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Roles of digitalization in the effect of entrepreneurial orientation on innovation in startups: mediator, moderator, capability?

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Abstract

Digitalization is imperative for a startup to be competitive, management consultants assert. Accordingly, many entrepreneurs found startups on the basis of digital technology. Many others, however, are not digitalizing. This raises a question for research, what are the roles of digitalization, specifically for turning an entrepreneur's entrepreneurial orientation into innovation performance in the startup? A globally representative sample of 22,508 entrepreneurs was surveyed by the Global Entrepreneurship Monitor, reporting on digitalization and likely sources and consequences. The effect of an entrepreneur's entrepreneurial orientation upon innovation performance in the startup is found to be moderated but not mediated by digitalization. As a distinct and separate capability, digitalization, alongside entrepreneurial orientation, is promoting innovation performance. Findings contribute to accounting for the roles of digitalization in startups.

Keywords Digitalization · Startup · Born digital · Capability · Individual entrepreneurial orientation · Innovation performance

1 Introduction

Management consultants claim that digitalization is imperative for a newborn business to be competitive. Indeed, many startups are born digital by being founded on digital technology, but many other startups are not adopting digital technology. The roles of digitalization in operations may conceivably be manifold (Steininger 2019). Is digital technology a capability for becoming competitive? Is it facilitating operations, mediating in operations, or transforming resources into outputs? We focus on

digitalization as it may be turning an entrepreneur's entrepreneurial orientation into innovation performance in the startup. We argue that digitalization may facilitate and mediate between entrepreneurial orientation and innovation performance. We find, however, that digitalization is notably moderating but hardly mediating and is a separate capability that, alongside the entrepreneur's entrepreneurial orientation, is promoting innovation performance in the startup.

Scholarship on startups by entrepreneurs has for decades focused on the entrepreneurs' capital, comprising general human capital, specific human capital, social capital, and financial capital, as they promote viable startups (Estrin et al. 2016). Recently, several of these attributes have been summarily subsumed under the concept of entrepreneurial orientation at the individual level (Clark et al. 2024a, b). An entrepreneur's entrepreneurial orientation, manifest in business processes and decision-making, can offer competitive advantage or strategic renewal, even for those not launching new ventures (Lumpkin and Dess 1996; Covin and Slevin 1989). The proposition is that the entrepreneurial orientation of an entrepreneur benefits the entrepreneur's startup and operations to create and capture value and thereby become competitive.

Digital technology may play a role in the operation of turning individual entrepreneurial orientation into innovation performance. Entrepreneurial orientation at the individual level may become manifest in the adoption of digital technology. Digital technology may be adopted as a means to innovate. Simultaneously, or alternatively, digital technology may be adopted for building capability in general, especially capability that may be readily applied in a turbulent environment (Almeida et al. 2020; Amankwah-Amoah et al. 2021; Kraus et al. 2019). However, it is unknown whether digitalization is actually playing such a mediating role, a facilitating role, or yet another role in turning individual entrepreneurial orientation into innovation performance.

The identified gap in accounting for the roles of digitalization in an entrepreneur's startup frames our research question. *What is the role of digitalization in the effect of entrepreneurial orientation upon innovation – is it a mediator, is it a moderator, or is digitalization playing a more independent role as a capability?*

The question is addressed by analyzing a globally representative sample of 22,508 entrepreneurs, who were surveyed by the Global Entrepreneurship Monitor, reported on their own entrepreneurial orientation, adoption of digital technology for marketing, and innovation performance in their startups. Representativeness of sampling enables generalizability to the world's entrepreneurs and their startups.

We find that the entrepreneurial orientation of entrepreneurs promotes digitalization, and that digital technology promotes innovation performance in their startups. Digitalization is not mediating but is positively moderating the effect of individual entrepreneurial orientation on innovation performance. As an additional capability, digitalization, along with, and in addition to individual entrepreneurial orientation, is promoting innovation performance.

Findings contribute to an account of the roles of digitalization in an entrepreneur's startup. Digitalization is promoted by entrepreneurial orientation and is promoting innovation. Thereby entrepreneurial orientation is promoting innovation through digitalization, but this indirect effect is of negligible size and is not mediating the substantial effect of entrepreneurial orientation upon innovation; that is, digitaliza-

tion is not playing the role of mediator. But entrepreneurial orientation jointly with digitalization is boosting innovation; that is, digitalization is playing the role of moderator. The effect of digitalization on innovation is considerable; that is, digitalization is a capability that has an additional, distinct, separate, and beneficial effect, above and beyond the effect of entrepreneurial orientation on innovation; that is, the role of digitalization is building capability.

The following first develops a theoretical perspective and hypotheses, then describes our research design, reports analyses and results, and discusses findings, contributions, relevance and also limitations suggesting further research on the role of digitalization in startups.

2 Theoretical perspective and hypotheses

Our starting point is a proposition grounded in the contemporary theory of entrepreneurship and innovation in a startup. The baseline proposition is that the individual entrepreneurial orientation of an entrepreneur promotes innovation performance in the entrepreneur's startup. Individual entrepreneurial orientation denotes the combination of self-efficacy, risk-willingness, opportunity-alertness, proactiveness, vision, and creativity of a person, specifically an entrepreneur (Clark et al. 2024a, b). These attributes have been found in numerous studies to promote people's entrepreneurial endeavors and entrepreneurs' performance-related outputs (e.g. Estrin et al. 2016; Su et al. 2011). Notably, research on entrepreneurs has shown that general human capital, as acquired in education and experience, specific human capital, as acquired in entrepreneurial training and practice, social capital, as tacit knowledge acquired through networking with role-models, and also financial capital, all are promoting innovation performance. The proposition that the individual entrepreneurial orientation of entrepreneurs promotes innovation performance in their startups is reconfirmed in our analysis.

The well-established proposition that individual entrepreneurial orientation promotes innovation performance is our baseline, our starting point for developing hypotheses about the roles of digitalization. Scholars identified the significant role of entrepreneurial orientation and digitalization strategy in either promoting or obstructing businesses' disruptive innovation (Kraus et al. 2023). Based on capabilities, businesses with strong capabilities can quickly adapt their resources to changing market conditions (Teece et al. 1997; Teece 2012; Lim et al. 2020). Today's innovations and past digitalization drive the intention to adopt new digital technologies in the future (Samsami and Schøtt 2022b). A capability for adopting various alternatives in the market is driven not only by individual entrepreneurial orientation (Clark et al. 2024a; Lumpkin and Dess 1996), but also by the digital capabilities (Cahen and Borini 2020; Samsami and Schøtt 2022b). Digitalization serves as a resource that enables key players to pursue adaptive response, that is, to innovate rapidly through new processes and products (Vogel and Güttel 2013). Roles of digitalization have been conceptualized by Steininger (2019). His systematic literature review of studies of uses of information technology for entrepreneurial endeavoring led to identification and conceptualization of roles frequently played by digitalization in the opera-

tions of a startup. Digitalization may play a facilitating role, and digitalization may play a mediating role, and some other roles (*ibid.*). Here, Steiningger's conceptualization of roles leads us to develop several hypotheses.

2.1 Entrepreneurial orientation affecting digitalization

The conceptualization that digitalization plays a mediating role means, first, that a resource or some other input in a startup is considered to promote the adoption of digital technology, and second, that adopted digital technology is thought to promote the creation or capture of value, i.e. a performance-related output (*ibid.*, Amit and Han 2017; Amit and Zott 2001, 2007). Applied to our situation this means, first, that an input, here the entrepreneurial orientation of an entrepreneur, is considered to promote the adoption of digital technology in the startup (Berman et al. 2023; Caldeira and Ward 2003; Lal 1999; Matt et al. 2015; Spiegel et al. 2016; Warner and Wäger 2019; Zahra and Bogner 2000; Kraus et al. 2023). Accordingly, we specify this effect as our first hypothesis,

Hypothesis 1 *Entrepreneurial orientation promotes digitalization.*

2.2 Digitalization affecting innovation performance

The second step in the conceptualization of the mediating role of digitalization is that digitalization is thought to promote output. Indeed, the motive for adopting digital technology is typically that digital technology predictably will promote output (Ferreira et al. 2019; Gaglio et al. 2022; Huang et al. 2022; Jarosiński et al. 2023; Ray et al. 2013; Rosin et al. 2020). Thus, for example, digitalization is promoting job-creation (Avom et al. 2021) and internationalization (Birkinshaw 2022; Brouthers et al. 2016; Hagsten and Kotnik 2017; Mathews and Healy 2007; Monaghan et al. 2020; Vadana et al. 2019, 2020, 2021), specifically exporting (Tolba et al. 2022). Here we examine output in the form of innovation performance in the startup (Lyytinen et al. 2016; Samsami and Schött 2022b). Accordingly, we specify this effect as our second hypothesis,

Hypothesis 2 *Digitalization promotes innovation performance.*

2.3 Digitalization boosting benefit of entrepreneurial orientation for innovation

The other role played by digitalization in a startup is facilitation of the transformation of input to output (Karakara and Osabuohien 2020). For example, capabilities may be positively moderating the effect of international entrepreneurial orientation upon internationalization (Fernandes et al. 2024). Accordingly, applied to our situation, we suggest that adopted digital technology is facilitating the realization of an entrepreneur's entrepreneurial orientation as innovation performance in the startup. That is, the digital technology adds a boost or enhancement to the already positive effect of entrepreneurial orientation upon innovation. We specify this amplification as our last hypothesis,

Hypothesis 3 *Digitalization enhances the effect of entrepreneurial orientation on innovation.*

The baseline proposition that entrepreneurial orientation promotes innovation and our three hypotheses concerning digitalization are represented in the causal model in Fig. 1.

In our analyses, we reconfirm the baseline proposition that entrepreneurial orientation promotes innovation performance, and we test our three hypotheses.

Such modeling with mediation and moderation is common in scholarly research. But such modeling is usually incomplete in that mediation is typically partially, rather than fully, channeling the effect of the independent variable upon the dependent variable. Moreover, moderation may be strong, but it typically does not account for all remaining variation in the outcome. In our situation, we should not expect entrepreneurial orientation to account for most variation in digitalization, and we should not expect digitalization to account for most variation in innovation, not even when including the moderating effect of digitalization. Rather, we should theorize that digitalization also has a distinct effect, separate from mediation and moderation, upon the outcome, here innovation. In other words, we should consider digitalization to have its own effect on the outcome, and thus theorize it to be a capability in its own role, in addition to playing the role of mediator and the role of moderator. Therefore, we test whether digitalization plays the role of mediator, and test whether digitalization plays the role of moderator, and we also explore whether and to what extent digitalization acts as a distinct capability.

3 Research design

The issue of digitalization concerns the entrepreneurs and their startups in the contemporary world. Annually, entrepreneurs around the world are surveyed by the Global Entrepreneurship Monitor, GEM (2022, 2023). We use the surveys conducted in 2021–2022 when questions asking entrepreneurs about adoption of digital technology were included in the survey.

3.1 Sampling of entrepreneurs and their startups

In 2021–2022 the GEM survey was conducted in 58 countries (ibid.). The countries are very diverse in region, economy, and culture, and despite an overrepresentation of wealthy countries, they form a fairly representative sample of societies around the

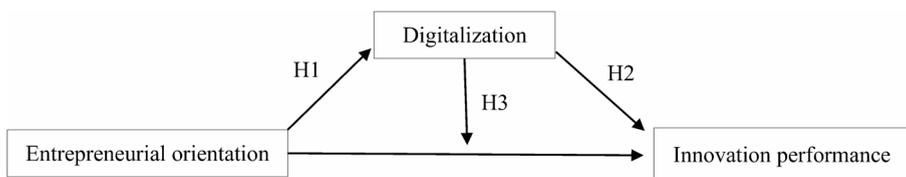


Fig. 1 Hypothesized effects

world. Within each country, GEM randomly sampled adults and asked whether they owned and managed a startup (Samsami and Klyver 2025). The so-identified entrepreneurs reported whether and when their startup had begun compensating owners. To minimize bias toward surviving businesses, we select to study the startups that are at the very early stage (Agarwal and Gort 2002). Our sample is the 22,508 entrepreneurs (nascent entrepreneurs) whose startups had not yet or had only in the year of the survey begun to compensate their owners. We excluded the few outliers that were recorded as startups with more than five owners or more than five employees.

Representativeness of sampling implies that findings can be generalized, with usual statistical uncertainty, to the world's entrepreneurs and their startups.

3.2 Measurements

3.2.1 Innovation

Innovation in a business comprises both product and process innovation. They are measured in the survey of entrepreneurs by asking, *Are any of your products or services new to people in the area where you live, or new to people in your country, or new to the world?* and also, *Are any of the technologies or procedures used for your products or services new to people in the area where you live, or new to people in your country, or new to the world?* Each question was answered on a scale going from 'Not new to any' up to 'New to the world', coded 1 to 4. The two variables are positively correlated 0.59 and therefore averaged as a formative index of innovation.

These measures of innovation are used in GEM's annual reports (2022, 2023, 2024) and academic publications (e.g. Samsami et al., 2022b). The index is ascertained as reasonably valid by its positive association with measures of entrepreneur education, exporting, and business growth expectations.

3.2.2 Digitalization

In each business, digitalization was measured dichotomously by asking the entrepreneur whether or not the firm had adopted digital technology for marketing. This measure has been used in several reports and academic studies (Global Entrepreneurship Monitor 2022, 2023, 2024; Samsami and Schøtt 2022a; Schøtt et al. 2022; Tolba et al. 2022).

3.2.3 Entrepreneurial orientation

Entrepreneurial orientation of an entrepreneur is a broad concept combining several attributes that are commonly found in entrepreneurs, especially in ambitious entrepreneurs. We are able to use six indicators measured in the survey of entrepreneurs,

- Self-efficacy; measured on a Likert scale from 1 to 5.
- Risk-willingness; measured on a Likert scale from 1 to 5.
- Opportunity-assessment; measured on a Likert scale from 1 to 5.
- Creativity, rating on a Likert scale from 1 to 5 “Other people think you are highly

innovative".

- Vision, measured on a Likert scale from 1 to 5.
- Knowledge acquisition by networking with starters; measured on a Likert scale from 0 to 3.

The six indicators are intercorrelated, with all positive correlations and Cronbach alpha 0.45. An exploratory factor analysis shows a first eigenvalue 1.7, and a second eigenvalue 1.0. Extracting a single factor yields factor loadings that all exceed 0.27. Accordingly, the six standardized variables are averaged as a formative index of entrepreneurial orientation.

Validity of the index of entrepreneurial orientation can be ascertained. We would expect the index of an entrepreneur's entrepreneurial orientation to correlate positively with the entrepreneur's education, being young, being male, exporting. Indeed, all five associations turn out to be positive, indicating reasonable validity of the index of entrepreneurial orientation.

3.2.4 Control variables at individual level

Digitalization is related to many other conditions. So, our hypotheses should be tested with controls for other conditions. We can control for several conditions measured in the GEM survey, which have routinely been used in two decades of GEM-based studies (Global Entrepreneurship Monitor 2022, 2023, 2024). Here we list control variables, but it should be emphasized that digitalization is a recently measured phenomenon, and only very few multivariate analyses have used these measures. A methodological principle is to include controls even if the basis is speculative, especially when the sample is large, like here. The control variables are the following,

- Sector, categorized as extraction, transformation, business services, and consumer-oriented sector.
- Owners, as a count, logged.
- Employees, as a count, logged.
- Motive of making an impact in the world; measured on a Likert scale from 1 to 5.
- Motive of accumulating financial wealth; measured on a Likert scale from 1 to 5.
- Motive of continuing a family tradition; measured on a Likert scale from 1 to 5.
- Motive of earning a livelihood; measured on a Likert scale from 1 to 5.
- Gender, reported dichotomously as male or female, coded 1 and 0, respectively.
- Age of the entrepreneur, counted in years, logged.
- Education, counted in years to highest completed degree.

3.2.5 Control variables at national level

Digitalization and its utilization require resources, both financial and human resources. Multivariate analyses should control for resources that are likely to be related digitalization. We control for wealth of the society, both total wealth and wealth relative to population, and also change in wealth. Specifically, we use the readily available data from the World Bank to control for three national conditions,

- Gross Domestic Product, GDP, total in each country, in international dollars at purchase power parity, logged;
- Gross Domestic Product relative to population, GDP per capita; in international dollars at purchase power parity, logged; and.
- Economic growth, annual change in GDP, percentage.

3.3 Techniques for data analysis

The data form a two-level hierarchy of data on individuals nested in countries, where individual behavior is considered affected by individual background and national conditions. Such effects are appropriately tested by hierarchical linear modeling (Snijders and Bosker 2011). Hierarchical linear modeling is similar to regression but also takes into account that the independent variables are at both micro- and macro-levels.

4 Results

Here we first analyze the background of the entrepreneurs and their startups. Then we examine the role of digitalization in startups in the relationship between entrepreneurial orientation by a sequence of analyses answering a string of questions,

- Can we reconfirm the positive effect of entrepreneurial orientation on innovation?
- Is individual entrepreneurial orientation promoting digitalization?
- Is digitalization promoting innovation performance?
- Is digitalization mediating the effect of entrepreneurial orientation on innovation performance?
- Is digitalization moderating the effect of entrepreneurial orientation on innovation performance?

4.1 Background of the entrepreneurs and their startups

The background is briefly described by frequencies and means (standard deviations) of characteristics of the entrepreneurs and their startups, Table 1. Most startups are in the consumer-oriented sector. Of course, the startups typically have only one or very few owners, and typically have no or extremely few employees. The entrepreneurs have several motives for starting a business, of varying strengths.

The background is described further by the correlations, Table 2. The correlations among the three variables of interest are positive, as expected, but are weak. The baseline proposition is that entrepreneurial orientation promotes innovation; the correlation is positive, reconfirming the proposition. Our first hypothesis is that entrepreneurial orientation promotes digitalization; the correlation is positive, lending some support for our first hypothesis. Our second hypothesis is that digitalization promotes innovation; the correlation is positive, providing some support for our second hypothesis. The three variables of interest are rather weakly related to the many control variables. The correlations among the control variables are of no importance here.

Table 1 Frequencies and means (sd) of characteristics of entrepreneurs and startups ($N=22,508$ entrepreneurs)

		Frequency or mean (sd)
Sector: Extraction	Percent startups in this sector	5%
Sector: Transformation	Percent startups in this sector	20%
Sector: Business services	Percent startups in this sector	18%
Sector: Consumer-oriented	Percent startups in this sector	57%
Owners of startup	Number of owners, mean (sd)	1.7 (1.0)
Employees in startup	Number of employees, mean (sd)	0.3 (0.9)
Motive of impact	Strength of motive, 1–5 scale, mean (sd)	3.3 (1.5)
Motive of accumulating wealth	Strength of motive, 1–5 scale, mean (sd)	3.5 (1.4)
Motive of family tradition	Strength of motive, 1–5 scale, mean (sd)	2.5 (1.6)
Motive of earning a livelihood	Strength of motive, 1–5 scale, mean (sd)	3.8 (1.4)
Gender of entrepreneur: Female	Percent females among the entrepreneurs	45%
Age of entrepreneur	Years of age of entrepreneurs, mean (sd)	37.5 (11.6)
Education of entrepreneur	Years schooling of entrepreneurs, mean (sd)	13.8 (5.6)
GDP total	Annual GDP, int dollars, ppp; mean (sd)	1,330,814 (2,623,839)
GDP per capita	Annual GDP pc, int dollars, ppp; mean (sd)	29,630 (20,354)
GDP growth	Percent change in annual GDP, mean (sd)	1.3% (1.5%)

The relations among the major variables are tested more appropriately, with controls for other conditions, below.

4.2 Reconfirming the effect of entrepreneurial orientation on innovation performance

Our first substantive question is, can we reconfirm that entrepreneurial orientation of an entrepreneur promotes innovation in the startup? We estimate the effect in a linear model, Table 3. The effect is positive ($\beta=0.057$; $p=.02$), reconfirming that entrepreneurial orientation benefits innovation performance. The size of the effect is indicated by the standardized coefficient 0.057 which is a notable size.

4.3 Entrepreneurial orientation affecting digitalization, and digitalization affecting innovation performance

To begin ascertaining the role of digitalization in transforming entrepreneurial orientation into innovation performance in a startup, we test the effect of entrepreneurial orientation upon digitalization and the effect of digitalization upon innovation performance.

Our Hypothesis 1 posits that entrepreneurial orientation promotes digitalization. Hypothesis 1 is tested in model B in Table 4. The coefficient is positive ($\beta=0.017$; $p<.001$), supporting Hypothesis 1. The standardized coefficient is 0.017, showing that the effect of entrepreneurial orientation on digitalization is small, but not so small as to be completely negligible.

Our Hypothesis 2 asserts that digitalization promotes innovation performance. Hypothesis 2 is tested in model C. The coefficient is positive ($\beta=0.220$; $p<.001$), sup-

Table 2 Correlations ($N=22,508$ entrepreneurs in startups)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 Innovation																		
2 Digitalization	0.15 ***																	
3 Entrepreneurial ori.	0.08 ***	0.02 ***																
4 S: Extraction	-0.04 ***	-0.06 ***	-0.04 ***															
5 S: Transformation	-0.01 *	-0.07 ***	0.00 ***	-0.11 ***														
6 S: Business service	0.06 ***	0.15 ***	0.01 ***	-0.11 ***	-0.23 ***													
7 S: Consumer-orient.	-0.02 ***	-0.04 ***	0.01 *	-0.26 ***	-0.58 ***	-0.55 ***												
8 Owners of startup	0.08 ***	0.08 ***	0.01 *	0.00 ***	0.00 ***	0.03 ***	-0.03 ***											
9 Employees	-0.02 **	0.01 *	-0.01	0.00	0.01 *	-0.01	0.00	0.02										
10 Motive of impact	0.18 ***	0.07 ***	0.25 ***	-0.02 ***	-0.04 ***	-0.03 ***	0.06 ***	0.01	0.01									
11 M of wealth	0.04 ***	0.05 ***	0.14 ***	-0.03 ***	0.01 **	-0.02 **	0.02 **	0.00	0.03 ***	0.26 ***								
12 M of tradition	0.03 ***	-0.04 ***	0.07 ***	0.09 ***	0.03 ***	-0.14 ***	0.04 ***	0.03 ***	0.08 ***	0.26 ***	0.18 ***							
13 M of livelihood	-0.06 ***	-0.06 ***	-0.02 ***	0.00 ***	0.01 **	-0.11 ***	0.08 ***	-0.05 ***	0.02 ***	0.10 ***	0.11 ***	0.19 ***						
14 Gender: Female	-0.06 ***	-0.02 ***	-0.08 ***	-0.06 ***	-0.09 ***	-0.10 ***	0.18 ***	-0.08 ***	-0.03 ***	0.04 ***	-0.08 ***	-0.02 ***	0.07 ***					
15 Age of entrepren.	-0.03 ***	-0.06 ***	-0.05 ***	0.05 ***	0.04 ***	0.03 ***	-0.08 ***	-0.05 ***	0.02 ***	-0.11 ***	-0.19 ***	-0.02 ***	-0.04 ***	-0.02 ***				
16 Education of entre.	0.09 ***	0.19 ***	-0.01 ***	-0.05 ***	-0.05 ***	0.21 ***	-0.11 ***	0.09 ***	0.01 ***	-0.05 ***	-0.01 ***	-0.16 ***	-0.20 ***	-0.03 ***	0.00			

Table 2 (continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
17 GDP total	-0.01 *	0.14 ***	-0.12 ***	-0.03 ***	-0.02 ***	0.06 ***	-0.02 ***	0.04 ***	0.04 ***	-0.01 ***	-0.03 ***	0.01 ***	-0.08 ***	-0.01 ***	0.06 ***	0.10 ***		
18 GDP per capita	0.11 ***	0.17 ***	-0.05 ***	-0.06 ***	-0.03 ***	0.19 ***	-0.10 ***	0.09 ***	-0.01 ***	-0.10 ***	-0.12 ***	-0.13 ***	-0.24 ***	-0.07 ***	0.11 ***	0.31 ***	0.25 ***	
19 GDP growth	0.02 ***	-0.10 ***	-0.02 ***	-0.02 ***	0.01 ***	0.00 ***	0.00 ***	-0.04 ***	-0.01 ***	-0.02 ***	-0.04 ***	-0.04 ***	-0.05 ***	0.00 ***	-0.02 ***	-0.01 ***	-0.21 ***	-0.06 ***

† $p < .10$ * $p < .05$ ** $p < .01$ *** $p < .001$

Table 3 Innovation performance, dependent on entrepreneurial orientation

	Innovation
	Model A
Entrepreneurial orientation	0.057 *
Motive of impact	0.186 ***
Motive of accumulating wealth	0.025 ***
Motive of family tradition	0.014 †
Motive of earning a livelihood	-0.022 **
Gender of entrepreneur: Female	-0.092 ***
Age of entrepreneur	-0.015 *
Education of entrepreneur	0.049 ***
Owners of startup	0.043 ***
Employees in startup	-0.008
Sector: Extraction	-0.100 **
Sector: Transformation	-0.020
Sector: Business services	0.070 ***
GDP per capita	0.130 ***
GDP total	-0.033
GDP growth	0.011
Country	Yes
Year	Yes
Constant	-0.054 †
N countries	58
N years	2
N entrepreneurs in startups	19,141

Hierarchical linear model, with random effects of country and year.

For sector, the reference is the consumer-oriented sector.

The national-level variables are standardized.

The individual-level numerical variables are standardized and centered within country.

The dichotomous variables are 0 and 1 dummies.

† $p < .10$ * $p < .05$ ** $p < .01$ *** $p < .001$

porting Hypothesis 2. The standardized coefficient is 0.220, indicating that the effect of digitalization on innovation performance is large.

4.4 Is digitalization mediating between entrepreneurial orientation and innovation performance?

Above Table 4 shows that entrepreneurial orientation promotes digitalization (with a standardized coefficient of 0.017) and that digitalization promotes innovation (with a standardized coefficient of 0.220). In sequel, therefore, the two effects form an indirect effect of entrepreneurial orientation upon innovation performance, through digitalization. We estimate the size of this indirect effect as the product of the two standardized coefficients, 0.017×0.220 or 0.004. This estimated standardized coefficient, 0.004, is so small that we should consider the impact to be negligible. That is, digitalization can hardly be mediating between entrepreneurial orientation and innovation performance.

Furthermore, the possible mediation can be ascertained by comparing the effect of entrepreneurial orientation on innovation ignoring digitalization (Table 3) with the effect of entrepreneurial orientation on innovation when including digitalization in the model (Table 4). Comparing the two coefficients 0.057 and 0.053 (Tables 3 and 4), shows that the effects are virtually the same without and with digitalization in the model. This indicates that the effect of entrepreneurial orientation upon innovation performance can hardly be mediated by digitalization.

Table 4 Digitalization dependent on entrepreneurial orientation, and innovation performance dependent on digitalization

	Digitalization	Innovation
	Model B	Model C
Entrepreneurial orientation	0.017 ***	0.053 ***
Digitalization		0.220 ***
Motive of impact	0.031 ***	0.179 ***
Motive of accumulating wealth	0.023 ***	0.020 **
Motive of family tradition	-0.014 ***	0.017 *
Motive of earning a livelihood	-0.007 *	-0.020 **
Gender of entrepreneur: Female	-0.005	-0.091 ***
Age of entrepreneur	-0.028 ***	-0.009
Education of entrepreneur	0.052 ***	0.038 ***
Owners of startup	0.019 ***	0.039 ***
Employees in startup	0.003	-0.009
Sector: Extraction	-0.100 ***	-0.078 *
Sector: Transformation	-0.044 ***	-0.011
Sector: Business services	0.097 ***	0.048 **
GDP per capita	0.048 **	0.120 ***
GDP total	-0.003	-0.033
GDP growth	-0.025 *	0.017
Country	Yes	Yes
Year	Yes	Yes
Constant	0.655 ***	-0.198 ***
N countries	58	58
N years	2	2
N entrepreneurs in startups	19,251	19,141

Hierarchical linear model, with random effects of country and year.

For sector, the reference is the consumer-oriented sector.

The national-level variables are standardized.

The individual-level numerical variables are standardized and centered within country.

The dichotomous variables are 0 and 1 dummies.

† $p < .10$ * $p < .05$ ** $p < .01$ ***
 $p < .001$

4.5 Is digitalization moderating the effect of entrepreneurial orientation on innovation performance?

To further ascertain the role of digitalization in transforming entrepreneurial orientation into innovation, we evaluate whether digitalization moderates the effect on entrepreneurial orientation on innovation performance. The main effect of entrepreneurial orientation on innovation was estimated in Table 4, and the main effect of digitalization on innovation was estimated in Table 4. Here we focus on the joint effect of entrepreneurial orientation and digitalization upon innovation performance, Table 5, model D.

Our Hypothesis 3 claims that digitalization enhances the effect of entrepreneurial orientation on innovation performance. Hypothesis 3 is tested by the coefficient for the interaction term in model D. The coefficient is positive ($\beta = 0.042$; $p = .003$), supporting Hypothesis 3. The size of the effect is indicated by the coefficient 0.042 which means that, for digitalized startups, a standard deviation increase in entrepreneurial orientation entails a 0.042 standard deviation increase in innovation performance. This effect is small but notable.

In short, digitalization plays a facilitation role for the effect of entrepreneurial orientation on innovation performance, a small but notable role.

The above string of analyses concerning the role of digitalization in startups is summarized in the five results,

Table 5 Innovation performance, dependent on digitalization and entrepreneurial orientation. Entrepreneurs in startups

	Innovation performance
	Model D
Digitalization	0.222 ***
Entrepreneurial orientation	0.024 *
Digitalization * Entrepreneurial orientation	0.042 **
	H3
Motive of impact	0.178 ***
Motive of accumulating wealth	0.020 **
Motive of family tradition	0.017 *
Motive of earning a livelihood	-0.020 **
Gender of entrepreneur: Female	-0.092 ***
Age of entrepreneur	-0.009
Education of entrepreneur	0.038 ***
Owners of startup	0.039 ***
Employees in startup	-0.008
Sector: Extraction	-0.079 *
Sector: Transformation	-0.011
Sector: Business services	0.048 *
GDP per capita	0.119 ***
GDP total	-0.033
GDP growth	0.017
Country	Yes
Year	Yes
Constant	-0.200
N countries	58
N years	2
N entrepreneurs in startups	19,141

Hierarchical linear model, with random effects of country and year.

For sector, the reference is the consumer-oriented sector.

The national-level variables are standardized.

The individual-level numerical variables are standardized and centered within country.

The dichotomous variables are 0 and 1 dummies.

† $p < .10$ * $p < .05$ ** $p < .01$ *** $p < .001$

- We reconfirm a positive effect of entrepreneurial orientation on innovation performance in startups.
- Entrepreneurial orientation is promoting digitalization.
- Digitalization is promoting innovation performance.
- Digitalization is not mediating the effect of entrepreneurial orientation on innovation performance.
- Digitalization is moderating the effect of entrepreneurial orientation on innovation in startups.

4.6 Robustness: role of digitalization in established businesses

Our focus is on the startups, but it is reasonable to query whether the role of digitalization is similar for owners in established businesses (Acemoglu and Cao 2015; Agarwal and Gort 2002; Balasubramanian and Lee 2008; BarNir et al. 2003; Coad et al. 2018; Drori et al. 2009; Frank et al. 2019; Leong et al. 2016). Like we asked about entrepreneurs in startups, we wonder about owners in established businesses,

- Can we confirm positive effect of entrepreneurial orientation on innovation in established businesses?

- Is entrepreneurial orientation promoting digitalization?
- Is digitalization promoting innovation?
- Is digitalization mediating the effect of entrepreneurial orientation on innovation?
- Is digitalization moderating the effect of entrepreneurial orientation on innovation?

These issues about established businesses are addressed by conducting analyses like those for entrepreneurs in startups (reported in subsections 4.2 to 4.5), but now analyzing the owners in established business, a sample of 21,519 established businesses, of which 61% are digitalized. The effects are estimated in Table 6.

First, model F in Table 6 confirms that entrepreneurial orientation promotes innovation in established businesses; the effect in established businesses is similar to the

Table 6 Digitalization and innovation performance, dependent on entrepreneurial orientation. Owners in established businesses

	Digitalization		Innovation performance	
	Model E	Model F	Model G	Model H
Entrepreneurial orientation	0.027 ***	0.070 ***	0.065 ***	0.036 ***
Digitalization			0.187 ***	0.189 ***
Digitalization * Ent.orientation				0.047 ***
Motive of impact	0.030 ***	0.173 ***	0.167 ***	0.167 ***
Motive of accumulating wealth	0.013 ***	-0.006	-0.008	-0.008
Motive of family tradition	0.004	0.016 *	0.015 *	0.015 *
Motive of earning a livelihood	-0.009 **	-0.021 **	-0.019 **	-0.019 **
Gender of owner: Female	0.014 *	-0.062 ***	-0.065 ***	-0.065 ***
Age of owner	-0.016 ***	-0.018 *	-0.015 *	-0.015 *
Education of owner	0.058 ***	0.033 ***	0.022 **	0.022 **
Age of established business	-0.011 **	-0.012 †	-0.010	-0.010
Owners of established business	0.021 ***	0.034 ***	0.030 ***	0.030 ***
Employees in established bus.	0.036 ***	0.125 ***	0.119 ***	0.119 ***
Sector: Extraction	-0.145 ***	-0.117 ***	-0.090 ***	-0.091 ***
Sector: Transformation	-0.054 ***	-0.037 *	-0.027	-0.027
Sector: Business services	0.114 ***	0.022	0.001	0.000
GDP per capita	0.053 ***	0.095 **	0.085 **	0.085 **
GDP total	-0.009	0.012	0.015	0.015
GDP growth	-0.023 †	0.005	0.010	0.009
Country	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Constant	0.601 ***	0.063 †	-0.049	-0.052
N countries	58	58	58	58
N years	2	2	2	2
N owners in established bus.	19,173	19,088	19,088	19,088

Hierarchical linear model, with random effects of country and year.

For sector, the reference is the consumer-oriented sector.

The national-level variables are standardized.

The individual-level numerical variables are standardized and centered within country.

The dichotomous variables are 0 and 1 dummies.

† $p < .10$ * $p < .05$ ** $p < .01$ *** $p < .001$

effect found in startups (Table 3). Second, we find in model E that entrepreneurial orientation positively affects digitalization in established businesses; the effect in established businesses is similar to the effect found in startups (model B in Table 4). Third, we see in model G that digitalization promotes innovation; the effect in established businesses is strong like the effect found in startups (model C in Table 4). Fourth, the mediating effect of entrepreneurial orientation through digitalization upon innovation is estimated as the product of the two standardized coefficients, 0.027×0.187 , or 0.005, which is tiny and substantively insignificant, so digitalization is not mediating the effect of owners' entrepreneurial orientation upon innovation performance in established businesses, like digitalization was found to not be mediating in startups (Sect. 4.4). Fifth, we find in model H that digitalization is positively moderating the effect of entrepreneurial orientation upon innovation, like digitalization was found to be moderating in startups (Table 5).

In short, the effects among entrepreneurial orientation, digitalization, and innovation performance here seen in established businesses are similar to the effects found in startups. In established businesses, like in startups, digitalization plays no mediating role, but plays a substantial moderating role.

5 Discussion

The above analyses of entrepreneurs' startups address our research question. *What is the role of digitalization in the effect of entrepreneurial orientation upon innovation – is it a mediator, is it a moderator, or is digitalization playing an independent role as a capability?* Here we discuss the findings and their contribution and relevance, and also consider limitations suggesting further research on the role of digitalization in startups.

5.1 Findings

To enable us to ascertain the roles played by digitalization in startups, the above sections (Sect. 4.2 to 4.4 with Tables 3 to 5) estimate several effects on entrepreneurs' entrepreneurial orientation, digitalization, and innovation in the entrepreneurs' startups. The effects, with their standardized coefficients, are listed in Table 7.

First, the mediation effect, the effect of entrepreneurial orientation through digitalization upon innovation performance, is estimated as 0.004 which is so small that we consider it substantively unimportant. The impact of entrepreneurial orientation upon digitalization is relatively small, so, although the effect of digitalization on innova-

Table 7 Effects with their standardized coefficients

Effect of entrepreneurial orientation on innovation in startups, ignoring digitalization	0.057
Effect of entrepreneurial orientation on innovation, separate from the effect of digitalization	0.053
Effect of entrepreneurs' entrepreneurial orientation on digitalization	0.037
Effect of digitalization on innovation performance in startups	0.220
Mediation: Effect of entrepreneurial orientation through digitalization on innovation	0.004
Moderation: Added effect of entrepreneurial orientation on innovation in digital startups	0.047

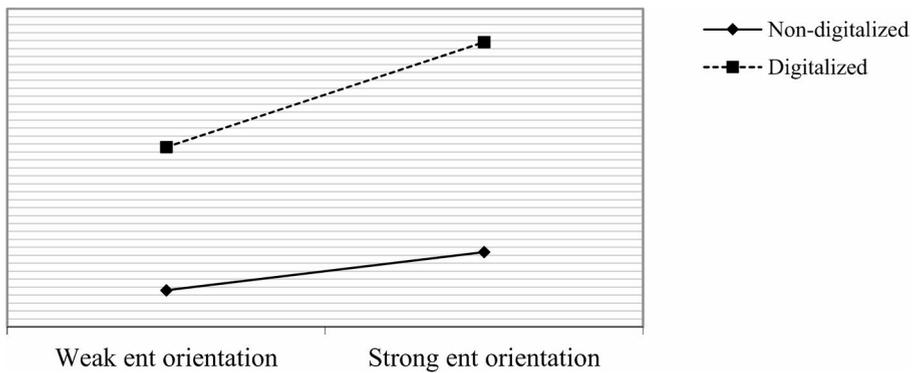


Fig. 2 Digitalization moderating the effect of entrepreneurial orientation upon innovation in startups

tion performance is considerable, the sequence of the two effects is tiny. This is also seen in the similarity between the impact of entrepreneurial orientation without and with digitalization in the model (0.057 and 0.053). In short, digitalization is not playing the role of mediator between entrepreneurial orientation and innovation.

Second, the moderating effect, the boost that digitalization gives to the benefit of entrepreneurial orientation for innovation, is notable, which is in line with previous studies (Kraus et al. 2023) Digitalization raises the effect from the estimated 0.053 by 0.047, almost a doubling. This boost comes in addition to the large direct effect of digitalization on innovation, estimated at 0.220 standard deviations of innovation. In short, digitalization is playing a large role as positive moderator of the benefit of entrepreneurial orientation for innovation performance.

These findings augment the conceptualizing by Steininger (2019) developed in a review of the roles of digitalization in startups. Steininger found, in a systematic review, that digitalization often plays the role of mediator between input and output; and that digitalization also often plays the role of moderator, facilitating the effects of input upon outputs in startups. Our situation does not fit the role of mediator but notably fits the role of facilitating moderator.

The finding that digitalization plays the role of moderator in the effect of entrepreneurial orientation upon innovation can informatively be graphed in Fig. 2, where the graph is based on coefficients in Table 5. The graph illustrates three conclusions. First, entrepreneurial orientation positively affects innovation performance. Second, digitalized startups have higher innovation than non-digitalized startups. Third, the positive effect of entrepreneurial orientation on innovation is stronger in digitalized startups than in non-digitalized startups. In short, the graph illustrates the role of digitalization as an enhancing moderator of the benefit of entrepreneurial orientation for innovation performance.

5.2 Contribution: digitalization as an additional capability

Our findings go beyond Steininger's conceptualizing review by our further finding that digitalization has a distinct and separate additional and substantial effect on innovation in a startup (and also in an established business). Therefore, this role of digi-

talization is appropriately conceptualized as an additional capability, a quite distinct and separate capability (Koch 2010; Kohli and Melville 2019; Nambisan 2017).

Our study thereby contributes to accounting for the roles of digitalization in startups. Specifically, concerning digitalization in the link between entrepreneurial orientation and innovation, our findings make three contributions.

First, digitalization is promoted by individual entrepreneurial orientation and digitalization greatly promotes innovation performance, but digitalization is not acting as a mediator. Rather, we have an indirect effect that is separate from the impact of individual entrepreneurial orientation on innovation performance.

Second, digitalization is acting as a moderator, considerably amplifying the benefit of individual entrepreneurial orientation for innovation performance.

Third, digitalization is playing the role of building a considerable additional capability. The adopted digital technology may be narrowly tied to specific operations in the startup and thus not in itself be a capability. However, the adoption of digital technology is tied to an enhanced digital knowledge of the people working in the startup, and their digital skills form a capability. This is in line with Vogel & Güttel's review (2013). That digitalization significantly promotes innovation performance, which has an inherent unpredictability, also indicates that the capability is applicable in turbulent environments. Digitalization can thereby be appropriately considered as a capability (Koch 2010; Teece 2012; Zahra and George 2002).

5.3 Relevance

The boosted high performance-related outputs of digitalized startups may satisfy politicians and business leaders promoting entrepreneurship and innovation through digitalization (Marciano 2024; World Bank Group 2016). The high investments that societies make in startups and digitalization bring returns in outputs such as innovation and its concomitants such as exporting, growth and also sustainability.

Conversely, however, older businesses that are not digitalizing, have far lower performance-related outputs. They are left behind in the competition. The two different paths are diverging, and they entail a widening of the digital divide in society.

5.4 Limitations

The major limitation, in our own assessment, is that our study examines the role of digitalization in only one link, the link between entrepreneurial orientation and innovation performance. We focused on this link because it is a frequently researched link found to be of considerable magnitude. But there are numerous other links, e.g. effects on job creation (Balasubramanian and Lee, 2008; Balsmeier and Woerter 2019; Häsel et al. 2010; Kollmann et al. 2009). When we find that digitalization plays the role of moderator but not the role of mediator, this should not be generalized to other links.

Another limitation is that our study only measures one aspect of digitalization, namely the adoption of digital technology for marketing, and thus ignores digitalization for other uses, e.g. a more comprehensive degree of digitalization of the entire value chain of the business.

Yet another major limitation is that our sample is cross-sectional, sampling entrepreneurs at a very early stage, with startups that had not yet or had only in the year of the survey begun to compensate their owners. This minimizes bias toward sampling survivors; but still misses some startups that failed very early in the formation phase (Oludapo et al. 2024). Conversely, the sample undoubtedly includes entrepreneurs, a sizeable portion, who will stop after operating a very short time (Agarwal and Gort 2002). Dynamics among individual entrepreneurial orientation, digitalization, and innovation performance are similar in established businesses, as we see in our robustness check, but we are still ignoring attrition, specifically the role of digitalization in attrition.

5.5 Further research

The two limitations point toward desirable further studies. First, of course, longitudinal research is desirable, especially when considering that digitalization is a temporal phenomenon, although often recurrent. Second, our approach to researching the roles of digitalization in startups can informatively be applied to other links between inputs and outputs of startups and established businesses.

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Declarations

Conflict of interest No conflict of interest.

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