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A Conceptual Framework for Evaluating Technology Readiness and Digital Transformation Among Early-Stage Enterprises

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Abstract

Early-stage enterprises are frequently described as "born digital," yet many lack the capabilities, resources and strategic clarity required to convert access to digital technologies into durable competitive advantage. Existing readiness instruments were developed either for individual consumers, such as the Technology Readiness Index, for specific technologies, such as NASA's Technology Readiness Levels, or for large incumbent firms undergoing digital transformation. None adequately captures the resource constraints, founder centrality, liability of newness and rapid pivoting that characterize new ventures. Using an integrative literature review and conceptual framework analysis, this paper develops a framework that links technology readiness to digital transformation in early-stage enterprises. Drawing on the Technology-Organization-Environment framework, the resource-based view, dynamic capabilities theory, organizational readiness for change and the emerging literature on digital entrepreneurship, the framework specifies three antecedent conditions, seven readiness dimensions aggregated into a Digital Readiness Index, a four-stage transformation trajectory, four categories of outcomes, a set of contextual moderators and a learning feedback loop. Seven research propositions are advanced, and a scoring procedure is proposed that combines a compensatory index with a non-compensatory threshold rule. The framework offers researchers a structured basis for empirical testing and provides founders, incubators, investors and policymakers with a diagnostic tool for identifying readiness gaps and sequencing digital investments.

Keywords: technology readiness; digital transformation; early-stage enterprises; startups; digital entrepreneurship; maturity models; conceptual framework

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1. INTRODUCTION

Digital technologies have altered the economics of venture creation. Cloud computing, mobile platforms, open-source software, application programming interfaces and digital payment systems have reduced the fixed costs of starting and scaling a business, while social media and digital marketplaces have lowered the cost of reaching customers (Brynjolfsson & McAfee, 2014; Nambisan, 2017). These developments have encouraged a widespread assumption that new ventures are inherently digital and therefore naturally positioned to benefit from technological change. The assumption is attractive but incomplete. Access to digital tools is not the same as the capacity to deploy them productively, and a growing body of work shows that the value of technology depends on complementary organizational capabilities, strategy and context (Bharadwaj, El Sawy, Pavlou, & Venkatraman, 2013; Westerman, Bonnet, & McAfee, 2014).

Two research streams address this problem, but from different directions. The first concerns *technology readiness*, which has been conceptualized at the level of the individual as a predisposition to embrace new technologies (Parasuraman, 2000; Parasuraman & Colby, 2015), at the level of a technology as its developmental maturity (Mankins, 1995) and at the level of the organization as its preparedness to adopt and absorb innovations (Iacovou, Benbasat, & Dexter, 1995; Weiner, 2009). The second concerns *digital transformation*, understood as the reconfiguration of value creation, business models and organizational structures through digital technologies (Matt, Hess, & Benlian, 2015; Hess, Matt, Benlian, & Wiesböck, 2016). In operations management, for example, digital transformation has been traced through advances in automation, analytics and process redesign (Agboada et al., 2018b). Digital transformation research has focused overwhelmingly on established firms whose challenge is to change legacy structures. Readiness research, meanwhile, has rarely been connected to transformation outcomes.

Early-stage enterprises sit uncomfortably between these streams. They have few legacy systems to dismantle, yet they face severe resource constraints, depend heavily on the cognition and skills of founders, lack established routines and suffer from what Stinchcombe (1965) termed the liability of newness. Their business models are often provisional and subject to repeated pivots (Ries, 2011). For such firms, digital transformation is less a matter of replacing old systems than of building digital capability into the organization as it forms. Assessing their readiness therefore requires instruments that reflect their distinctive conditions.

This paper responds to that need by developing a conceptual framework for evaluating technology readiness and digital transformation among early-stage enterprises. It addresses three questions. First, what dimensions constitute technology readiness in an early-stage enterprise? Second, how does readiness relate to the progression of digital transformation and to venture outcomes? Third, how can readiness be operationalized in a form useful to both researchers and practitioners? The paper contributes an integrative model that links antecedents, readiness dimensions, transformation stages and outcomes; a set of testable propositions; and a scoring procedure, the Digital Readiness Index (DRI), that can serve as a diagnostic for founders and support organizations.

The remainder of the paper is organized as follows. Section 2 describes the research method. Section 3 presents and discusses the results, comprising the literature synthesis, the theoretical foundations, the conceptual model and its propositions, the operationalization of the model, and the implications, limitations and future research directions that follow from it. Section 4 concludes.

2. RESEARCH METHOD

2.1 Research Design

This study adopts a conceptual, theory-building design. Because the phenomenon of interest spans several literatures that have developed largely in isolation, and because empirical evidence on the technology readiness of early-stage enterprises remains sparse, the study combines an integrative literature review (Torraco, 2005) with conceptual framework analysis (Jabareen, 2009). An integrative review is suited to emerging topics that benefit from a holistic reconceptualization of existing knowledge, while conceptual framework analysis provides a structured procedure for identifying, categorizing and integrating concepts into a coherent model. The intended contribution is therefore one of theory synthesis and model building rather than hypothesis testing (MacInnis, 2011; Gregor, 2006).

2.2 Literature Identification and Selection

Relevant literature published up to and including 2018 was identified through searches of Scopus, Web of Science, Google Scholar and the AIS Electronic Library, supplemented by backward and forward citation searching from seminal works (Webster & Watson, 2002). Search strings combined terms for readiness and adoption (for example, "technology readiness",

"organizational readiness", "technology adoption" and "maturity model") with terms for transformation ("digital transformation", "digitalization" and "digital business strategy") and terms for the target population ("startup", "new venture", "early-stage enterprise", "small business" and "digital entrepreneurship").

Sources were included if they (a) addressed technology readiness, technology adoption, digital transformation, digital maturity or digital entrepreneurship; (b) offered a conceptual or empirical contribution at the individual, technology, organizational or ecosystem level; and (c) were published in peer-reviewed journals, conference proceedings, scholarly books or authoritative institutional reports. Purely technical studies without organizational implications were excluded. Applied studies from emerging-economy contexts were deliberately retained to capture the infrastructure, skills and governance conditions under which many early-stage enterprises operate. The final corpus comprises the sources listed in the reference section.

2.3 Analysis and Synthesis

The selected sources were analysed using a concept-centric approach (Webster & Watson, 2002). Each source was coded for its level of analysis, its core constructs, its relevance to early-stage enterprises and its limitations for that population. Codes were then grouped iteratively into thematic streams, which form the structure of the literature synthesis in Section 3.1. Gaps were identified by comparing what each stream explains with the distinctive conditions of new ventures.

The conceptual model was constructed in three further steps. First, the theoretical lenses that best explained the identified gaps were integrated to establish the model's causal logic (Section 3.2). Second, concepts from the synthesis were organized into antecedents, readiness dimensions, transformation stages, outcomes and moderators, following design principles for maturity and assessment models that emphasize clear scope, theoretically grounded dimensions and defined stages (de Bruin et al., 2005; Becker et al., 2009). Third, testable propositions were derived from the relationships specified in the model (Whetten, 1989). Finally, the usefulness of the resulting instrument was illustrated through a hypothetical application. Table 1 summarizes the methodological stages.

Table 1. *Stages of the research methodology*

Stage	Activities	Output
1. Scoping	Defining the research questions and the boundaries of the target population	Research questions; search strategy
2. Identification and selection	Database searches; backward and forward citation searching; application of inclusion criteria	Corpus of literature published up to 2018
3. Concept-centric analysis	Coding by level of analysis, constructs, relevance and limitations; thematic grouping	Concept matrix (Table 2); research gaps
4. Theoretical integration	Selecting and combining lenses that explain the gaps	Causal logic of the model
5. Model construction	Specifying antecedents, dimensions, stages, outcomes and moderators	Conceptual model (Figure 1); research propositions
6. Operationalization and illustration	Designing the Digital Readiness Index and applying it to a hypothetical case	Scoring procedure; illustrative profile

Source: Developed by the author, following Torraco (2005), Jabareen (2009) and Webster and Watson (2002).

2.4 Rigour

Several measures were taken to strengthen rigour. The search and selection procedures are reported transparently so that they can be replicated. Searching continued until additional sources ceased to introduce new concepts relevant to the model. Concepts were triangulated across streams, so that each readiness dimension is supported by more than one body of literature. The limitations that remain, including those inherent to a conceptual design, are discussed in Section 3.8.

3. RESULTS AND DISCUSSION

This section presents the results of the integrative review and conceptual framework analysis, followed by their discussion. It first synthesizes the literature and identifies research gaps (Section 3.1), then sets out the theoretical foundations (Section 3.2), the conceptual model (Section 3.3) and the research propositions (Section 3.4). It then operationalizes the model (Section 3.5) before

discussing the results (Section 3.6), their implications (Section 3.7), the limitations of the study (Section 3.8) and directions for future research (Section 3.9).

3.1 Literature Synthesis

3.1.1 Technology Readiness at the Individual and Technology Levels

The term technology readiness has acquired several meanings. In marketing and services research, Parasuraman (2000) defined it as people's propensity to embrace and use new technologies to accomplish goals in home life and at work. The resulting Technology Readiness Index (TRI) captures two enabling dimensions, optimism and innovativeness, and two inhibiting dimensions, discomfort and insecurity. Parasuraman and Colby (2015) later refined the instrument into a shorter TRI 2.0 that retained the same four-factor structure. The TRI is valuable because it recognizes that readiness is shaped by both positive and negative beliefs, and that the two can coexist within the same individual.

In engineering and defense contexts, readiness refers instead to the maturity of a technology. The Technology Readiness Level (TRL) scale developed at NASA describes nine stages, from the observation of basic principles to the proven operation of a system in its intended environment (Mankins, 1995). Sauser, Verma, Ramirez-Marquez and Gove (2006) extended this logic to systems readiness, observing that mature components do not guarantee a mature system when integration is weak. The TRL tradition offers a useful insight for early-stage enterprises, many of which are themselves developing technologies, but it evaluates the artifact rather than the organization that must exploit it.

Closely related is the technology acceptance literature. The Technology Acceptance Model (Davis, 1989) and the Unified Theory of Acceptance and Use of Technology (Venkatesh, Morris, Davis, & Davis, 2003) explain individual adoption through perceived usefulness, ease of use, social influence and facilitating conditions. These models have strong predictive power for individual behaviour, and they matter for new ventures because adoption decisions are often made by one or two founders. However, they treat adoption as a discrete decision rather than as the start of an organizational capability-building process.

3.1.2 Organizational Readiness and Firm-Level Adoption

At the organizational level, the Technology-Organization-Environment (TOE) framework proposed by Tornatzky and Fleischer (1990) holds that adoption is shaped by the characteristics of the technology, the internal attributes of the organization and the external environment. TOE has been widely applied and is consistent with the Diffusion of Innovations perspective (Rogers, 2003), which emphasizes relative advantage, compatibility, complexity, trialability and observability (Oliveira & Martins, 2011). Studies of small firms have shown that organizational readiness, measured through financial and technological resources, is a significant predictor of adoption (Iacovou et al., 1995), and that the value realized after adoption depends on usage depth and complementary resources rather than adoption alone (Zhu & Kraemer, 2005).

A separate line of work treats readiness as a psychological and collective state. Armenakis, Harris and Mossholder (1993) described readiness for change as the beliefs, attitudes and intentions of organizational members regarding the need for change and the organization's capacity to undertake it. Weiner (2009) proposed that organizational readiness comprises change commitment and change efficacy. This perspective is important for new ventures because their small size means that the commitment and efficacy beliefs of a few individuals effectively constitute the organization's readiness. Readiness also has a societal dimension: in emerging economies, digital inclusion and workforce-readiness interventions shape the pool of digitally capable founders and employees on which new ventures draw (Unamma et al., 2018a).

3.1.3 Digital Transformation and Maturity Models

Digital transformation research describes how firms use digital technologies to change their value propositions, operations and customer relationships. Matt et al. (2015) identified four dimensions of a digital transformation strategy: the use of technologies, changes in value creation, structural changes and financial aspects. Hess et al. (2016) built on this work to describe strategic options available to firms. Bharadwaj et al. (2013) argued that digital business strategy should be understood as organizational strategy executed through digital resources rather than as a functional IT strategy. Practitioner research reached a similar conclusion, finding that strategy, culture and leadership were stronger drivers of digital maturity than technology itself (Kane, Palmer, Phillips, Kiron, & Buckley, 2015; Westerman et al., 2014).

To assess progress, scholars and consultancies have proposed numerous digital maturity models. Berghaus and Back (2016) identified stages of digital business transformation across multiple dimensions, while Schumacher, Erol and Sihn (2016) developed a maturity model for Industry 4.0 readiness in manufacturing. Chanias and Hess (2016) and Remane, Hanelt, Wiesböck and Kolbe (2017) reviewed and tested such models, noting that many lack theoretical grounding and that their dimensions are often designed with large, established firms in mind. Methodological guidance on maturity model construction (de Bruin, Freeze, Kaulkarni, & Rosemann, 2005; Becker, Knackstedt, & Pöppelbuß, 2009) stresses that a model must be fit for its intended population, which reinforces the case for an instrument designed specifically for new ventures.

3.1.4 Digital Entrepreneurship and Early-Stage Enterprises

A distinct literature on digital entrepreneurship has emerged. Nambisan (2017) argued that digital artifacts, platforms and infrastructures make entrepreneurial processes and outcomes less bounded, with the result that opportunities, products and venture boundaries become more fluid. This view builds on the layered modular architecture of digital technologies, in which devices, networks, services and content can be recombined independently to create new products (Yoo et al., 2010). Giones and Brem (2017) distinguished between technology entrepreneurship, digital technology entrepreneurship and digital entrepreneurship according to the role technology plays in the venture. Sussan and Acs (2017) proposed the concept of a digital entrepreneurial ecosystem, and Autio, Nambisan, Thomas and Wright (2018) showed how digital affordances reshape the formation of entrepreneurial ecosystems. Davidsson (2015) and von Briel, Davidsson and Recker (2018) conceptualized digital technologies as external enablers that can create or amplify opportunities for new venture creation.

This literature establishes that digital technologies change what entrepreneurs can do, but it says comparatively little about how individual ventures differ in their capacity to capture these possibilities. Lean startup practice (Ries, 2011) emphasizes rapid experimentation and validated learning, both of which depend on data capabilities and digital infrastructure, yet these capabilities are rarely measured. As a result, incubators, accelerators and early-stage investors typically assess digital capability informally.

3.1.5 Synthesis of the Literature

Table 2 synthesizes the streams reviewed above. Read together, they show that each stream contributes an essential element of the proposed model, but none on its own captures the coupled individual, organizational and contextual nature of readiness in early-stage enterprises.

Table 2. *Concept matrix synthesizing the literature*

Stream	**Representative sources**	**Core contribution**	**Limitation for early-stage enterprises**	**Use in the model**
Individual technology readiness and acceptance	Parasuraman (2000); Parasuraman and Colby (2015); Davis (1989); Venkatesh et al. (2003)	Beliefs and dispositions shape adoption	Individual level only; adoption treated as a discrete decision	D1 founder digital disposition
Technology maturity	Mankins (1995); Sauser et al. (2006)	Staged maturity of technologies and systems; integration matters	Evaluates the artifact, not the organization	Staged logic; D2 infrastructure integration
Organizational adoption and readiness	Tornatzky and Fleischer (1990); Iacovou et al. (1995); Zhu and Kraemer (2005); Weiner (2009)	Technological, organizational and environmental drivers; commitment and efficacy	Assumes established structures and slack resources	Overall architecture; D2, D6, D7
Digital transformation and maturity models	Matt et al. (2015); Hess et al. (2016); Berghaus and Back (2016); Remane et al. (2017); Agboada et al., 2018b	Dimensions of transformation strategy; staged maturity	Designed for incumbents; often weakly theorized	Transformation trajectory; D5

Stream	**Representative sources**	**Core contribution**	**Limitation for early-stage enterprises**	**Use in the model**
Digital entrepreneurship and ecosystems	Nambisan (2017); Sussan and Acs (2017); Autio et al. (2018); von Briel et al. (2018)	Digital technologies as external enablers; ecosystem effects	Little attention to venture-level capability differences	D5, D7; contextual moderators
Emerging-economy applied studies	Amayo & Popoola, 2017; Fadero et al., 2018; Sunday & Omoegun, 2018; Unamma et al., 2018a, 2018c	Infrastructure, skills and governance constraints	Sector-specific and fragmented	Antecedents; moderators; D4

Source: Developed by the author from the literature reviewed in Section 3.1.

3.1.6 Research Gaps

The review reveals four gaps that motivate the present framework.

- **Level-of-analysis gap.** Readiness has been measured for individuals and technologies, and transformation for large organizations, but rarely for new ventures where the individual and the organization are tightly coupled.
- **Linkage gap.** Few models connect readiness explicitly to stages of digital transformation and then to venture-level outcomes.
- **Contextual gap.** Existing maturity models assume stable structures, mature processes and slack resources, conditions that seldom hold in early-stage enterprises, particularly in emerging economies where infrastructure and institutional support are uneven. Unreliable power, variable network quality and low-connectivity environments impose constraints that standard models ignore (Amayo & Popoola, 2017; Sunday & Omoegun, 2018; Unamma et al., 2018c).
- **Measurement gap.** Compensatory indices that average across dimensions can mask critical weaknesses, yet resource-constrained ventures are especially vulnerable to the weakest link in their capability set.

3.2 Theoretical Foundations

The framework integrates five theoretical lenses, each contributing a distinct element.

The Technology-Organization-Environment framework (Tornatzky & Fleischer, 1990) provides the overall architecture by establishing that readiness has technological, organizational and environmental components. In the present framework, these appear respectively as infrastructure and data dimensions, internal capability dimensions and ecosystem connectedness.

The resource-based view (Barney, 1991) explains why readiness should be associated with performance. Digital resources rarely provide advantage alone because they are widely available. Advantage arises when they are combined with complementary resources, such as skills, data and customer relationships, that are valuable, rare and difficult to imitate. Readiness therefore reflects the bundle of resources that allows technology to be leveraged. Work on financial analytics in technology firms supports this view by showing that data assets create enterprise value only when they are embedded in decision processes (Lawal & Oduleye, 2018a).

Dynamic capabilities theory (Teece, Pisano, & Shuen, 1997; Teece, 2007) addresses change over time. Its emphasis on sensing opportunities, seizing them and reconfiguring resources maps naturally onto the transformation trajectory proposed here, and it explains why readiness is not static but must be continually renewed as the venture and its environment evolve.

Organizational readiness for change (Armenakis et al., 1993; Weiner, 2009) contributes the insight that readiness has motivational and efficacy components. In a new venture, these are concentrated in the founding team, which is why founder digital disposition is treated as a separate dimension and why the individual-level TRI constructs of optimism, innovativeness, discomfort and insecurity are incorporated (Parasuraman & Colby, 2015).

Digital entrepreneurship and external enabler theory (Nambisan, 2017; von Briel et al., 2018) situates the framework within entrepreneurship research. It suggests that the same technology can enable very different outcomes depending on how ventures perceive and act upon it, which justifies treating strategic and business model fit as a dimension of readiness rather than an outcome.

Together, these perspectives imply that technology readiness in an early-stage enterprise is a multidimensional, dynamic and context-dependent construct. It reflects both the dispositions of founders and the resources of the firm, it develops over time through learning, and its effects depend on the environment in which the venture operates.

3.3 Conceptual Model

3.3.1 Overview

Figure 1 presents the proposed framework. It comprises six elements: antecedent conditions that shape initial readiness; seven readiness dimensions that together form a Digital Readiness Index; a four-stage transformation trajectory; four categories of outcomes; contextual moderators that condition the strength of relationships; and a learning feedback loop through which outcomes recalibrate readiness. The framework is intended to be read from left to right as a causal sequence, while the feedback loop signals that the process is iterative rather than linear.

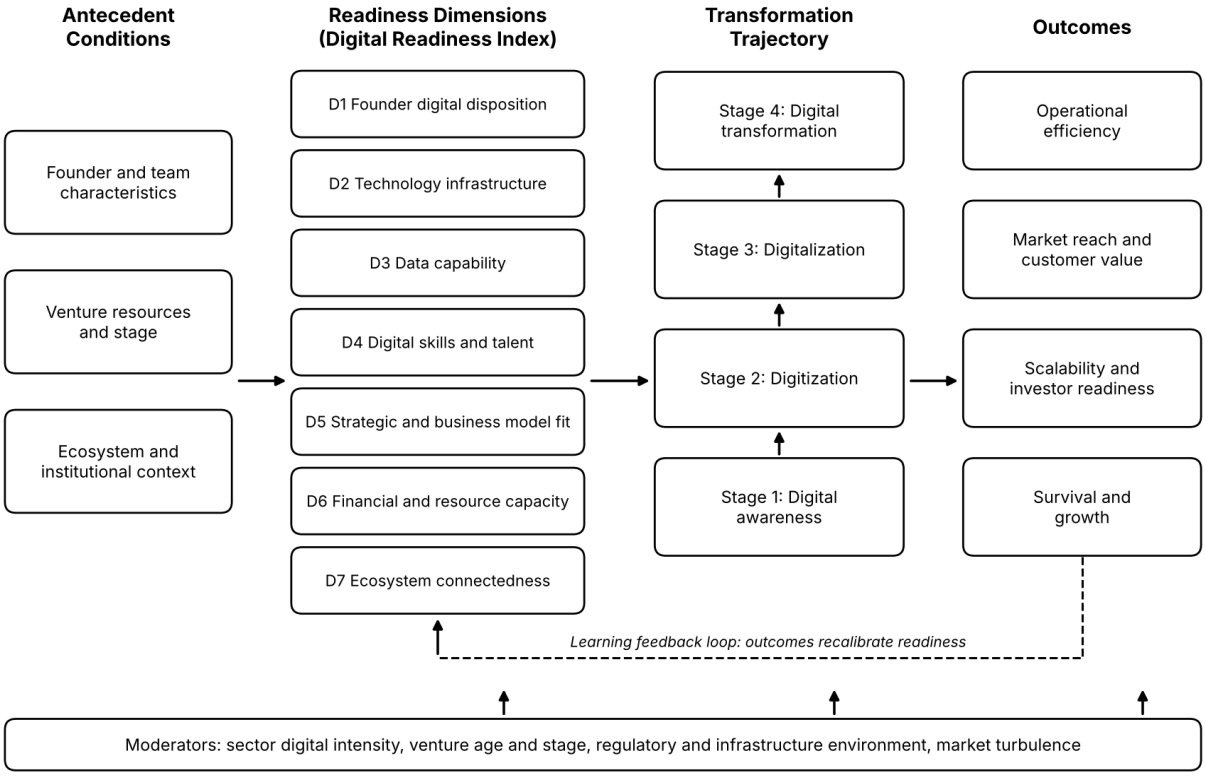

Figure 1. *Conceptual framework for evaluating technology readiness and digital transformation among early-stage enterprises.*

3.3.2 Antecedent Conditions

Three antecedent conditions shape the readiness a venture brings to its digital development. **Founder and team characteristics** include prior industry and technical experience, education, digital literacy and the composition of the founding team. Because founders make most early decisions, these attributes are likely to exert a strong imprinting effect on later capabilities. **Venture resources and stage** include initial capital, intellectual property, access to equipment

and the venture's position in its lifecycle, from ideation through validation to early scaling. **Ecosystem and institutional context** includes access to broadband and power infrastructure, the availability of digital payment systems, the density of incubators, accelerators and investors, and the regulatory environment for data and online commerce (Sussan & Acs, 2017; OECD, 2017). These conditions are especially variable across countries, and ventures in emerging economies may face infrastructure constraints that are absent in mature markets. Interventions that widen digital inclusion and build workforce readiness therefore form part of the context in which ventures are founded (Unamma et al., 2018a), and the competency frameworks and onboarding practices a young firm adopts help determine how quickly new staff become digitally productive (Ukadike, 2018).

3.3.3 Readiness Dimensions

The core of the framework consists of seven readiness dimensions. Each captures a distinct aspect of a venture's capacity to adopt and exploit digital technologies, and each is anchored in one or more of the theoretical lenses described in Section 3.2. Table 3 summarizes their definitions, illustrative indicators and theoretical anchors.

Table 3. *Readiness dimensions, indicators and theoretical anchors*

Dimension	**Definition**	**Illustrative indicators**	**Theoretical anchor**
D1 Founder digital disposition	The beliefs and attitudes of the founding team toward digital technologies	Optimism and innovativeness; low discomfort and insecurity; personal use of digital tools; willingness to experiment	TRI 2.0; readiness for change; TAM/UTAUT
D2 Technology infrastructure	The hardware, software, connectivity and security arrangements available to the venture	Cloud adoption; reliable connectivity; integrated core systems (CRM, accounting, e-commerce); basic cybersecurity practice	TOE (technology); TRL/SRL
D3 Data capability	The ability to collect, store, analyse and act on data	Defined key metrics; analytics tools in use; data-informed decisions; data protection compliance	RBV; lean experimentation

Dimension	**Definition**	**Illustrative indicators**	**Theoretical anchor**
D4 Digital skills and talent	The technical and digital competences available inside or accessible to the venture	In-house technical skills; access to freelancers or partners; training activity; product development capability	RBV; dynamic capabilities
D5 Strategic and business model fit	The degree to which digital technologies are integrated into the value proposition and strategy	Explicit digital strategy; digital channels in revenue model; alignment of technology choices with customer needs	Digital business strategy; external enablers
D6 Financial and resource capacity	The financial and time resources available for digital investment	Budget allocated to technology; runway; access to grants or investment; ability to absorb switching costs	TOE (organization); RBV
D7 Ecosystem connectedness	The venture's links to partners, platforms and support organizations that supply digital resources	Incubator or accelerator membership; platform partnerships; API integrations; mentor networks	TOE (environment); digital entrepreneurial ecosystems

Source: Developed by the author from the literature reviewed in Sections 3.1 and 3.2.

Several features of these dimensions deserve comment. First, D1 deliberately retains the inhibiting factors of the TRI. A founder may be highly innovative yet uncomfortable relying on technologies they do not control, and this tension affects decisions about outsourcing, cloud adoption and data sharing. Second, D3 is separated from D2 because the availability of systems does not imply the capacity to use the data they generate; many small firms collect data that they never analyse. Third, D5 recognizes that readiness is not only about capability but also about purpose. A venture with sophisticated tools but no clear digital value proposition is not ready in any meaningful sense. Finally, D7 reflects the observation that early-stage enterprises often access capabilities through their networks rather than by building them internally (Autio et al., 2018).

The applied literature offers support for several of these dimensions. For technology infrastructure (D2), studies of scalable and secure cloud architectures, multi-tenant productivity platforms, continuous integration and deployment pipelines, energy-efficient virtual machine placement and resource allocation algorithms describe the technical foundations on which digital

ventures build and the trade-offs between cost, performance and security that they must manage (Adjei et al., 2018; Ahmed & Odejobi, 2018a, 2018b; Badmus et al., 2018; Odejobi & Ahmed, 2018). For data capability (D3), work on predictive forecasting for resource allocation, data-driven risk control and the quality of data in digital information systems shows that the value of data depends on how reliably it is collected and how well it informs decisions (Ekemezie et al., 2018; Obriki & Arumosoye, 2018; Unamma et al., 2018b). Data capability also includes governance, and studies of legal and ethical risk in data protection, compliance analytics, insider threats and technology-enabled audit stress that data must be trustworthy and lawfully handled (Akeju et al., 2018; Akomolafe & Agu, 2018; Lawal & Oduleye, 2018b; Mbonu et al., 2018). For digital skills and talent (D4), research on competency frameworks and digital workforce readiness highlights the importance of structured capability building (Ukadike, 2018; Unamma et al., 2018a). For strategic and business model fit (D5), studies of integrated marketing communications, trade finance product design and strategic procurement show how strategic intent is translated into the design of offerings and operations (Agboada et al., 2018a; Agyei et al., 2018; Okonkwo et al., 2018).

3.3.4 Transformation Trajectory

Following the distinction commonly drawn in the literature between digitization, digitalization and digital transformation, the framework conceptualizes the digital development of an early-stage enterprise as progressing through four stages. The stages are cumulative but not strictly sequential; ventures that are born on digital platforms may enter at Stage 2 or Stage 3, and ventures may regress if key capabilities are lost, for example when a technical co-founder leaves. Table 4 describes each stage.

Table 4. *Stages of the digital transformation trajectory for early-stage enterprises*

Stage	**Description**	**Typical evidence**	**Primary readiness levers**
1. Digital awareness	Founders recognize the relevance of digital technologies but use them informally and in isolation	Personal devices and free tools; social media presence; manual record keeping	D1, D6
2. Digitization	Analogue information and tasks are converted into digital form	Digital bookkeeping; online payments; basic website; cloud storage	D2, D4, D6

Stage	Description	Typical evidence	Primary readiness levers
3. Digitalization	Digital technologies are used to improve and integrate business processes	Integrated systems; automated workflows; customer data used for decisions; e-commerce channels	D2, D3, D4, D7
4. Digital transformation	Digital technologies reshape the value proposition and business model	Platform or data-driven offerings; new revenue streams; scalable digital operations; continuous experimentation	D3, D5, D7

Source: Developed by the author, drawing on Berghaus and Back (2016), Matt et al. (2015) and Westerman et al. (2014).

The move from digitization to digitalization is illustrated by research on operations management, which shows how automation, analytics and process redesign progressively integrate business processes once core information has been converted into digital form (Agboada et al., 2018b).

3.3.5 Outcomes

The framework identifies four categories of outcomes. **Operational efficiency** captures reductions in cost and time from automation and process integration. **Market reach and customer value** captures expanded access to customers, improved service and greater personalization. **Scalability and investor readiness** captures the ability to grow output without proportional increases in cost, as well as the credibility that digital capability provides to investors. **Survival and growth** captures the ultimate venture-level outcomes of continuity, revenue growth and employment. These outcomes are ordered roughly from proximal to distal, with efficiency gains expected earliest and survival effects observable only over longer periods.

3.3.6 Contextual Moderators

Four moderators condition the relationships in the framework. **Sector digital intensity** affects how much digital capability is required for competitiveness; a software venture and a food processing venture face very different thresholds. **Venture age and stage** affects which dimensions matter most, with founder disposition likely to dominate in the earliest phases and data capability later. **The regulatory and infrastructure environment** affects both the cost of digital

adoption and the returns it generates, particularly in economies with unreliable power, costly connectivity or uncertain data regulation. Studies of IT governance frameworks and regulatory compliance, and of legal and ethical risk in data protection, show that regulatory regimes shape both the obligations and the design choices of digital firms (Fadero et al., 2018; Mbonu et al., 2018). The cyber threat environment is a related consideration, since insider threats and weaknesses in security-critical systems grow with digital exposure (Akeju et al., 2018; Ladapo et al., 2018). Infrastructure constraints, including the cost of reliable power and the quality of telecommunications networks, likewise condition the returns to digital investment (Amayo & Popoola, 2017; Sunday & Omoegun, 2018). **Market turbulence** affects the value of agility, so that readiness should yield higher returns in rapidly changing markets where the capacity to reconfigure is most valuable (Teece, 2007).

3.3.7 Learning Feedback Loop

The framework includes a feedback loop from outcomes to readiness. Positive outcomes generate revenue, legitimacy and data that can be reinvested in infrastructure, skills and networks, while failures can provide learning that refines strategy and technology choices. This loop reflects the experimental logic of lean startup practice (Ries, 2011) and the reconfiguring element of dynamic capabilities. It implies that readiness should be assessed repeatedly rather than once, and that change in readiness over time is itself an informative indicator.

3.4 Research Propositions

Consistent with guidance on theory building (Whetten, 1989; Gregor, 2006), the framework yields the following propositions, which specify relationships amenable to empirical testing.

P1: *The digital disposition of the founding team (D1) is positively associated with the other readiness dimensions, and this association is stronger in younger ventures.*

P2: *Higher overall readiness, as measured by the Digital Readiness Index, is positively associated with a venture's progression along the transformation trajectory.*

P3: *The relationship between readiness and transformation is non-compensatory: a venture whose score on any single dimension falls below a minimum threshold will not progress beyond its current stage regardless of its scores on other dimensions.*

P4: *Data capability (D3) and strategic and business model fit (D5) are stronger predictors of progression from digitalization to digital transformation than technology infrastructure (D2).*

P5: *Ecosystem connectedness (D7) partially substitutes for internal digital skills (D4) and financial capacity (D6), such that the negative effect of low internal resources on transformation is weaker for highly connected ventures.*

P6: *The transformation stage mediates the relationship between readiness and venture outcomes.*

P7: *The positive effect of readiness on outcomes is stronger in sectors of high digital intensity and in turbulent markets, and weaker where infrastructure and regulatory constraints are severe.*

3.5 Operationalizing the Conceptual Model

3.5.1 The Digital Readiness Index

To make the framework usable, each readiness dimension is measured through four to six items rated on a five-point scale, where 1 indicates no capability and 5 indicates an advanced and well-embedded capability. Items for D1 can be adapted from TRI 2.0 (Parasuraman & Colby, 2015), while items for the remaining dimensions can be derived from the indicators in Table 3. The dimension score S*i* is the mean of its items. The overall index is computed as a weighted mean and then rescaled to a 0 to 100 range:

$$DRI = [\ (\Sigma\, w_i \times S_i\ ) - 1\ ] \div 4 \times 100, \quad where\ \Sigma\, w_i = 1$$

In the absence of empirical evidence, equal weights of one-seventh are recommended. Once data become available, weights can be estimated statistically, for example from the loadings of a confirmatory factor model, or elicited from experts through pairwise comparison. Sector-specific weights may also be appropriate given the moderating role of sector digital intensity.

Because P3 proposes a non-compensatory relationship, the index is paired with a **threshold rule**: a venture is classified as ready to progress to the next transformation stage only if its DRI falls in the corresponding band and no single dimension scores below 2.0. This combination preserves the convenience of a single summary score while preventing a strong performance on one dimension from concealing a critical weakness on another. Table 5 presents the proposed interpretation bands.

Table 5. *Interpretation bands for the Digital Readiness Index*

DRI score	Readiness profile	Interpretation	Indicative priority
0 to 25	Nascent	Digital use is ad hoc and dependent on individual initiative	Build founder awareness; adopt foundational tools
26 to 50	Emerging	Core activities are digitized but systems are fragmented	Integrate systems; develop basic data practices
51 to 75	Developing	Processes are digitalized; data informs some decisions	Strengthen analytics; align digital with business model
76 to 100	Advanced	Digital capability is embedded in strategy and value creation	Scale platforms; pursue data-driven innovation

Note: Progression to a higher band additionally requires that no dimension score falls below 2.0 (threshold rule).

3.5.2 Illustrative Application

To demonstrate how the instrument might be applied, consider a hypothetical eighteen-month-old agricultural technology venture that connects smallholder farmers with buyers through a mobile application. The scores below are illustrative only and are not drawn from empirical data.

Table 6. *Illustrative readiness profile of a hypothetical agricultural technology venture*

Dimension	Score (1 to 5)	Diagnostic observation
D1 Founder digital disposition	4.2	Founders are optimistic and experimental, with mild insecurity about data privacy
D2 Technology infrastructure	3.1	Mobile application and cloud hosting in place; accounting and CRM not integrated
D3 Data capability	2.0	Transaction data collected but rarely analysed; no defined metrics dashboard
D4 Digital skills and talent	2.8	One technical co-founder; development partly outsourced
D5 Strategic and business model fit	3.9	Digital platform is central to the value proposition
D6 Financial and resource capacity	2.4	Limited runway; technology budget constrained

Dimension	**Score (1 to 5)**	**Diagnostic observation**
D7 Ecosystem connectedness	3.3	Accelerator alumni; payment platform integration; few data partnerships
Digital Readiness Index (equal weights)	52.5	Developing profile; D3 at threshold

Note: Hypothetical data for illustration. Mean dimension score = 3.10; DRI = (3.10 − 1) ÷ 4 × 100 = 52.5.

The overall score places the venture in the Developing band, consistent with Stage 3 (digitalization). However, its data capability sits exactly at the threshold, which signals that progression to digital transformation is at risk. The profile suggests that the venture's next investments should prioritize analytics and metric definition rather than additional infrastructure, a recommendation that an aggregate score alone would not reveal. This illustrates how the diagnostic value of the framework lies as much in the dimensional profile as in the summary index.

3.5.3 Validation Pathway

Empirical validation should proceed in three phases. In the first phase, item development and content validity can be established through expert panels drawn from founders, incubator managers and investors. In the second phase, a cross-sectional survey of early-stage enterprises can be used to assess reliability, convergent and discriminant validity and the dimensional structure through exploratory and confirmatory factor analysis. In the third phase, longitudinal designs can test the propositions, particularly the mediating role of transformation stage (P6) and the threshold effect (P3), which may be examined through necessary condition analysis or configurational methods such as fuzzy-set qualitative comparative analysis.

3.6 Discussion

3.6.1 Interpreting the Conceptual Model

The conceptual model advances three central arguments. The first is that technology readiness in an early-stage enterprise is a bundle rather than a single attribute. Infrastructure without data capability, or skills without strategic purpose, does little to move a venture forward, which is why the model specifies seven distinct but interdependent dimensions. The second is that the founding team occupies a pivotal position. In established firms, readiness is distributed across departments and routines; in a new venture, the dispositions and capabilities of a few people effectively

constitute the organization's readiness, at least in its earliest stages. The third is that readiness is dynamic and context-dependent. It develops through learning, can be lost when key people leave, and yields different returns depending on sector, market conditions and the infrastructure and regulatory environment.

These arguments carry an important implication for how readiness is assessed. If capabilities create value as bundles, then a weakness in one dimension can limit the value of strengths elsewhere. The pairing of a compensatory index with a non-compensatory threshold rule is the model's response to this problem. It allows a venture's overall position to be summarized while ensuring that critical gaps, such as weak data capability in a venture whose value proposition depends on data, are not hidden by averaging.

3.6.2 Comparison with Existing Approaches

Table 7 compares the proposed model with the principal existing approaches to readiness and maturity assessment. The comparison shows that the proposed model differs in three respects: it is designed for the early-stage enterprise as its unit of analysis, it explicitly accounts for resource constraints and founder centrality, and it links readiness to transformation stages and venture outcomes rather than treating readiness as an end in itself.

Table 7. *Comparison of the proposed model with existing approaches*

Approach	**Unit of analysis**	**Primary focus**	**Treatment of resource constraints**	**Link to outcomes**
Technology Readiness Index (Parasuraman & Colby, 2015)	Individual	Propensity to embrace new technology	Not addressed	Indirect, through adoption
Technology Readiness Levels (Mankins, 1995)	Technology	Developmental maturity of an artifact	Not addressed	Not addressed
TOE framework (Tornatzky & Fleischer, 1990)	Organization	Determinants of adoption	Partly, through organizational resources	Adoption decision only

Approach	**Unit of analysis**	**Primary focus**	**Treatment of resource constraints**	**Link to outcomes**
Digital maturity models (e.g. Berghaus & Back, 2016)	Established firm	Stage of digital transformation	Limited; slack resources assumed	Implicit
Proposed model	Early-stage enterprise	Readiness, transformation stage and outcomes	Explicit, through D6, threshold rule and moderators	Explicit, through mediation and feedback

Source: Developed by the author.

3.6.3 Theoretical Contributions

The model makes three theoretical contributions. First, it bridges the individual, technological and organizational conceptions of technology readiness by treating them as complementary dimensions of a single construct suited to organizations in which founders and firms are closely intertwined. Second, it connects readiness to digital transformation and to venture outcomes in an explicit causal sequence, addressing the linkage gap identified in Section 3.1.6. Third, it introduces a non-compensatory logic into readiness assessment, consistent with the resource-based insight that capabilities create value as bundles and that missing complements can block value capture.

3.7 Implications

3.7.1 Implications for Founders

Founders can use the Digital Readiness Index as a self-assessment to identify capability gaps and to sequence digital investments according to their stage of development, rather than adopting tools opportunistically. The dimensional profile is particularly useful in showing where the next unit of time or money will have the greatest effect. For many ventures, the model suggests that investment in data capability and in the alignment of technology with the business model will yield greater returns than further spending on infrastructure. Founders should also recognize that their own attitudes toward technology are part of the venture's readiness, and that building a team with complementary digital skills and dispositions is itself a readiness strategy (Ukadike, 2018).

3.7.2 Implications for Incubators, Accelerators and Investors

Incubators and accelerators can apply the instrument at intake and at regular intervals during their programmes to tailor support, match ventures with mentors and partners, and track progress consistently across cohorts. Because the model treats ecosystem connectedness as a readiness dimension, support organizations can also see their own contribution reflected in participants' profiles. Investors can incorporate readiness profiles into due diligence, recognizing that a weak dimension, particularly data capability, may limit a venture's ability to scale even where the product is promising. Readiness profiles may also inform the design of post-investment support, directing resources toward the dimensions most likely to constrain growth.

3.7.3 Implications for Policymakers

Policymakers can aggregate readiness profiles to identify systemic weaknesses in an entrepreneurial ecosystem, such as widespread shortages of digital skills or gaps in infrastructure, and design targeted interventions. This application is particularly relevant in emerging economies, where digital entrepreneurship is often promoted as a driver of employment and inclusion but where infrastructure and skills constraints are binding. Evidence on digital inclusion and workforce-readiness interventions suggests where such programmes are most needed (Unamma et al., 2018a), while attention to reliable power and network quality addresses the infrastructure conditions on which digital ventures depend (Amayo & Popoola, 2017; Sunday & Omoegun, 2018). Clear and proportionate rules on data protection and IT governance can also lower the compliance burden that falls disproportionately on small firms (Fadero et al., 2018; Mbonu et al., 2018).

3.7.4 Implications for Researchers

For researchers, the model provides a structured set of constructs and propositions that can guide empirical work on digital entrepreneurship. It encourages studies that measure readiness at the venture level rather than inferring it from founder characteristics or technology adoption alone, and it invites the use of methods, such as necessary condition analysis and configurational approaches, that are suited to testing threshold and bundling effects.

3.8 Limitations

As a conceptual contribution, the model has not yet been empirically validated, and its dimensions, weights and thresholds should be treated as provisional. The threshold of 2.0 in

particular is a reasoned starting point rather than an empirically derived value. The model also simplifies a complex reality. The transformation stages are presented as discrete categories, whereas ventures may exhibit characteristics of several stages simultaneously across different business functions. In addition, self-reported assessments are vulnerable to optimism bias, which may be especially pronounced among founders whose disposition toward technology is itself one of the constructs being measured.

The methodology carries further limitations. The review was restricted to English-language sources published up to 2018, and relevant work published in other languages or in practitioner outlets may have been missed. The coding and thematic grouping of sources necessarily involved researcher judgement, and different analysts might have organized the literature differently. Finally, the illustrative application uses hypothetical data and demonstrates how the instrument works rather than providing evidence that it is valid.

3.9 Future Research

The model opens several avenues for future research.

- **Instrument development and validation.** Researchers should develop and refine items for each readiness dimension, establish content validity through expert panels and assess reliability, convergent and discriminant validity and dimensional structure through survey research.
- **Testing the propositions.** Cross-sectional and longitudinal studies should test the seven propositions, with particular attention to the threshold effect (P3), the substitution between ecosystem connectedness and internal resources (P5) and the mediating role of transformation stage (P6).
- **Context and moderators.** Comparative studies across sectors and countries, especially in emerging economies, should examine how sector digital intensity, market turbulence and infrastructure and regulatory conditions moderate the relationships in the model.
- **Dynamics of readiness.** Longitudinal and process studies could examine how readiness profiles evolve, whether particular sequences of capability development are associated with superior outcomes, and how events such as founder exits or pivots affect readiness.
- **Measurement beyond self-report.** Researchers could examine whether objective indicators, such as system usage logs, digital footprints or third-party assessments, can supplement self-reported measures and reduce optimism bias.

- **Emerging technologies.** The model could be extended to account for technologies such as artificial intelligence, blockchain and the Internet of Things, which may require new or more specialized readiness dimensions.

4. CONCLUSION

Digital technologies have lowered the barriers to starting a business, but they have not eliminated the differences among ventures in their ability to use those technologies well. This paper has argued that technology readiness in early-stage enterprises is a multidimensional construct that combines founder dispositions, organizational resources and ecosystem connections, and that it shapes how far and how fast a venture progresses toward digital transformation. The proposed framework integrates insights from readiness, adoption, resource-based, dynamic capabilities and digital entrepreneurship research into a single model, advances seven testable propositions and provides a practical scoring instrument. By shifting attention from whether ventures have access to digital tools to whether they are ready to exploit them, the framework offers a foundation for both further research and more targeted support for the next generation of digital enterprises.

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