

THE IMPACT OF DIGITAL TRANSFORMATION ON ENTREPRENEURIAL ACTIVITY. EMPIRICAL EVIDENCE FROM THE EUROPEAN UNION

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Abstract. The paper explores the impact of digital transformation (DT) on new business creation in the case of European Union member states over the period 2015–2020 by employing several econometric techniques such as Ordinary Least Squares (OLS) and quantile regression (QR). The results of OLS regression indicate a positive and significant link between DT and entrepreneurial activity. However, the quantile regression results highlight a parameter heterogeneity in the effect of DT on entrepreneurial activity. Furthermore, the magnitude of the impact is greater at the higher size quantiles of the new business density distribution. Overall, the empirical findings highlight the key role of DT in developing public policies aimed to spur entrepreneurial activity. Thus, this paper brings significant contributions to the extant literature on the macro determinants of firm creation.

Keywords: digital transformation, Digital Economy and Society Index, digital skills, digital public services, entrepreneurial activity, new business creation, European Union, quantile regression.

JEL Classification: L26, O33.

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1. Introduction

The COVID-19 pandemic is considered one of the key drivers of digital transformation (DT) (Li et al., 2020; Amankwah-Amoah et al., 2021; Andrei et al., 2022; European Investment Bank, 2022; Reuschl et al., 2022; Sun et al., 2022) that is currently influencing the global economy and society¹. As a result, digitalization has become a buzzword and a growing number of papers have investigated its impact on various aspects of firm activity and performance². However, little is known about the role of DT³ in new firm creation/entrepreneurial activity

¹ An earlier version of this paper has been presented at the International Workshop "Innovation and shocks in the global economy", West University of Timișoara, Romania, 10–13 April 2023.

² See Verhoef et al. (2021) and Kraus et al. (2022) for an extensive review on the implications of DT on various aspects at the firm level.

³ In this paper, I use the definitions provided by Verhoef et al. (2021, p. 889) for digitization – "the encoding of analog information into a digital format such that computers can store process, and transmit such information" (Verhoef et al., 2021, p. 891), digitalization – "describes how IT or digital technologies can be used to alter existing business processes" (Verhoef et al., 2021, p. 891), and digital transformation – "a change in how a firm employs digital technologies, to develop a new digital business model that helps to create and appropriate more value for the firm" (Verhoef et al., 2021, p. 889).

(EA) and additional research is needed (Nambisan, 2017; Elia et al., 2020). Recent studies (Galindo-Martín et al., 2019; Zhang et al., 2022) found a positive link between digital transformation (DT) and entrepreneurial activity (EA), but their findings are based on only one facet of digital transformation (e.g., connectivity) and standard conditional mean regressions (mean oriented econometric approaches) that provide an incomplete picture about this relationship. Thus, additional evidence is necessary to see the impact of other aspects (e.g., integration of digital technologies) on entrepreneurial activity.

This study focused on the European Union (EU) countries for a variety of reasons. Firstly, the EU has implemented the Digital Single Market strategy since 2015 to support digitalization and digital competitiveness (European Commission, 2017) as it operated only at 12% of its digital potential as highlighted by some authors (Bughin et al., 2016) and most of its member countries lags behind the US in terms of digitalization. Secondly, compared to other regions, it has allocated numerous funds to support the digital transition process. For example, within the Recovery and Resilience Facility, at least 20% of total funds (€723.8 billion in current prices) have been allocated to spur the digital transition. Furthermore, the EU developed the Digital Economy and Society Index (DESI) to track the progress over time and space. Despite the improvement recorded in the last years, there is still a significant divide in terms of DT between EU Member States (the Northern countries in general have the highest level of digitalization, while Southern countries have a lower performance). Also, according to the European Investment Bank (2022), only 37% of firms reported investments to become more digital, compared to 48% in Western and Northern Europe. Thirdly the European Union has implemented several strategies for supporting entrepreneurship and innovation (Arenal et al., 2021). Thus, the empirical findings can be useful for European policymakers in designing new measures and actions to foster entrepreneurial activity. Fourthly, EU member states have faced “one of the most advanced economic integration processes in the world” (Liñán & Fernandez-Serrano, 2014, p. 686) with implications for institutions and rules.

This paper explores the impact of DT on entrepreneurial activity employing a sample of EU member states over the time span ranging from 2015 to 2020 and a quantile regression (QR) approach. The empirical results indicate a positive and significant link between DT and entrepreneurial activity. In other words, countries with a better score for digital transformation have higher new firm rates. However, the results of QR show that there is a parameter heterogeneity in the effect of DT on entrepreneurial activity. Furthermore, the magnitude of the impact of DT on entrepreneurial activity is greater at higher quantiles of the new business density distribution.

This study extends the extant literature on the macro determinants of firm creation at the national level in three ways. Firstly, as far as I know, this study represents the first effort to examine the impact of digital transformation on entrepreneurial activity over a longer period (2015–2020). Secondly, to offer a thorough insight⁴, the paper employs a quantile regression (QR) approach in investigating the link between digital transformation and entrepreneurial activity. Thirdly, our proxy for digital transformation allows us to gauge the impact of various aspects (skills, connectivity, use of the Internet, integration of digital technology, and digital public services) on entrepreneurial activity over time and across a large sample of countries with different economic backgrounds. Thus, I respond to the call for different aspects of DT when “studying its impacts on such a heterogeneous phenomenon as entrepreneurship” (Fossen & Sorgner, 2022, p. 549). Also, the study brings an important contribution to the

⁴ As OLS estimates may provide a potentially incomplete picture about the relation between the digital transformation and entrepreneurial activity for countries with very good (poor) performance.

literature focused on the economic consequences of digital transformation. Contrary to the previous papers that focused on established firms, the current paper offers insights into how digital transformation and its components affect the decision to establish a new venture.

The rest of this paper is organized as follows. Section 2 briefly presents the theoretical background and introduces the research hypotheses. Section 3 explains the data and methodology employed in the paper. Section 4 is devoted to the presentation and discussion of the empirical results. The last section presents the conclusions, practical and policy implications, and the limits of the paper.

2. Theoretical background and hypothesis development

Until recently, the role of digital technologies and digital transformation in the entrepreneurial process has been largely neglected (Nambisan, 2017; Elia et al., 2020; Verhoef et al., 2021).

Also, empirical evidence on the role of digital technologies/digital transformation in new firm creation is very limited. One explanation is that there is no perfect measure for digital transformation for a large sample of countries over a long period. Employing data from 29 European countries for only one year (2016) and the partial least square methodology, Galindo-Martín et al. (2019) showed that digital transformation (measured by digital commerce variables) has a positive impact on entrepreneurial employee activity (a measure for intrapreneurship).

Digital transformation may support entrepreneurial activity/new business creation through several channels:

- the digitalisation of procedures regarding business creation;
- new forms of entrepreneurship (e.g., digital entrepreneurship) or new business models (e.g., platforms) that allow firms to sell products to a broad range of customers (World Bank, 2016). Fossen and Sorgner (2022) found a positive link between the digitalization of occupations and digital entrepreneurship (with an unincorporated business);
- new financing opportunities such as crowdfunding platforms or fintech services (Cumming & Schwienbacher, 2018; Skare et al., 2023);
- expanding the number of customers (World Bank, 2016; Nambisan, 2017);
- access to new niche markets (Galindo-Martín et al., 2019) and new marketing opportunities;
- lowering the labour costs by using artificial intelligence or remote work arrangements (Fossen & Sorgner, 2022);
- improved abilities and entrepreneurial mindset through easier access to online entrepreneurial education (e.g., MOOCs) (Youssef et al., 2021; Fossen & Sorgner, 2022);
- improve the overall competitiveness (Ritter & Pedersen, 2020)

Given all the above considerations and the previous findings (Galindo-Martín et al., 2019), the following hypothesis is tested:

H.1: Higher level of DT will result in higher EA.

The importance of connectivity to new business models, innovation and competitiveness is recognized in the extant literature. Improved connectivity (to fixed broadband take-up, fixed broadband coverage, and mobile broadband) to affordable prices is considered to be “a prerequisite for business in the digital era” (World Bank, 2016). Better connectivity facilitate access to new potential customers from all around the world (World Bank, 2016), new financing sources (Cumming & Schwienbacher, 2018; Skare et al., 2023), marketing opportunities,

and technical expertise. Thus, connectivity reduces many barriers to entry into businesses and makes entrepreneurship easier in many regions (Youssef et al., 2021). Taking into account the above-mentioned arguments, this paper proposes the following hypothesis:

H.1a: Higher level of connectivity will result in higher EA.

A few studies (Fossen & Sorgner, 2022; Youssef et al., 2021) analyze the role of digital skills in new venture creation. Fossen and Sorgner (2022) used data from the Current Population Survey for the United States over the period 2011–2018 and found a positive relationship between the digitalization of occupations (that suppose better digital skills) and digital entrepreneurship (with an unincorporated business). Employing a sample of 310 Kosovarian students from two main universities, Youssef et al. (2021) show that the use of digital technologies improves their “education experience, learning process and outcomes, and resulting entrepreneurial intent” (Youssef et al., 2021, p. 6). Hence, the following hypothesis is tested in the current study:

H.1b: Higher level of digital skills (human capital) will result in higher EA.

Previous research on the role of the use of the Internet in fostering entrepreneurial activity is scarce. Zhang et al. (2022) found a positive link between the number of internet users/number of mobile users per 100 inhabitants and a composite index for entrepreneurship. Hence, the following hypothesis is tested in the current study:

H.1c: Higher level of the use of the Internet will result in higher EA.

Von Briel et al. (2018) argued that digital technologies (DTech) are key enablers of firm creation in the Information Technology (IT) sector. In their theoretical model, they consider DTech as “objective, actor-independent factors within a process view of new venture creation” (von Briel et al., 2018, p. 64). In a similar approach, Autio et al. (2018) showed that DTech has a positive impact on EA through three key digital affordances: decoupling, disintermediation, and generativity. Other studies considered that digital technology represents a determinant of the development of the national entrepreneurial ecosystem (e.g., Kenney & Zysman, 2016; Nambisan, 2017).

Zhang et al. (2022) employed a sample of 101 countries over the period 2001–2018 to investigate the impact of digital technologies on national entrepreneurship. They measure digital technologies through two indicators, namely the use of digital artefacts (by “the number of mobile users per 100 inhabitants”) and digital platforms and infrastructure (by “the number of internet users per 100 inhabitants”) (Zhang et al., 2022). The results of the econometric model show a positive and statistically significant link between digital technology and national entrepreneurship. Taking into account the above-mentioned considerations, this paper proposes the following hypothesis:

H.1d: Higher level of the integration of digital technology will result in higher EA.

The digitalisation of procedures regarding business creation reduces the time and cost of starting a new venture. OECD (2020) reported that several countries (e.g., Portugal) implemented a single point of contact for entrepreneurs (an online platform) that facilitates access to information (regarding legal requirements, procedures and available services) and also the conduct of administrative procedures (e.g. incorporation, brand registration) in a less costly way. Taking into account the above-mentioned arguments, this paper proposes the following hypothesis:

H.1e: Higher level of digital public services will result in higher EA.

3. Data and methodology

Except for data on digital transformation that was sourced from the European Commission, all other data were obtained from the World Bank, 2022 (Entrepreneurship database, World Development Indicators, International Debt Statistics, and Doing Business). The study covers 28 European Union countries over the period 2015–2020, the sample comprising 168 country-year observations. This time span was chosen in line with the data available for all the variables. Table 1 depicts the variables employed in the paper together with the original description.

Table 1. Variables definition and sources

Dependent variable	Definition	Source
NBD	New business density – “New registrations per 1,000 people ages 15–64” (World Bank, 2022a)	World Bank (2022a)
Independent variables		
DESI_OVERALL	DESI is computed as “the weighted average of the five main dimensions: (1) Connectivity (25.0%), (2) Human Capital (25.0%), (3) Use of the Internet (15.0%), (4) Integration of Digital Technology (20.0%), and (5) Digital Public Services (15.0%)” (European Commission, 2020).	European Commission (2020)
DESI_1_CONN	1 Connectivity – “fixed broadband take-up, fixed broadband coverage, mobile broadband and broadband prices” (European Commission, 2020, p. 11)	European Commission (2020)
DESI_2_HC	2 Human capital – “Internet user skills and advanced skills” (European Commission, 2020, p. 11)	European Commission (2020)
DESI_3_UI	3 Use of Internet – “citizens’ use of Internet services and online transactions” (European Commission, 2020, p. 11)	European Commission (2020)
DESI_4_IDT	4 Integration of digital technology – “business digitisation and e-commerce” (European Commission, 2020, p. 11)	European Commission (2020)
DESI_5_DPS	5 Digital public services – e-Government (European Commission, 2020, p. 11)	European Commission (2020)
Control variables		
FDI	Foreign direct investments – net inflows (% of GDP) (World Bank, 2022b)	World Bank (2022b)
EG	Economic growth – GDP per capita growth (annual %) (World Bank, 2022c)	World Bank (2022c)
UNEMP	Total unemployment – % of the total labour force (World Bank, 2022c)	World Bank (2022c)
DCPS	Access to finance – “domestic credit to the private sector (% of GDP)” (World Bank, 2022c)	World Bank (2022c)
CBSP	Cost of business start-up procedures (% of GNI per capita) (World Bank, 2022d)	World Bank (2022d)

The dependent variable in our study is new business density (NBD) computed as “the number of newly registered corporations per 1,000 working-age people (those ages 15–64)” (World Bank, 2022a)⁵. This variable has been employed in other studies (e.g., Awoa et al., 2023) as it allows cross-country comparisons.

As the main independent variable, the Digital Economy and Society Index (DESI) was employed to capture the degree of digital transformation. This index covers 28 EU countries over the period 2015–2020 and is computed as a weighted average of five sub-indexes measuring various aspects such as connectivity, human capital (digital skills), use of the Internet, integration of digital technology, and digital public services (European Commission, 2020). Several recent studies used DESI as a measure of DT (Andrei et al., 2022; Liu, 2022; Skare et al., 2023). Alternative variables for digital transformation would have been the Digital Adoption Index (DAI) created by the World Bank and employed in several papers (Tores & Augusto, 2020; Yamen et al., 2022). This indicator captures three facets of society (people, business, and government) for a large sample of countries (180) but it is available only for two years (2014 and 2016). Thus, I consider that DAI does not capture the latest evolution in digital transformation.

The remaining control variables follow from previous work on the determinants of entrepreneurial activity (Anton & Bostan, 2017; Berrill et al., 2018; Gaies et al., 2021), namely the cost of business start-up procedures, access to finance, total unemployment, economic growth, and foreign direct investments.

To investigate the impact of DT on entrepreneurial activity the following linear model is developed:

$$NBD_{i,t} = \alpha_{i,j} + \beta_1 DESI_{i,t} + \beta_2 COUNTRY_{i,t} + \varepsilon_{i,t}, \quad (1)$$

where: $NBD_{i,t}$ is the new business density; $DESI_{i,t}$ represents the Digital Economy and Society Index (or one of its components) for $COUNTRY$ i over year t ; $COUNTRY_{i,t}$ refers to country-specific variables (e.g., foreign direct investments, economic growth, total unemployment, access to finance and cost of business start-up procedures; β_i represents the coefficients of the variables; i indexes the countries; t indexes time; $\varepsilon_{i,t}$ represents the error term⁶.

Given the disadvantages of mean regression techniques for heterogeneous populations⁷, a QR approach is used in this paper as it offers a better picture of the relation between digital transformation and entrepreneurial activity for countries with very good (poor) performance (in terms of new business density). Furthermore, QR can overcome some statistical issues such as outliers (Kizhakethalackal et al., 2013) and non-Gaussian error distribution (Barnes & Hughes, 2002; Coad & Rao, 2008).

In their seminal paper, Koenker and Bassett (1978) proposed the QR technique with the following equation:

$$[y]_{-}(i,t) = [x]_{-}(i,t) \wedge \beta_{-} \theta + u_{-}(\theta i, t), \quad (2)$$

⁵ An alternative measure for entrepreneurial activity would have been total entrepreneurial activity (TEA) from Global Entrepreneurship Monitor. However, this measure was not available for all the countries in our sample over the period 2015–2020.

⁶ Following the recommendations made by one of the reviewers, two additional variables have been introduced in the analysis. Firstly, a dummy variable COV-PAN (taking value 1 for the year 2020) has been included in the first additional model to investigate the impact of the COVID-19 pandemic on EA. Secondly, the interaction effect between digitalization (DESI and its components) and the dummy variable COV_PAN have been included to see if digital transformation is more important during the first year of the pandemic. As the empirical results were not statistically significant, they have not been included in the paper, but they are available upon request.

⁷ The OLS estimate is just a single measurement of the link between DT and EA, focusing only on the average (i.e., conditional mean) behaviour. Thus, it is not considering that the impact of DT on EA can differ for the extreme NBD regions.

with

$$[[Quant]]_{\theta}(y_{-}(i,t) | x_{-}(i,t)) = [[x]]_{-}(i,t)^{\beta} \theta, \quad (3)$$

with the following restriction:

$$[[Quant]]_{\theta}(u_{-}(i,t) | x_{-}(i,t)) = 0, \quad (4)$$

where $y_{-}(i,t)$ stands for new business density (NBD), $x_{-}(i,t)$ represents regressors, $\beta\theta$ is the coefficient estimates for each quantile, $u_{-}(i,t)$ is the error, i indexes country (in our case, $i = 1, \dots, 28$) and t indexes year (in our case, $t = 1, \dots, 6$). $[[Quant]]_{\theta}(y_{-}(i,t) | x_{-}(i,t))$ represents the θ^{th} conditional quantile of $y_{-}(i,t)$ given $x_{-}(i,t)$. In line with extant literature, standard errors (SE) have been estimated using the bootstrap method (BM) with one thousand replications and reported in parentheses.

4. Results and discussions

4.1. Summary of statistics

Summary statistics for the dependent and independent variables are presented in Table 2. It can be noticed that the average new business density (NBD) is approximately 6.48 with a median of 4.50. However, it masks large differences in the sample across countries and over time as the minimum and maximum values show. The minimum level (0.51) has been reported for Austria (2018), while the maximum level (24.79) is registered in Estonia (2019)⁸. New business density is left-skewed, meaning it has long left tails. Thus, the distribution of the dependent variable raises the efficiency of QR. In our balanced sample, the level of digitalization displays a wide variation across countries and over time – from 26.13 in Greece (2015) to 72.31 in Finland (2020).

Table 2. Descriptive statistics of dependent/independent variables (2015–2020)

Variable	Mean	Std. Dev.	Min	Max	25th percentile	50th percentile	75th percentile	Skewness	Kurtosis
NBD	6.48	5.53	0.51	24.79	2.93	4.50	7.82	1.39	4.11
DESI_OVERALL	46.40	10.16	26.13	72.31	39.18	45.71	53.25	0.22	2.51
DESI_1_CONN	41.39	9.94	17.44	65.82	34.45	40.36	48.48	0.18	2.66
DESI_2_HC	46.87	11.92	27.27	78.44	36.49	45.55	55.76	0.46	2.56
DESI_3_UI	51.19	11.67	21.71	76.34	43.37	49.94	59.57	0.14	2.60
DESI_4_IDT	37.42	13.11	15.28	74.32	27.98	35.82	45.13	0.50	2.68
DESI_5_DPS	61.11	15.29	20.62	89.33	50.73	62.37	73.62	-0.39	2.41
FDI	8.09	23.84	-40.08	163.04	1.00	2.73	4.74	3.77	21.34
EG	1.59	4.01	-11.25	24.00	0.85	1.89	3.83	-0.05	9.21

⁸ Similar values and rankings have been reported by Awoa et al. (2023) and Gaies et al. (2021) using alternatives measures for new business creation.

End of Table 2

Variable	Mean	Std. Dev.	Min	Max	25th percentile	50th percentile	75th percentile	Skewness	Kurtosis
UNEMP	7.52	4.10	2.01	24.90	4.96	6.55	8.68	1.92	7.19
DCPS	80.52	38.54	24.74	244.19	50.79	77.52	103.44	1.07	4.72
CBSP	3.59	3.96	0.00	14.40	0.70	1.70	5.40	1.32	3.79

Notes: NBD stands for new business density; DESI_OVERALL - Digital Economy and Society Index; DESI_1_CONN - Connectivity; DESI_2_HC - Human capital; DESI_3_UI - Use of Internet; DESI_4_IDT - Integration of digital technology; DESI_5_DPS - Digital public services; FDI - Foreign direct investments; EG - Economic growth; UNEMP - Total unemployment; DCPS - Access to finance; CBSP - Cost of business start-up procedures.

Table 3. Pearson correlations (pooled sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) NBD	1.00											
(2) DESI_OVERALL	0.31	1.00										
(3) DESI_1_CONN	0.20	0.74	1.00									
(4) DESI_2_HC	0.33	0.88	0.47	1.00								
(5) DESI_3_UI	0.37	0.93	0.65	0.88	1.00							
(6) DESI_4_IDT	0.13	0.83	0.40	0.71	0.74	1.00						
(7) DESI_5_DPS	0.28	0.82	0.64	0.58	0.66	0.61	1.00					
(8) FDI	0.28	-0.08	-0.10	-0.07	-0.05	-0.08	-0.02	1.00				
(9) EG	0.04	-0.32	-0.43	-0.19	-0.33	-0.18	-0.25	0.15	1.00			
(10) UNEMP	-0.19	-0.37	-0.43	-0.32	-0.33	-0.22	-0.25	0.04	0.00	1.00		
(11) DCPS	0.32	0.33	0.04	0.37	0.41	0.31	0.27	0.19	-0.21	0.25	1.00	
(12) CBSP	-0.09	-0.31	-0.30	-0.29	-0.26	-0.28	-0.16	0.16	-0.02	0.06	0.07	1.00

Notes: NBD stands for new business density; DESI_OVERALL - Digital Economy and Society Index; DESI_1_CONN - Connectivity; DESI_2_HC - Human capital; DESI_3_UI - Use of Internet; DESI_4_IDT - Integration of digital technology; DESI_5_DPS - Digital public services; FDI - Foreign direct investments; EG - Economic growth; UNEMP - Total unemployment; DCPS - Access to finance; CBSP - Cost of business start-up procedures.

4.2. Correlation

Table 3 presents the Pearson correlation among our variables. A positive correlation between digital transformation (and its components) and new business density can be noticed. The results can be preliminary support for our research hypotheses.

As the correlation coefficients among the independent variables are not high, the issue of multicollinearity can be ruled out. Furthermore, the variance inflation factors (VIF) have been computed, the results being available upon request. As the values are below the cut-off level of 10 (Hair et al., 2010), I conclude that multicollinearity is not an issue in the estimations.

4.3. Baseline regressions and discussions

Table 4 reports the pooled OLS regression results (first column) and the QR results (columns 2–6). The OLS estimation predicts a positive relationship between DT and new business density, a result in line with those reported by Galindo-Martín et al. (2019) and Zhang et al. (2022). A higher level of DT leads to a higher level of entrepreneurial activity. More precisely, a one-point increase in the level of DT is related to a 0.0846 rise in NBD, with statistical significance observed at the 10% level.

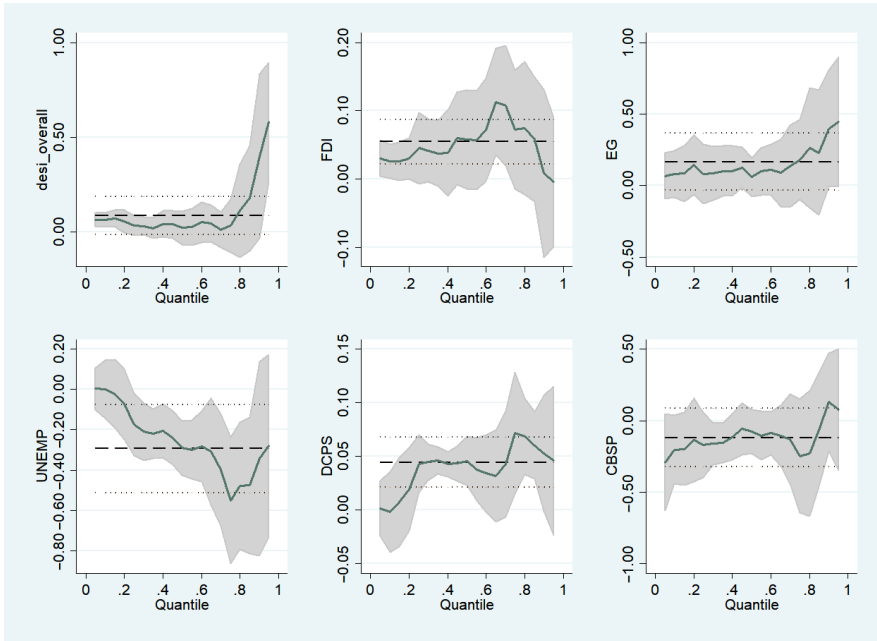
Table 4. Digital transformation and entrepreneurial activity

	(1) OLS	(2) 10 th quant	(3) 25 th quant	(4) 50 th quant	(5) 75 th quant	(6) 90 th quant
DESI_	0.0846*	0.0620***	0.0321	0.0201	0.0316	0.3987**
OVERALL	(0.0510)	(0.0229)	(0.0294)	(0.0433)	(0.0849)	(0.1876)
FDI	0.0547***	0.0259*	0.0451**	0.0583*	0.0725	0.0085
	(0.0165)	(0.0155)	(0.0179)	(0.0325)	(0.0466)	(0.0508)
EG	0.1674	0.0809	0.0811	0.0597	0.1816	0.3986
	(0.1014)	(0.0712)	(0.0907)	(0.0766)	(0.1491)	(0.2747)
UNEMP	-0.2940***	0.0005	-0.174**	-0.290***	-0.551***	-0.3432*
	(0.1104)	(0.0637)	(0.0738)	(0.0723)	(0.1574)	(0.2019)
DCPS	0.0445***	-0.0020	0.043***	0.0459***	0.0717**	0.0526**
	(0.0119)	(0.0175)	(0.0143)	(0.0099)	(0.0276)	(0.0251)
CBSP	-0.1180	-0.2008*	-0.1703*	-0.0756	-0.2452	0.1300
	(0.1040)	(0.1188)	(0.0897)	(0.0750)	(0.1842)	(0.2080)
Constant	0.8654	-0.3238	0.1321	2.3293	5.6294	-8.0689
	(2.7619)	(1.0370)	(1.4622)	(2.2089)	(4.0029)	(7.9658)
R ² /Pseudo R ²	0.2695	0.1302	0.1279	0.1877	0.2275	0.2259
N. of cases	168	168	168	168	168	168

Notes: *p < 0.1, **p < 0.05, ***p < 0.01. SE and bootstrapped standard errors (BSE) are presented in brackets. NBD stands for new business density; DESI_OVERALL – Digital Economy and Society Index; FDI – Foreign direct investments; EG – Economic growth; UNEMP – Total unemployment; DCPS – Access to finance; CBSP – Cost of business start-up procedures.

However, as the quantile regressions show (columns 2–6), the impact of digitalization on the new business density is heterogeneous in various quantile levels of the NBD. The relationship is positive and statistically significant only for countries in the lower and higher quantiles (Q10 and Q90) of the NBD distribution. For countries in the middle quantile region (i.e., from 0.25 to 0.50) the relationship is positive but statistically insignificant. Also, it is worth noticing that the magnitude of the impact of DT on EA is greater at higher quantiles of the new business density distribution. Thus, hypothesis 1 has been verified. Figure 1 depicts the variation in coefficients for digital transformation and control variables over the conditional quantiles.

The nuanced effects identified through quantile regression can be explained by several factors such as the level of economic development, the strength of the entrepreneurial systems, and the regulatory environment. Regarding the first factor, countries in the lower



Notes: The horizontal dashed lines indicate the (constant) pooled OLS estimates, while the connected lines in the shaded (confidence level) region are separate QR estimates.

Figure 1. Quantile regression plot of DESI_OVERALL

quantiles (Q10) (e.g., Bulgaria) have fewer ventures and more room for new entrants to benefit from digitalization. Countries in the higher quantiles of NBD (e.g., the United Kingdom) may leverage digital technologies for growth. In contrast, middle-income countries might be in a transitional phase where the impact of digitalization is still evolving. Also, the strength of a country's entrepreneurial ecosystem, including access to funding, support networks, and education, can influence the impact of digitalization on new business creation. In countries with well-developed ecosystems, the impact might be more evenly spread across quantiles. Finally, the regulatory environment can significantly affect the relationship between digitalization and new business density. Some countries with more flexible regulations may encourage digital innovation and the creation of new businesses (e.g., Estonia), while countries with strict regulations might hinder such growth.

Regarding control variables, the results presented in Table 4 support the findings of other papers on the determinants of entrepreneurial activity. For example, access to finance measured as domestic credit to the private sector (DCPS) has a significant positive impact on EA across all quantiles of NBD distribution, except Q10. These results are similar to those reported by other studies in the European area (Anton & Bostan, 2017).

According to the initial expectations, a negative association between the cost of starting a venture and new business density has been found. In other words, higher start-up costs may lead to lower new firm registration rates. This finding is consistent with previous results reported by Djankov et al. (2002) and Cordier and Bade (2022).

In line with prior research (Audretsch & Fritsch, 1994; Garofoli, 1994), a negative impact of unemployment on new firm density is found. A higher unemployment rate leads to lower EA.

In addition, it is observable that, in line with prior research, economic growth positively affects new firm registration rates (Gaies et al., 2021). Also, a positive relationship has been found between foreign direct investments (FDI net inflows) and entrepreneurial activity but this is statistically significant only for low quantiles (q10–q50). The nuanced relationship suggests that FDI net inflows are more beneficial for supporting entrepreneurial activity in regions or countries with lower new business density. In these countries, there may be more untapped market opportunities and foreign investors might see them as attractive investment destinations as they offer a higher potential for growth and development. This result is partially in line with the findings obtained by Newman et al. (2015) and Berrill et al. (2018) using mean-oriented econometric approaches.

In the last part of the study, I rerun the models for the subcomponents of the DESI index in order to disentangle their impact on entrepreneurial activity.

Table 5. Connectivity and entrepreneurial activity

	(1) OLS	(2) 10 th quant	(3) 25 th quant	(4) 50 th quant	(5) 75 th quant	(6) 90 th quant
DESI_1_CONN	0.0875* (0.0506)	0.1017*** (0.0207)	0.0569 (0.0379)	0.0845* (0.0505)	0.0977* (0.0588)	0.2339 (0.1529)
FDI	0.0521*** (0.0165)	0.0174 (0.0146)	0.0406** (0.0205)	0.0612** (0.0309)	0.0537 (0.0441)	0.0749 (0.0624)
EG	0.2100* (0.1104)	0.1733*** (0.0625)	0.1403 (0.0900)	0.1511 (0.1004)	0.2170* (0.1282)	0.3229 (0.2562)
UNEMP	-0.299*** (0.1076)	0.0236 (0.0556)	-0.1580** (0.0776)	-0.1982** (0.0813)	-0.482*** (0.1702)	-0.5202** (0.2261)
DCPS	0.0523*** (0.0105)	0.0116 (0.0167)	0.0449*** (0.0113)	0.0343*** (0.0107)	0.0822*** (0.0282)	0.1140*** (0.0291)
CBSP	-0.1214 (0.1025)	-0.1849 (0.1303)	-0.1945** (0.0767)	-0.0937 (0.0723)	-0.2203 (0.2136)	0.2177 (0.2841)
Constant	0.5380 (2.8390)	-2.8023** (1.0932)	-1.1293 (1.7851)	0.1230 (2.0834)	1.7602 (3.5111)	-4.3462 (9.1133)
R ² /Pseudo R ²	0.2706	0.1490	0.1385	0.1994	0.2357	0.1861
N. of cases	168	168	168	168	168	168

Notes: *p < 0.1, **p < 0.05, ***p < 0.01. SEs and BSEs are presented in brackets. NBD stands for new business density; DESI_1_CONN – Connectivity; FDI – Foreign direct investments; EG – Economic growth; UNEMP – Total unemployment; DCPS – Access to finance; CBSP – Cost of business start-up procedures.

First, connectivity has a positive impact on new firm creation for countries in the lower and middle quantiles of the new business density distribution (Q10, Q50, and Q75) (see Table 5). However, only for the lower quantile (Q10), the positive impact is statistically significant at 1%. The positive sign for connectivity supports hypothesis 1a.

New ventures with improved connectivity have better access to new potential customers from all around the world and financing and marketing opportunities. Furthermore, they can access “essential technical expertise through online freelancing platforms” (World Bank, 2016). However, only improved connectivity is not enough to support entrepreneurial activity.

Some countries in the sample (e.g., Romania or Spain) exhibit higher levels of connectivity compared with the EU average, but their level of entrepreneurial activity is low.

Table 6. Human capital (digital skills) and entrepreneurial activity

	(1) OLS	(2) 10 th quant	(3) 25 th quant	(4) 50 th quant	(5) 75 th quant	(6) 90 th quant
DESI_2_HC	0.0740* (0.0412)	0.0408 (0.0411)	-0.0250 (0.0247)	-0.0005 (0.0360)	0.0571 (0.0942)	0.2679** (0.1322)
FDI	0.0559*** (0.0166)	0.0298* (0.0173)	0.0366** (0.0155)	0.0580* (0.0340)	0.0721* (0.0432)	0.0204 (0.0520)
EG	0.1367 (0.0975)	0.0595 (0.0750)	0.0705 (0.0831)	0.0568 (0.0759)	0.1829 (0.1350)	0.1756 (0.2089)
UNEMP	-0.297*** (0.1070)	-0.0442 (0.0932)	-0.204*** (0.0618)	-0.299*** (0.0575)	-0.527*** (0.1168)	-0.611*** (0.1816)
DCPS	0.0428*** (0.0122)	0.0028 (0.0254)	0.0482*** (0.0092)	0.0457*** (0.0098)	0.0669*** (0.0254)	0.0649** (0.0322)
CBSP	-0.1209 (0.1021)	-0.2812* (0.1512)	-0.2045** (0.0891)	-0.0963 (0.0797)	-0.1781 (0.1789)	0.0208 (0.3020)
Constant	1.5441 (2.2453)	0.8114 (1.5606)	2.8703** (1.3841)	3.4331** (1.7111)	4.4111 (4.1032)	-0.7119 (4.8831)
R ² / Pseudo R ²	0.2716	0.1020	0.1291	0.1861	0.2332	0.2489
N. of cases	168	168	168	168	168	168

Notes: *p < 0.1, **p < 0.05, ***p < 0.01. SEs and BSEs are presented in brackets. NBD stands for new business density; DESI_2_HC – Human capital; FDI – Foreign direct investments; EG – Economic growth; UNEMP – Total unemployment; DCPS – Access to finance; CBSP – Cost of business start-up procedures.

Secondly, digital skills have a positive impact on new firm creation for countries situated in the higher quantile of the new business density distribution (Q90) and the magnitude of this coefficient is quite high (see Table 6). These empirical results reinforce the importance of digital skills for any economy and provide empirical support for hypothesis 1b. The quality of the broadband infrastructure is not sufficient if entrepreneurs and employees don't have the required skills to exploit the opportunities brought by the DT process. Thus, investing in the development of digital skills should represent one important pillar of the strategies/policies to accelerate the pace of digital transformation, especially in those countries from Eastern Europe (Bulgaria, Hungary, Latvia, Lithuania, Poland, Romania, and Slovakia) or Southern Europe (Cyprus, Greece, Italy, and Portugal) that consistently performed below the EU average.

Thirdly, like the baseline results, I found that the use of the Internet supports new firm creation for countries in the lower and higher quantiles of the NBD distribution (Q10 and Q90) (see Table 7). This result supports the findings reported by Zhang et al. (2022) and hypothesis 1c. For countries in the lower quantiles of NBD, the use of the Internet can provide opportunities for entrepreneurs to access national and international markets more easily. On the other hand, for countries in the higher quantiles of NBD, e-commerce and online business models can thrive, leading to increased new firm creation.

Table 7. Use of the Internet and entrepreneurial activity

	(1) OLS	(2) 10 th quant	(3) 25 th quant	(4) 50 th quant	(5) 75 th quant	(6) 90 th quant
DESI_3_UI	0.1178***	0.0756***	0.0431	0.0377	0.0914	0.2437**
	(0.0444)	(0.0213)	(0.0306)	(0.0405)	(0.0805)	(0.1161)
FDI	0.0559***	0.0255*	0.0409**	0.0574	0.0751*	0.0259
	(0.0163)	(0.0151)	(0.0201)	(0.0360)	(0.0445)	(0.0587)
EG	0.1917*	0.0987*	0.0830	0.1336*	0.2592*	0.3188
	(0.0997)	(0.0580)	(0.0885)	(0.0737)	(0.1426)	(0.2316)
UNEMP	-0.2423**	-0.0111	-0.1657**	-0.2372***	-0.4825***	-0.5038***
	(0.1082)	(0.0644)	(0.0739)	(0.0645)	(0.1305)	(0.1560)
DCPS	0.0360***	0.0009	0.0397***	0.0425***	0.0560**	0.0398
	(0.0123)	(0.0174)	(0.0148)	(0.0099)	(0.0228)	(0.0304)
CBSP	-0.0923	-0.2657**	-0.1742*	-0.0641	-0.1667	0.1627
	(0.1008)	(0.1105)	(0.0919)	(0.0792)	(0.1697)	(0.1875)
Constant	-1.0759	-1.2110	-0.3365	1.0381	3.1863	-0.1012
	(2.5554)	(0.9269)	(1.5443)	(2.1259)	(4.6258)	(4.8005)
R ² /Pseudo R ²	0.2881	0.1383	0.1270	0.1909	0.2394	0.2564
N. of cases	168	168	168	168	168	168

Notes: *p < 0.1, **p < 0.05, ***p < 0.01. SEs and BSEs are presented in brackets. NBD stands for new business density; DESI_3_UI – Use of Internet; FDI – Foreign direct investments; EG – Economic growth; UNEMP – Total unemployment; DCPS – Access to finance; CBSP – Cost of business start-up procedures.

Table 8. Integration of digital technology and entrepreneurial activity

	(1) OLS	(2) 10 th quant	(3) 25 th quant	(4) 50 th quant	(5) 75 th quant	(6) 90 th quant
DESI_4_IDT	-0.0333	0.0475***	0.0432**	-0.0015	-0.0729	-0.1239*
	(0.0339)	(0.0177)	(0.0192)	(0.0342)	(0.0448)	(0.0711)
FDI	0.0509***	0.0251	0.0363*	0.0579*	0.0729*	0.0524
	(0.0166)	(0.0162)	(0.0194)	(0.0336)	(0.0429)	(0.0562)
EG	0.1099	0.0621	0.0870	0.0582	0.1238	0.2402
	(0.0981)	(0.0757)	(0.0885)	(0.0706)	(0.1155)	(0.2068)
UNEMP	-0.4221***	-0.0359	-0.180***	-0.3014***	-0.644***	-0.9776***
	(0.1002)	(0.0604)	(0.0612)	(0.0730)	(0.1215)	(0.1407)
DCPS	0.0585***	-0.0017	0.0418***	0.0461***	0.0794***	0.0887***
	(0.0115)	(0.0194)	(0.0115)	(0.0080)	(0.0207)	(0.0274)
CBSP	-0.2160**	-0.1928	-0.1380	-0.0979	-0.3124	-0.0276
	(0.1011)	(0.1359)	(0.0920)	(0.0776)	(0.1952)	(0.2531)
Constant	6.3396***	1.0123	0.1311	3.4696*	9.9397***	17.0594***

End of Table 8

	(1) OLS	(2) 10 th quant	(3) 25 th quant	(4) 50 th quant	(5) 75 th quant	(6) 90 th quant
	(1.6815)	(0.9791)	(1.0111)	(2.0210)	(2.2474)	(5.5738)
R ² / Pseudo R ²	0.2614	0.1331	0.1383	0.1862	0.2354	0.2015
N. of cases	168	168	168	168	168	168

Notes: *p < 0.1, **p < 0.05, ***p < 0.01. SEs and BSEs are presented in brackets. NBD stands for new business density; DESI_4_IDT – Integration of digital technology; FDI – Foreign direct investments; EG – Economic growth; UNEMP – Total unemployment; DCPS – Access to finance; CBSP – Cost of business start-up procedures.

Fourthly, the QR results presented in Table 8 show a positive association between the integration of digital technology and new firm creation for countries in the lower quantiles of the NBD distribution (Q10 and Q25) but the magnitude of these coefficients is quite low. The results provide empirical evidence for the theory elaborated by von Briel et al. (2018) on the role of digital technologies in new firm creation. For the higher quantiles, the impact is negative and larger. Thus, it may be concluded that after a certain level of EA, the integration of digital technologies harms new firm creation.

Table 9. Digital public services and entrepreneurial activity

	(1) OLS	(2) 10 th quant	(3) 25 th quant	(4) 50 th quant	(5) 75 th quant	(6) 90 th quant
DESI_5_DPS	0.0532* (0.0279)	0.0299 (0.0228)	0.0236 (0.0175)	-0.0012 (0.0222)	0.0164 (0.0420)	0.2246** (0.0968)
FDI	0.0531*** (0.0164)	0.0273 (0.0181)	0.0455*** (0.0165)	0.0579* (0.0343)	0.0708 (0.0465)	0.0194 (0.0517)
EG	0.1562 (0.0988)	0.0759 (0.0766)	0.0939 (0.0871)	0.0582 (0.0763)	0.1462 (0.1379)	0.4148* (0.2354)
UNEMP	-0.326*** (0.0996)	-0.0124 (0.0825)	-0.181*** (0.0555)	-0.301*** (0.0587)	-0.567*** (0.1399)	-0.3694* (0.2143)
DCPS	0.0471*** (0.0110)	0.0020 (0.0209)	0.0433*** (0.0105)	0.0462*** (0.0092)	0.0728*** (0.0260)	0.0790*** (0.0266)
CBSP	-0.1520 (0.0970)	-0.1608 (0.1781)	-0.1921** (0.0775)	-0.0986 (0.0769)	-0.2870 (0.1869)	-0.2033 (0.2271)
Constant	1.7238 (2.0635)	0.4386 (1.4200)	0.1983 (1.2977)	3.4923** (1.5233)	6.3231*** (2.4166)	-3.4028 (5.3487)
R ² /Pseudo R ²	0.2735	0.1029	0.1283	0.1862	0.2260	0.2268
N. of cases	168	168	168	168	168	168

Notes: *p < 0.1, **p < 0.05, ***p < 0.01. Standard errors and bootstrapped standard errors are presented in brackets. NBD stands for new business density; DESI_5_DPS – Digital public services; FDI – Foreign direct investments; EG – Economic growth; UNEMP – Total unemployment; DCPS – Access to finance; CBSP – Cost of business start-up procedures.

Fifthly, digital public services (e.g., e-government) have a significant impact on NBD for countries situated in the highest quantile of the new business density distribution (Q90) and the magnitude of this coefficient is quite high (see Table 9). Therefore, it shows that the easier and faster the access to digital public services, the higher the number of new firms created. The positive sign for the coefficient of digital public services supports hypothesis 1e.

Regarding the coefficients of the control variables, it is observable that their sign and statistical significance remain the same as those in the baseline estimations (Table 4).

5. Conclusions

The paper aims to examine the impact of DT on EA. Contrary to the previous research, a sample of EU countries over a recent period (2015–2020) and a quantile regression approach are employed in the paper. A positive relationship between digital transformation and new business density has been found. These results show that digital transformation is an external enabler of entrepreneurial activity. However, QR analysis presents various perspectives on the relationship. The effect of digitalization on the NBD is heterogeneous across various quantile levels. The relationship is positive and statistically significant only for countries in the lower and higher quantiles (Q10 and Q90) of the new business density distribution. This nuanced relationship can be caused by several factors such as the level of economic development, the strength of the entrepreneurial systems, and the regulatory environment.

Furthermore, our empirical results shed light on the homogeneous role of different aspects (connectivity, digital skills, use of the Internet, integration of DTech, and digital public services) in supporting new business creation. Our results show that the highest impact is recorded in the case of human capital (digital skills), suggesting that public policies should target not only the adoption of new technologies (e.g., artificial intelligence, blockchain, quantum computing) but also the improvement of digital skills or digital public services. In Bulgaria, Romania, and Italy there is a large room for enhancing the digital skills of the population.

Control variables are significant in explaining entrepreneurial activity, except for economic growth. Better access to finance and higher foreign direct investments lead to higher new firm creation. On the other hand, higher costs of business start-up procedures and higher unemployment rates may lead to lower new firm registration rates.

Overall, the empirical findings bring significant implications for policymakers, entrepreneurs, and academics in the European Union and not only. First, these findings can be helpful for policymakers in using DT as a key driver to support entrepreneurial activity. Understanding the impact of DT on new firm creation, policymakers should include its components and make the necessary adjustments in the public policies aiming to foster entrepreneurial activity in countries or regions (e.g., Eastern and Southeastern Europe) with lower business density. Furthermore, our findings offer insights into the importance of connectivity, digital skills, use of the Internet, integration of digital technology, and digital public services. Thus, policymakers can identify the missing piece in the puzzle and take action to improve entrepreneurial activity and, consequently, job creation and economic growth. For example, given the large variations in terms of digital skills and their importance for economic activity, policymakers may implement measures/programmes to reduce this gap and consequently support entrepreneurial activity. Finally, policymakers outside the EU can learn from this experience when they develop national strategies for supporting entrepreneurial activity and the digitalization process.

Entrepreneurs may recognize the importance of various facets of digital transformation in the entrepreneurial process and take measures to improve their performance in an environment characterized by technological changes. For academics, this paper offers empirical evidence for a positive link between DT and EA. Thus, they may consider DT as a key determinant of the entrepreneurial process and include it in their empirical research.

This study has several limitations. First, due to the data availability, the study covers only the period 2015–2020 for the EU countries. Consequently, the outcomes of this study are constrained by the scope and quality of the available data, which influences the obtained results. Future research should consider alternative measures for entrepreneurial activity and digital transformation, a larger sample of countries or a larger period (as soon as they are available) to confirm the robustness of these results. Also, future research may find and investigate moderating factors of the relationship between DT and EA (e.g., regulatory environment or the strength of the entrepreneurial ecosystem).

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Author contributions

SGA conceived the study and was responsible for the design and development of the data analysis. SGA was responsible for data collection and analysis. SGA was responsible for data interpretation.

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