologies while safeguarding innovation protection and privacy concerns. Public policies should extend beyond direct monetary support and encompass indirect incubation measures and necessary market interventions to generate positive market effects from the demand side. Digital markets will continue to provide both opportunities and challenges to young firms. By fostering a digital environment conducive to resource access and utilization, policymakers can contribute to the growth and success of digital ASOs. Policymakers can encourage collaboration and networking among digital ASOs by creating platforms or programs that facilitate knowledge sharing, research collaborations and partnerships with other stakeholders such as universities, research institutions and industry experts. This can help bridge resource gaps and foster innovation within the digital entrepreneurship ecosystem.

6.3 Limitations and future research agenda

6.3.1 Limitations. While our study offers valuable insights, it is important to acknowledge its limitations. Although QCA is a robust set-theoretic method to explore configurations leading to the outcome, the generalizability of the findings may be limited due to the small sample size and case-based approach. Therefore, conducting large-scale quantitative studies would be beneficial to validate and reinforce the findings uncovered by the QCA. Another limitation is that our primary data source for this study is media articles. To mitigate potential media biases and ensure comprehensive information, we complemented the media articles with several additional sources, including company websites, firm legal events and registration data and patent information. Coding the variable related to "market condition" presented certain challenges in fully capturing the information available in the media. To prevent biased analysis, we enhanced the coding process by incorporating survey data specifically for this variable. Additionally, we excluded cases with insufficient or uncertain information to maintain the integrity of the analysis. This comprehensive approach allowed us to address potential limitations and provide a more reliable and balanced assessment of the conditions faced by the ASOs in our study.

We also carefully consider the generalizability of our Norwegian ASOs sample. Although the Norwegian context may be perceived as unique, it also shares similarities with ASOs in other countries such as the United States, United Kingdom and Europe. For instance, universities typically own ASO inventions, supported by Technology Transfer Offices (TTOs). Also, Norwegian ASOs are established by internationally-oriented academic institutions and they typically aim to commercialize technologies on the global market. Considering these similarities, our sample of Norwegian ASOs can be representative of ASOs in other countries. Related to generalizability with technology startups in general, ASOs may face unique challenges due to their academic origins, such as limited commercial orientation and market experiences (Mathisen and Rasmussen, 2019). So, the need for commercial resources through for instance strategic partnerships may be less intensive for non-academic startups compared to ASOs. However, ASOs still exhibit basic resource limitations such as lacking networks, partnerships and financial resources just as other startups. Additionally, digital attributes may apply for most firms and digital markets may provide several equal opportunities and challenges for either startups or ASOs. Thus, studying ASOs offers valuable insights into digital ASOs and startups overall. Our research contributes to understanding resource strategies employed by digital startups across various contexts while still recognizing the distinct nature of ASOs.

6.3.2 Future research agenda. Our findings open up intriguing avenues for further research. Building upon our study, researchers can delve deeper into the specific sets of resource configurations that contribute to the success of digital ASOs. Additionally, exploring the role of other contextual factors, such as regulatory environments or industry dynamics, could provide a more comprehensive understanding of the resource-based perspective and digital entrepreneurship literature. Furthermore, investigating the mechanisms through which financial resources interact with other resources in influencing the success of digital ASOs would be valuable. This could involve examining the dynamics of resource complementarity or exploring the role of specific resource combinations in different stages of ASO development.

Another line of inquiry is further investigating the role of digital markets as a crucial external environment factor in determining the resource requirements of new digital ventures. Expanding this line of inquiry to firms operating in other markets than digital markets would also provide further interesting insights. For instance, exploring ASOs in the biotechnology or nanotechnology sectors, where the commercialization process is longer and more resource-intensive (Pisano, 2010; Maine *et al.*, 2012), could shed light on successful resource configurations specific to these industries.

Given the limited number of variables explored in this study, it would be interesting to look at the presence and impact of additional technology-related and business-related resources to see if they have the same type of complementary effects on ASOs or technology startups in general. Investigating if these resources have similar complementary effects on ASOs or technology startups would provide a more comprehensive understanding of resource dynamics and their implications. Understanding the interplay between scientific and commercial resources, as emphasized in the literature on science commercialization and ASOs, can contribute to this line of research.

Furthermore, observing the long-term performance and sustainability of ASOs and technology startups and taking into account the changing market dynamics and evolving resource needs would be a fruitful avenue for future research. Since digital markets are more open, fast-changing and evolving, it would be interesting to include the time dimension in considering the resource management of digital ASOs and startups. Examining the strategies employed by successful ASOs in obtaining and leveraging resources, as well as their adaptation to shifting market dynamics over time, could provide valuable insights for practitioners, policymakers and researchers.

Finally, expanding the research scope to include a wider range of digital ventures and incorporating quantitative methodologies would enhance the generalizability of the findings and allow for more precise statistical analyses.

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