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THE NEXUS BETWEEN DIGITALIZATION, ENTREPRENEURIAL ECOSYSTEM QUALITY, AND ECONOMIC RESILIENCE

A CROSS-COUNTRY ANALYSIS DURING THE COVID-19 PANDEMIC

Yeng-May Tan, Erkko Autio, Gemma Estrada, Donghyun Park, and Gazi Salah Uddin

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ABSTRACT

Information and communication technology or digital technology helped entrepreneurs survive the coronavirus disease (COVID-19) restrictions. For instance, they shifted to online sales in the face of stringent lockdowns and mobility constraints. The enhanced resilience of entrepreneurs, in turn, contributed to the resilience of the broader economy. This study explores the relationship between the quality of a country's digital entrepreneurial ecosystem, measured by the Global Index of Digital Entrepreneurship Systems (GIDES), and its economic performance during the COVID-19 pandemic. Based on a cross-country analysis of 100 global economies, we find a positive association between GIDES and economic performance during the pandemic. This suggests that the quality of a country's environment for digital entrepreneurs can strengthen its economic resilience even in the face of major shocks.

Keywords: digital entrepreneurship, digitalization, entrepreneurial ecosystem, economic resilience, COVID-19, Global Index of Digital Entrepreneurship Systems (GIDES)

JEL codes: L26, L86, F62

1. Introduction

Entrepreneurship, or the activity of starting and running a business, is vital for economic growth and development. The advent of information and communication technology (ICT) or digital technology has significantly reduced the cost of entrepreneurship. For instance, ICT enables entrepreneurs to start a business without expensive physical stores, outsource a wide range of activities, and reach large numbers of potential customers at low costs. Digital or ICT-enabled entrepreneurship has blossomed, evident in the rapid growth of companies such as Alibaba, Amazon, and Google, which have become some of the biggest companies in the world. In addition, during the coronavirus disease (COVID-19) pandemic, ICT contributed greatly to the resilience of entrepreneurs, which, in turn, contributed to the resilience of the economy as a whole. For example, ICT enabled entrepreneurs to shift their sales online when lockdowns and community quarantines severely restricted in-store sales, thus enabling them to remain in business.

Such contribution of digital entrepreneurship to economic resilience suggests that countries with better environments for digital entrepreneurs would cope better in the face of big shocks such as the COVID-19 pandemic. The central objective of our paper is to empirically analyze whether better digital entrepreneurship ecosystems strengthened economic resilience during the pandemic. To do so, we perform a cross-country econometric analysis of 100 global economies. Our measure of economic resilience is the extent to which actual gross domestic product (GDP) growth during the pandemic fell short of the forecast GDP growth. The smaller the shortfall, the greater the economy's resilience. The main contribution of our paper to the literature is that it is the first attempt to empirically analyze the relationship between the quality of a country's environment for

digital entrepreneurs and its economic resilience. The lack of earlier studies is probably due to the lack of data on the quality of digital entrepreneurship environment.

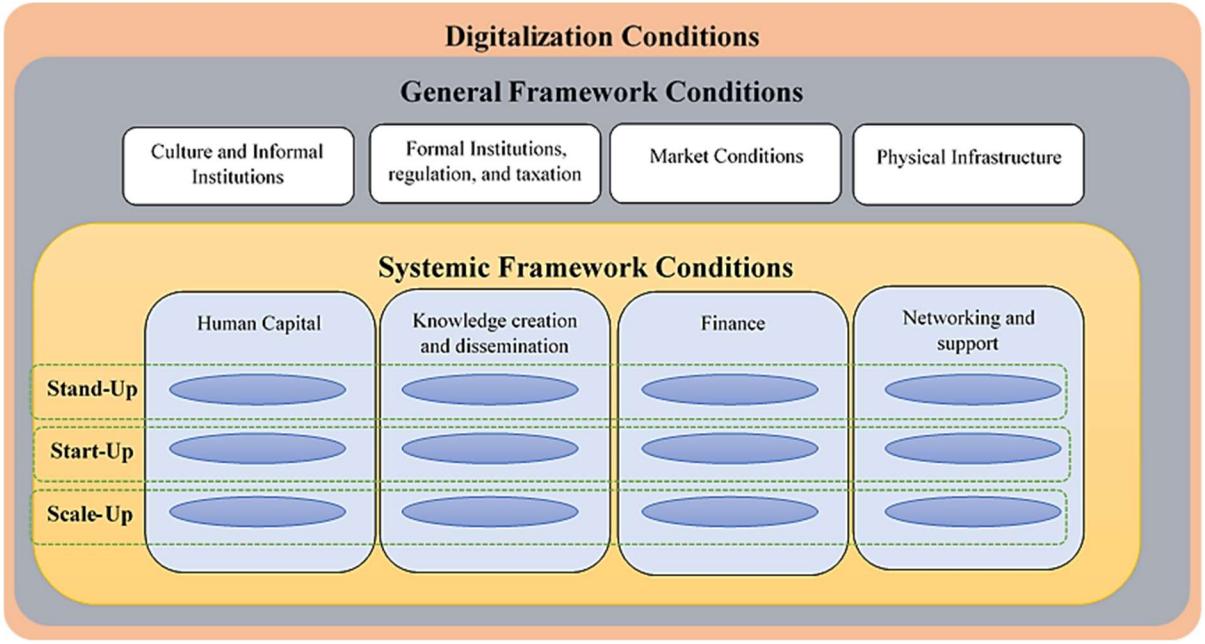
In this paper, we use the Global Index of Digital Entrepreneurship Systems (GIDES), a newly developed index, to measure the quality of an economy's digital entrepreneurial ecosystem. Please refer to the background paper for the Asian Development Outlook 2022 Update for a detailed explanation of how the index was constructed (ADB 2022, Autio et al. 2022). GIDES allows us to empirically assess the relationship between the quality of digital entrepreneurship system and economic resilience.

Covering 113 economies and using 103 indicators, GIDES assesses the quality of a country's digital framework conditions for entrepreneurial activities at the country level. It focuses on capturing digitalization in society and economy and is guided by two framework conditions: General Framework Conditions (GFC) and Systemic Framework Conditions (SFC). These conditions are further broken down into eight pillars that fall under either of the two frameworks.

The GFC describes the general context of an economy's entrepreneurship and focuses on four key areas: (i) culture and informal institutions; (ii) formal institutions, regulations, and taxation; (iii) market conditions; and (iv) physical infrastructure. On the other hand, the SFC narrates the resource provision directly connected with various phases of entrepreneurial development. The factors under SFC are (i) human capital and talent, (ii) knowledge creation and dissemination, (iii) finance, and (iv) networking and support. In summary, a country's general conditions regulate how systematic conditions facilitate different lifecycle stages of entrepreneurship, including stand-up, start-up, and

scale-up entrepreneurship. Therefore, the digital entrepreneurship ecosystem index comprises a total of 16 pillars, of which 4 are under GFC and 12 under SFC. For each pillar, a corresponding digital weight is calculated to account for the country-level digital conditions relevant to its entrepreneurship ecosystem. Furthermore, a non-digitalized version, representing the physical condition of the entrepreneurship ecosystem, is computed to facilitate comparison alongside the digitalized version. Lastly, the country's composite GIDES score is calculated as the bottleneck-corrected average of GFC and SFC digitalized versions. Figure 1 reproduces the structure and framework of GIDES for illustrative purposes.

Figure 1: Structure of the Global Index of Digital Entrepreneurship Systems



Source: Adapted from Autio et al. (2022, Figure 6).

The remainder of the paper is organized as follows: Section 2 discusses the relevant literature. Section 3 describes the data and empirical framework. Results and findings are discussed in Section 4. Section 5 concludes and discusses policy implications.

2. Literature Review

While there has been a noticeable rise in scholarly works focusing on the link between entrepreneurship and economic growth over time, the existing research remains somewhat fragmented and dispersed across various sources. The existing body of research in the field predominantly concentrates on cross-sectional analysis and focuses on developed countries, often relying on the Global Entrepreneurship Monitor (GEM) data (Kim, Castillejos-Petalcorin, et al. 2022). Generally, empirical evidence points toward a positive association between entrepreneurial activity and economic growth. It is conceivable that a well-functioning entrepreneurial environment can enhance an economy's overall total factor productivity (ADB 2022). Encompassing 18 developed markets, Acs et al. (2005) argue that entrepreneurial activity fosters economic growth. Furthermore, strong institutions are shown to influence growth positively (Urbano et al. 2019) by facilitating productive entrepreneurship (Acemoglu and Johnson 2012), socially productive entrepreneurship (Baumol and Strom 2007), and innovative entrepreneurship (ADB 2020). Additionally, Stam and van de Ven (2021) demonstrate a positive link between high-growth firms and the quality of the entrepreneurial ecosystem. Despite the somewhat consistent relationship between entrepreneurial activity and economic growth, various studies have reported more nuanced and diverse findings. While Salgado-banda (2007) considers 22 Organisation for Economic Co-operation and Development (OECD)

countries' entrepreneurship and finds a positive relationship between the proposed measure of productive entrepreneurship, the author reports a negative or null influence on economic growth when using self-employment data. With 44 countries' data, Valliere and Peterson (2009) document that high-performing entrepreneurs contribute substantially to economic growth in developed economies but not emerging markets. Kim, Castillejos-Petalcorin, et al. (2022) do not find evidence of a positive link between economic growth and total entrepreneurship using the GEM database,[1] though report a positive association between opportunity-driven entrepreneurship and growth for developing economies. To sum up, the current research had not yet yielded conclusive evidence establishing a consistent relationship between entrepreneurship and economic growth, particularly in emerging economies. Furthermore, the majority of the existing studies concentrate predominantly on developed markets.

The advent and widespread adoption of digitalization have revolutionized the entrepreneurial landscape, reshaping the way entrepreneurship is conducted. Digitalization has transformed societies and economies, enabling entrepreneurs to lower transaction costs, scale businesses, access new markets, and improve efficiency (World Bank 2016, Berman 2012, Cardona et al. 2013, Hawash and Lang 2020). Studies show that firms that adopt digitalization facilitate innovations (Gaglio 2022), spur productivity growth (Cette et al. 2022, Gal et al. 2019), and enhance competitiveness (de Rosnay and Stalder 2020, Ferreira et al. 2019, Dahlman et al. 2016). Despite emerging in the early 1990s, digital entrepreneurship is often perceived as a new occurrence (Kollmann et al. 2022). The outbreak of COVID-19 has accelerated digital adoption and further highlighted

[1] The GEM adopts three measures of entrepreneurship: total early-stage, opportunity-driven early-stage, and necessity-driven early-stage entrepreneurship.

the benefits of digitalization. In response to the crisis, there has been a notable surge in academic literature investigating the ramifications of the pandemic on business activity (Abidi et al. 2022). In their study examining the Middle East and Central Asia region, Abidi et al. (2022) provide evidence that digitally-enabled firms experienced a lower decline in sales than their digitally-constrained counterparts, highlighting the hedging effect of digitalization during the pandemic. Long et al. (2022) report a pronounced association between digital technology and entrepreneurial resilience measured as the likelihood of firms' closure during the pandemic. Xiong et al. (2021) argue that the social and economic crisis of the pandemic creates the "window of opportunity" leading to the leapfrogging of digital transformation. Kim, Estrada, et al. (2022) report that ICT has positively impacted economic performance during the pandemic. Hayakawa et al. (2021) find that although the severity of the pandemic significantly impeded international trade, positive development of the importing country's e-commerce mitigates the adverse effect. Using information technology (IT) adoption data for nearly three million establishments in the United States (US), Oikonomou et al. (2023) confirm the mitigating role of IT during the COVID-19 crisis.

Although prior research has discussed the potential contributions of entrepreneurship and digitalization to positive economic outcomes, it is imperative to integrate these two important concepts to shed light on their combined effects on economic resilience and growth. By understanding the interplay dynamics between the entrepreneurial ecosystem and digitalization, policymakers and practitioners can effectively navigate the evolving landscape of digital entrepreneurship and harness its potential to foster economic growth and resilience.

3. Empirical Approach and Data

This study uses cross-sectional, country-level data and performs ordinary least squares (OLS) regressions for 2020. We started with all 113 countries available from the GIDES dataset. Using a score point on a 0–100 scale, GIDES measures the quality of the entrepreneurial resource allocation dynamic, focusing primarily on the digital condition at the country level. After excluding countries with missing data, the final sample consists of 100 countries, of which 31 are advanced economies, and 69 are emerging markets and developing economies (hereinafter referred to as developing countries or economies). Table 1 shows the number of countries in each economy. The full list of countries is available in Appendix 1.

Table 1: Regional Distribution of Countries

Region	Number of Countries
North America	2
Europe and Central Asia	36
East Asia and Pacific	13
Middle East and North Africa	11
Latin America and Caribbean	16
South Asia	5
Sub-Saharan Africa	17
Total	100

Source: Authors' compilation.

The dependent variable is the economic damage measured as GDP growth deceleration. We define GDP growth deceleration by, firstly, the difference between the actual GDP growth in 2019 and the October forecast of GDP growth in 2020 and, secondly, the divergence between the October 2019 forecast of 2020 GDP growth and the October 2020 forecast of GDP growth in 2020. The key independent variables of our baseline empirical model are the quality of the digital entrepreneurial system, the prevalence of COVID-19, and the interaction term between the two. The GIDES quantifies

the quality and productivity potential of digital entrepreneurial resource allocation dynamics, and COVID-19 prevalence represents the cumulated number of COVID-19 confirmed cases for every 100 people. As we aim to examine the potential moderating role of a country's digital entrepreneurial environment quality in mitigating the adverse impact of COVID-19 prevalence on its economic resilience, we consider the interaction term involving the two main independent variables. A significant interaction term suggests that the relationship between COVID-19 prevalence and economic performance is contingent upon the level of digital entrepreneurship as measured by GIDES. This logical deduction implies that countries with a more robust digital entrepreneurship ecosystem are better equipped to navigate crises that require movement restrictions since businesses can continue unimpeded when economic activities are shifted online. To account for potential confounding factors, we incorporate several control variables related to COVID-19 or based on the economic profile of each country. The two COVID-19-related control variables are mobility restriction and the Oxford Stringency Index. Countries impose restrictions on mobility to contain the spread of the disease, and Oxford Stringency Index indicates the level of a country's containment measures. Predictably, when a higher value is observed for either of the two measurements, it leads to subdued economic activities, resulting in a decline in GDP. The other four control variables included in the model are trade openness, services' share of GDP, past GDP per capita growth, and economic development level. Trade openness was significantly impacted during the pandemic due to lockdowns and supply chain disruptions. Similarly, various shutdown measures imposed during the pandemic negatively impacted the share of services of GDP. Therefore, it is conceivable that the two variables dampen a country's

economic performance. Additionally, a country's past productivity trajectory may influence its ability to navigate present challenges. Typically, past solid GDP growth indicates a well-performing economy with favorable conditions, such as high investment, productivity, and consumer confidence. This positive momentum can contribute to sustained growth in the future. Hence, we posit a negative relationship between past GDP per capita growth and the dependent variable. Lastly, we introduce a dummy variable to account for variations in the economic development levels among countries, thereby controlling for potential confounding factors. The economic development dummy variable takes on the value of one if the country falls under the category of emerging markets and developing countries. Table 2 lists all variables, along with their respective descriptions and anticipated directional relationships with the dependent variable. The baseline model of our study is shown in Eq 1.

$$GDPDEC_i = \alpha + \beta_1 COVID_i + \beta_2 GIDES_i + \beta_3 GIDES_i * COVID_i + \beta_4 CONTROL_i + \varepsilon_i \quad \text{(Eq 1)}$$

where α is the intercept, ***GDPDEC*** denotes GDP deceleration, $COVID$ represents COVID-19 prevalence, $GIDES$ is the Global Index of Entrepreneurship Systems (GIDES), $GIDES * COVID$ is the interaction term between GIDES and COVID, and $CONTROL_i$ represents the subset of controlled variables, namely mobility reduction, Oxford Stringency Index, trade openness, services share, past GDP per capita growth, and economy. β_1 to β_4 are the coefficients of each variable, and α is the error term. The subscript *i* denotes country *i*. Additionally, we consider the interaction terms between GIDES and mobility reduction ($GIDES * MOBRED$) and GIDES and stringency index

($GIDES * STRINGENCY$) to capture the moderating effects between the independent variables. Eq 2 and 3 exhibit the two equations.

$$GDPDEC_i = \alpha + \beta_1 COVID_i + \beta_2 GIDES_i + \beta_3 GIDES_i * MOBRED_i + \beta_4 CONTROL_i + \varepsilon_i \quad \text{(Eq 2)}$$

$$GDPDEC_i = \alpha + \beta_1 COVID_i + \beta_2 GIDES_i + \beta_3 GIDES_i * STRINGENCY_i + \beta_4 CONTROL_i + \varepsilon_i \quad \text{(Eq 3)}$$

Table 2: Description of Variables

Variable	Description	Predicted Sign	Data Source
Dependent variable			
GDP growth deceleration 1	Actual 2019 growth - 2020 growth forecast (annual %)		IMF WEO October 2020
GDP growth deceleration 2	GDP growth deceleration 2 – 2020 growth forecast (Oct 2019) - 2020 growth forecast (Oct 2020) (annual %)		IMF WEO October 2020 and WEO October 2019
Independent variable			
GIDES	Global Index of Digital Entrepreneurship System (0-100) (annual %)	(-)	Autio et al. 2022
Entrepreneurial Ecosystem	Entrepreneurial Ecosystem Index (EEI) (0-100)	(-)	Autio et al. 2022
Digital Entrepreneurial	Digital Entrepreneurial Index (DEI) (0–100)	(-)	Autio et al. 2022
COVID-19 prevalence	The ratio of total cumulative COVID-19 infections to population, or the positivity ratio	(+)	WHO
Economy	Advanced economies (0) versus Emerging markets and developing economies (1)		World Bank's WDI
Control variable			
Mobility reduction	Reduction in movement of people due to movement restrictive measures such as lockdowns and stay-at-home orders.	(+)	Google
Stringency Index	Stringency level of containment measures	(+)	Oxford data in CSV from Github
Trade openness	The ratio between the sum of exports and imports and GDP	(+)	World Bank's WDI
Service share	Value added in the services sector as percent of GDP	(+)	World Bank's WDI
Past GDP per capita growth	Average GDP per capita growth (2000-2019) (annual %)	(-)	World Bank's WDI

COVID-19 = coronavirus disease, GDP = gross domestic product, GIDES = Global Index of Entrepreneurship Systems, WDI = World Development Indicators, IMF = International Monetary Fund, WEO = World Economic Outlook, WHO = World Health Organization.
Note: The predicted sign (+ or -) indicates the expected directional relationship between the dependent and the independent variable.
Source: Authors' compilation.

4. Results and Discussion of Findings

Table 3 presents the summary statistics of the whole sample (Panel A), advanced economies (Panel B), and developing economies (Panel C). As expected, all GIDES-related indexes exhibit higher values in advanced economies while registering lower values in developing economies. The difference between the mean GIDES values of advanced economies, which stands at 58.35 (ranging from 27.31 to 81.29), and developing economies, which is 21.63 (ranging from 8.03 to 54.33), is considerable. Likewise, when it comes to digital conditions, developing economies exhibit substantially lower scores, averaging at 0.40 (ranging from 0.23 to 0.66), in contrast to the higher mean score of 0.73 (ranging from 0.50 to 0.88) observed in developed economies. The observed difference is expected, considering advanced economies have access to superior resources, more developed infrastructure, and stronger institutions than their less developed counterparts (Autio et al. 2022). Despite the disparity in their economic resources, both advanced and developing economies faced comparable levels of economic damage during the pandemic, with advanced economies recording an average deceleration of 8.239% per annum while developing economies reported a slightly higher figure of 8.559% per annum. Table 4 shows the correlation matrix. The variance inflation factor (VIF) values range from 1.3 and 2.4, indicating low levels of multicollinearity among the variables.

Table 3: Summary Statistics

Panel A: Whole sample (100 countries)	Mean	Std. Dev.	Min	Max
GDP growth deceleration 1	8.181	3.171	2.010	18.100
GDP growth deceleration 2	8.738	3.597	2.320	25.860
COVID-19 prevalence	0.020	0.019	0.000	0.073
Global Index of Digital Entrepreneurship Systems (GIDES)	33.015	20.630	8.030	81.290
Entrepreneurial Ecosystem Index (EEI)	0.655	0.137	0.410	0.980
Digital Entrepreneurial Index (DEI)	0.504	0.183	0.230	0.880
Stand-up	33.023	20.514	7.840	79.940
Start-up	32.950	21.441	7.870	83.640
Scale-up	33.073	20.028	7.640	80.440
Mobility reduction	16.892	21.142	-43.470	58.370
Stringency Index	51.588	9.924	29.889	72.688
Trade openness	0.909	0.616	0.120	3.640
Services share	57.518	8.989	33.498	79.158
Past GDP per capita growth	2.501	1.749	-1.692	8.427
Panel B: Advanced economies (31 countries)	**Mean**	**Std. Dev.**	**Min**	**Max**
GDP growth deceleration 1	8.257	2.496	3.920	14.810
GDP growth deceleration 2	8.221	2.425	4.100	14.680
COVID-19 prevalence	0.030	0.020	0.000	0.073
Global Index of Digital Entrepreneurship Systems (GIDES)	58.352	15.136	27.310	81.290
Entrepreneurial Ecosystem Index (EEI)	0.808	0.098	0.610	0.980
Digital Entrepreneurial Index (DEI)	0.727	0.095	0.500	0.880
Stand-up sub-index	57.974	15.395	26.570	79.940
Start-up sub-index	59.759	14.990	29.780	83.640
Scale-up sub-index	57.321	15.179	25.570	80.440
Mobility reduction	2.357	18.044	-28.840	29.490
Stringency Index	46.482	7.372	31.186	56.155
Trade openness	1.195	0.817	0.310	3.640
Services share	65.522	5.765	56.606	79.158
Past GDP per capita growth	1.870	1.369	0.116	5.425
Panel C: Emerging markets and developing economies (69 countries)	**Mean**	**Std. Dev.**	**Min**	**Max**
GDP growth deceleration 1	8.148	3.448	2.010	18.100
GDP growth deceleration 2	8.971	4.008	2.320	25.860
COVID-19 prevalence	0.015	0.016	0.000	0.059
Global Index of Digital Entrepreneurship Systems (GIDES)	21.632	9.719	8.030	54.330
Entrepreneurial Ecosystem Index (EEI)	0.586	0.087	0.410	0.840
Digital Entrepreneurial Index (DEI)	0.403	0.108	0.230	0.660
Stand-up sub-index	21.813	9.836	7.840	54.920
Start-up sub-index	20.905	9.762	7.870	52.340

Continued on the next page

Panel A: Whole sample (100 countries)	Mean	Std. Dev.	Min	Max
Scale-up sub-index	22.179	9.687	7.640	55.720
Mobility reduction	23.422	19.170	-43.470	58.370
Stringency Index	53.883	10.108	29.889	72.688
Trade openness	0.781	0.452	0.120	2.760
Services share	53.922	7.788	33.498	78.848
Past GDP per capita growth	2.785	1.835	-1.692	8.427

COVID-19 = coronavirus disease, GDP = gross domestic product.
Source: Authors' estimates.

Table 4: Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) COVID-19 prevalence	1.0000						
(2) GIDES	0.4342	1.0000					
(3) Mobility reduction	-0.0264	-0.4027	1.0000				
(4) Stringency Index	0.0352	-0.3109	0.5899	1.0000			
(5) Trade openness	0.3090	0.3439	-0.2627	-0.2490	1.0000		
(6) Services share	0.4859	0.6273	-0.0763	-0.1042	0.1848	1.0000	
(7) Past GDP per capita growth	-0.2240	-0.2882	-0.1347	-0.0332	0.1375	-0.3319	1.0000

COVID-19 = coronavirus disease, GDP = gross domestic product, GIDES = Global Index of Digital Entrepreneurship Systems.
Source: Authors' estimates.

4.1 The Effects of GIDES on Economic Performance during COVID-19

We discuss the findings of our main analysis in this section. Table 5 establishes the main results for the entire sample.

Overall, the results are in accordance with our expectations. As predicted, the prevalence of COVID-19 exacerbates a country's economic contraction, consistent with prior COVID-19-related studies. Furthermore, our results reveal a significant negative relationship between a country's digital entrepreneurial environment's quality and economic deceleration. This is also consistent with our anticipation that a more robust digital entrepreneurial resource allocation dynamic contributes positively toward

economic resilience. Next, we analyze if GIDES moderates the overall negative effect of COVID-19 prevalence on economic performance, which is the central research question addressed in this study. As evident from Column 1 of Table 5, the interaction term between the two main independent variables is negative and statistically significant at a 5% level, indicating that the positive effect of COVID-19 prevalence on GDP growth deceleration becomes weaker or may even reverse when the level of GIDES increases.

Table 5: Estimation Results for the Whole Sample
(All Countries)

	1	2	3	4	5	6
	GDP Growth Deceleration 1			**GDP Growth Deceleration 2**		
COVID-19 prevalence	80.23**	27.45	26.65	81.62**	15.26	15.13
	(30.92)	(17.40)	(17.73)	(31.99)	(17.81)	(17.99)
GIDES	-0.0506**	-0.0732***	-0.0948	-0.0632**	-0.0914***	-0.0931
	(0.025)	(0.024)	(0.068)	(0.025)	(0.026)	(0.076)
Mobility reduction	0.0244	0.0203	0.0279	0.0098	0.0051	0.0141
	(0.021)	(0.032)	(0.021)	(0.023)	(0.035)	(0.023)
Stringency Index	0.0097	0.0143	-0.0001	0.0390	0.0446	0.0404
	(0.044)	(0.045)	(0.063)	(0.045)	(0.045)	(0.066)
Trade openness	0.638	0.525	0.575	0.882	0.743	0.790
	(0.501)	(0.544)	(0.534)	(0.543)	(0.589)	(0.582)
Services share	0.147**	0.150**	0.151**	0.205**	0.209**	0.209**
	(0.062)	(0.063)	(0.063)	(0.081)	(0.084)	(0.085)
Past GDP per capita growth	0.102	0.147	0.143	-0.373	-0.317	-0.319
	(0.200)	(0.202)	(0.203)	(0.237)	(0.234)	(0.236)
Advanced economies	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
Emerging markets and developing economies	-1.279	-1.189	-1.194	-0.0182	0.0960	0.1110
	(1.099)	(1.119)	(1.119)	(1.162)	(1.189)	(1.186)
GIDES*COVID-19 prevalence	-1.340**			-1.684***		
	(0.557)			(0.608)		
GIDES*Mobility reduction		0.000211			0.000250	
		(0.001)			(0.001)	
GIDES*Stringency Index			0.000480			0.000077
			(0.001)			(0.002)
Constant	0.023	0.225	0.772	-3.225	-2.975	-2.939

Continued on the next page

	1	2	3	4	5	6
	GDP Growth Deceleration 1			**GDP Growth Deceleration 2**		
	(3.612)	(3.663)	(4.098)	(4.648)	(4.770)	(5.172)
Number of observations	100	100	100	100	100	100
R-squared	0.2757	0.2524	0.2523	0.3530	0.3244	0.3235
Adjusted R-squared	0.2030	0.1780	0.1780	0.2880	0.2570	0.2560
F statistics	5.24	5.36	4.97	5.30	6.14	4.81

COVID-19 = coronavirus disease, GDP = gross domestic product, GIDES = Global Index of Digital Entrepreneurship Systems.
Note: Columns 1 and 4 show the baseline results from the estimation of Eq 1. Columns 2 and 3 are estimation results of Eq 2 and 3, respectively. GDP growth deceleration 1 is the gap between the actual 2019 Growth and 2020 growth forecast, while GDP growth deceleration 2 is the gap between the 2020 growth forecast (October 2019) and the 2020 growth forecast (October 2020). GIDES is the Global Index of Digital Entrepreneurship Systems. Advanced economies and emerging markets and developing economies are dummy variables. Robust standard errors are reported in parentheses. ** and *** indicate statistical significance at the 5%and 1% levels, respectively.
Source: Authors' estimates.

This suggests that a more robust digital entrepreneurial ecosystem helps attenuate the decline in economic activities, thereby contributing to enhanced economic resilience. Using GDPDEC1 as an illustration, the interaction term coefficient between the two independent variables stands at -1.34. This implies that when GIDES experiences a one standard-deviation increase (ranging from 33.015 to 53.646), the impact of a one-unit increase in COVID-19 prevalence on GDP growth deceleration, evaluated at the mean of COVID-19 prevalence, diminishes by 0.553 percentage points. The subdued effect of 0.553 percentage point is derived from the calculation of -1.34 x 20.63 x 0.02, where 0.02 represents the mean of COVID-19 prevalence, and 20.63 signifies the standard deviation of GIDES. The statistically significant coefficient suggests that the combined influence of the two main independent variables is vital in shaping the dependent variable. More precisely, the impact of lockdowns on reducing production factors is mitigated when entrepreneurs can pivot to digital channels and continue their operations during the pandemic. This finding aligns with our hypothesis that a high-quality digital

entrepreneurial environment enables an economy to navigate the crisis more adeptly. Moreover, including the interaction term improves the model fit, as evident by the higher R-squared. To capture the differences in national economic development level, we incorporate economic status as a dummy variable in our model. The negative coefficient demonstrates that developing countries are more susceptible to the adverse impacts of COVID-19 compared to their more advanced counterparts. Additionally, we consider the regional effect to account for any unobserved heterogeneity across regions. However, our analysis yields similar outcomes and hence not reporting the finding herein. Among the control variables examined, only the services share exhibits a statistically significant (at a 5% level) and positive relationship with the dependent variable. Predictably, countries with higher services share of GDP suffered more economic contraction during the crisis that led to various movement controls. The results of other control variables, such as mobility reduction, stringency index, trade openness, and past GDP per capita growth, align with our expectations, despite the lack of statistical significance in their effects. Overall, the results provide empirical evidence that economies with a higher quality of digital entrepreneurship are better equipped to withstand the shock of the pandemic.

4.2 Sub-sample Analysis Based on the Economic Development Level

For robustness check, we divide the whole sample into two subsamples based on a country's economic status and perform cross-sectional tests for advanced economies and developing countries separately. The results are reported in Table 6.

Table 6: Estimation Results for Advanced Economies and Emerging Markets and Developing Economies

	Advanced Economies		Emerging Markets and Developing Economies	
Variables	**GDP Growth Deceleration 1**	**GDP Growth Deceleration 2**	**GDP Growth Deceleration 1**	**GDP Growth Deceleration 2**
COVID-19 prevalence	88.02	107.5	192.5**	234.7**
	(87.41)	(83.86)	(90.31)	(97.40)
GIDES	-0.0661*	-0.0587*	0.0345	0.0370
	(0.035)	(0.033)	(0.049)	(0.049)
GIDES*COVID-19 prevalence	-1.190	-1.572	-6.181**	-8.196***
	(1.394)	(1.315)	(2.771)	(2.980)
Mobility reduction	0.0283	0.0221	0.0343	0.0158
	(0.020)	(0.020)	(0.026)	(0.029)
Stringency Index	0.0518	0.0392	-0.0176	0.0187
	(0.062)	(0.060)	(0.051)	(0.051)
Trade openness	0.0895	0.118	1.882*	2.013*
	(0.444)	(0.412)	(0.952)	(1.042)
Services share	0.110	0.121	0.113	0.172*
	(0.083)	(0.077)	(0.074)	(0.095)
Past GDP per capita growth	-0.280	-0.550	0.0873	-0.477*
	(0.381)	(0.380)	(0.225)	(0.282)
Constant	2.256	2.260	-0.670	-2.949
	(6.683)	(6.548)	(3.941)	(4.779)
Number of observations	31	31	69	69
R-squared	0.613	0.667	0.292	0.367
Adjusted R-squared	0.473	0.545	0.197	0.282
F statistics	8.55	10.05	3.86	4.50

COVID-19 = coronavirus disease, GDP = gross domestic product, GIDES = Global Index of Digital Entrepreneurship Systems.
Note: The table shows the baseline results from the estimation of Eq 1. Robust standard errors are reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.
Source: Authors' estimates.

In comparison to advanced economies, developing economies experienced greater economic and statistical impacts from the prevalence of COVID-19. This finding corroborates the results obtained from the entire sample, as discussed in section 4.1. Although the interaction term between GIDES and COVID-19 prevalence is negative for

both advanced and developing economies, the coefficient is statistically significant only for developing economies. For perspective, a one-standard deviation increase in the GIDES of developing economies (from 21.632 to 31.351) leads to a reduction of 0.901 units in the effect of a one-unit increase in COVID-19 prevalence on GDP growth deceleration, when evaluated at the mean of COVID-19 prevalence. The interaction effect of 0.901 units is derived from the calculation of -6.181 x 9.719 x 0.015, where -6.181 represents the coefficient of the interaction term, 0.015 denotes the mean of COVID-19 prevalence, and 9.719 signifies the standard deviation of GIDES. This substantial reduction indicates that the interaction effect almost entirely mutes the main effect of COVID-19 prevalence on GDP growth deceleration. Further, we examine the potential economic benefit associated with upscaling an economy's digital entrepreneurship ecosystem quality. We calculate the COVID-19-induced growth deceleration of the entire sample by multiplying the average coefficient of COVID-19 prevalence (80.93) by the mean infection rate (0.02%). The resulting negative growth rate attributable to COVID-19 prevalence amounts to 1.62%. Subsequently, we compute the additional effect of interaction term as the product of the average coefficient estimate of the interaction term and the difference in GIDES scores between the two economies, evaluated at the mean COVID-19 infection rate. This yields an interaction effect amounting to -1.11 (-1.512 x 36.72 x 0.02), implying that developing economies may reduce their economic deceleration by 68.6% (|1.11|/1.62) if the quality of their entrepreneurial ecosystem matches that of advanced economies. Specifically, if developing economies could enhance their digital entrepreneurial environment quality to match that of advanced economies, it could lead to a remarkable reduction of 68.6% in GDP growth decline for

the developing economies. This finding corroborates the notion that digitalization speeds up economic development in developing economies (Dahlman et al. 2016).

4.3 The Effects of Entrepreneurial Digitalization on Economic Performance During COVID-19

In this section, we address the question of whether country-level digital affordances of entrepreneurship enhance its ability to withstand the pandemic shocks. Presumably, entrepreneurs who are more adept at harnessing digital advancements are also more adaptable to overcoming challenges and navigating economic headwinds. GIDES has a unique way of capturing the digital conditions of an economy. Instead of crafting a specific index pillar to measure digitalization, the index embeds digital technologies by way of assigning a digital weight for each of the eight framework conditions. The pillar weight represents an appropriate multidimensional variable of digitalization (Autio et al. 2018) that quantifies the strengths and weaknesses of each country's digital conditions. To measure the performance of the entrepreneurship system in isolation of digitalization, GIDES creates another non-digitalized or physical sub-index. By leveraging the index methodological disentanglement of digital and non-digital components within the entrepreneurial dynamic, we compare the impacts of digital and non-digital conditions on economic performance during the crisis. Eq 4 and Eq 5 depict the two regression models for the purpose.

$$GDPDEC_i = \alpha + \beta_1 COVID_i + \beta_2 EEI_i + \beta_3 EEI_i * COVID_i + \beta_4 CONTROL_i + \varepsilon_i \quad \text{(Eq 4)}$$

$$GDPDEC_i = \alpha + \beta_1 COVID_i + \beta_2 DEI_i + \beta_3 DEI_i * COVID_i + \beta_4 CONTROL_i + \varepsilon_i \quad \text{(Eq 5)}$$

where EEI denotes the Entrepreneurial (non-digital) Ecosystem Index, DEI represents Digital Ecosystem Index, and $EEI * COVID$ and $DEI * COVID$ is the interaction term between EEI and COVID and DEI * COVID, respectively. All other variable descriptions follow that of Eq 1. Table 7 presents the findings.

Table 7: Estimation Results of the Effect between Digital and Non-digital Dynamics on GDP per Capita Growth Deceleration

	1	2	3	4
	GDP Growth Deceleration 1		**GDP Growth Deceleration 2**	
	Entrepreneurial Ecosystem (EEI)	**Digital Ecosystem (DEI)**	**Entrepreneurial Ecosystem (EEI)**	**Digital Ecosystem (DEI)**
COVID-19 prevalence	185.2***	165.7***	199.9***	191.3***
	(67.31)	(58.11)	(69.95)	(63.70)
Entrepreneurial Ecosystem (EEI)	-0.0342		-0.0506	
	(0.035)		(0.035)	
Digital Ecosystem (DEI)		-0.0500*		-0.0655**
		(0.029)		(0.029)
EEI*COVID-19 prevalence	-2.316**		-2.710***	
	(0.888)		(0.932)	
DEI*COVID-19 prevalence		-2.247**		-2.852***
		(0.855)		(0.973)
Mobility reduction	0.0291	0.0211	0.0158	0.0052
	(0.021)	(0.021)	(0.023)	(0.024)
Stringency Index	0.0156	0.0046	0.0468	0.0323
	(0.046)	(0.044)	(0.046)	(0.045)
Trade openness	0.566	0.615	0.793	0.861
	(0.532)	(0.534)	(0.568)	(0.572)
Services share	0.135**	0.137**	0.191**	0.192**
	(0.063)	(0.061)	(0.084)	(0.079)
Past GDP per capita growth	0.085	0.121	-0.391	-0.352
	(0.208)	(0.198)	(0.249)	(0.235)
Advanced economies	0	0	0	0
	(.)	(.)	(.)	(.)
Emerging markets and developing economies	-0.549	-1.302	0.826	-0.129
	(1.129)	(1.142)	(1.291)	(1.172)
Constant	0.612	1.637	-2.097	-1.041
	(4.114)	(3.580)	(4.917)	(4.327)
Number of observations	100	100	100	100

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	1	2	3	4
	GDP Growth Deceleration 1		**GDP Growth Deceleration 2**	
	Entrepreneurial Ecosystem (EEI)	**Digital Ecosystem (DEI)**	**Entrepreneurial Ecosystem (EEI)**	**Digital Ecosystem (DEI)**
R-squared	0.256	0.268	0.329	0.349
Adjusted R-squared	0.181	0.195	0.262	0.283
F statistics	4.48	4.35	4.41	4.68

COVID-19 = coronavirus disease, GDP = gross domestic product, GIDES = Global Index of Digital Entrepreneurship Systems.
Note: Columns 1 and 3 show the estimation results of Eq 4, while columns 2 and 4 display the estimation results of Eq 5. EEI is Entrepreneurial Ecosystem Index, and DEI represents Digital Entrepreneurial Ecosystem Index. Robust standard errors are reported in parentheses. ** and *** indicate statistical significance at 5% and 1%, respectively.
Source: Authors' estimates.

Consistent with earlier findings, it is observed that the severity of COVID-19 amplifies the economic slowdown for both non-digital (EEI) and digital (DEI) entrepreneurship. However, while both EEI and DEI contribute positively to economic resilience, the impact is only statistically significant for DEI (Kim, Castillejos-Petalcorin, et al. 2022). Moreover, the coefficient estimates of DEI are more sizeable: for a one-index score increase in DEI, there is an easing-up of economic deceleration by an average of 0.058% per annum (average of -0.05 and -0.0655) compared to 0.035% for EEI. Concerning the moderating effect, it is evident that the interaction terms of both EEI and DEI entrepreneurship exhibit statistically significant results. This suggests that as the levels of EEI and DEI increase, the negative impact of COVID-19 prevalence on economic performance diminishes. Overall, the results point toward a favorable impact of digitalization on the system's ability to foster a thriving entrepreneurial environment. The findings are broadly consistent with our hypothesis that digitalization is pivotal in bolstering an entrepreneurial ecosystem that is more resilient to the pandemic shock. Furthermore, as we also consider the potential confounding effect of economic development, we turn to the results of the economic

development dummy variable. Noticeably, in developing countries, the coefficient of -1.302 for the digital condition indicates that digitalization has a stronger mitigating effect on economic loss compared to developed economies. Additionally, for the non-digital condition in developing markets, the coefficient of -0.549 suggests that the entrepreneurial system plays a role in attenuating economic loss, but to a much lesser extent than the digital condition in the entrepreneurial landscape. Though not statistically significant, these findings highlight the importance of digitalization in enhancing economic resilience, particularly in developing countries.

4.4 The Effects of Entrepreneurial Sub-dynamics (Stand-up, Start-up, and Scale-up) on Economic Performance

The immense heterogeneity of entrepreneurial activities highlights the need to distinguish between various types of entrepreneurship to gain a deeper understanding of the intricacies involved (Kim, Castillejos-Petalcorin, et al. 2022). In this section, we analyze the impact of three distinct developmental stages of entrepreneurship on economic performance during the crisis. The three stages - Digital Entrepreneurship Stand-up, Digital Entrepreneurship Start-up, and Digital Entrepreneurship Scale-up - correspond to various resource allocations at different developmental stages within the systemic framework conditions. As the earliest lifecycle stage, stand-up represents the group where ideas are formed and individuals self-select to entrepreneurship. The actual launch of new ventures and early business model experiments are captured at the start-up stage. Finally, the scale-up encompasses new ventures that have developed a scalable business model. To provide a more nuanced perspective on entrepreneurial dynamics,

we perform estimations on the three types of entrepreneurship. Eq 6–8 show the regression models.

$$GDPDEC_i = \alpha + \beta_1 COVID_i + \beta_2 STAND_i + \beta_3 STAND_i * COVID_i + \beta_4 CONTROL_i + \varepsilon_i \quad \text{(Eq 6)}$$

$$GDPDEC_i = \alpha + \beta_1 COVID_i + \beta_2 START_i + \beta_3 START_i * COVID_i + \beta_4 CONTROL_i + \varepsilon_i \quad \text{(Eq 7)}$$

$$GDPDEC_i = \alpha + \beta_1 COVID_i + \beta_2 SCALE_i + \beta_3 SCALE_i * COVID_i + \beta_4 CONTROL_i + \varepsilon_i \quad \text{(Eq 8)}$$

where $STAND,\ START, and\ SCALE$ denote digital entrepreneurship stand-up, start-up, and scale-up, respectively. The corresponding interaction terms are $STAND * COVID$, $START * COVID$, and $SCALE * COVID$. All remaining variable descriptions are the same as Eq 1.

Table 8: Estimation Results of the Effects of Entrepreneurship Stand-up, Start-up, and Scale-up Sub-dynamic on GDP Growth Eeceleration

	1	2	3	4	5	6
Variables	**GDP Growth Deceleration 1**			**GDP Growth Deceleration 1**		
	Stand-up	**Start-up**	**Scale-up**	**Stand-up**	**Start-up**	**Scale-up**
COVID-19 prevalence	82.26***	79.49**	77.75**	83.31**	82.28**	77.72**
	(30.96)	(30.95)	(30.94)	(32.07)	(32.26)	(31.80)
Stand-up	-0.0470*			-0.0593**		
	(0.025)			(0.024)		
Stand-up*COVID-19 prevalence	-1.398**			-1.735***		
	(0.560)			(0.616)		
Start-up		-0.0491*			-0.0609**	
		(0.025)			(0.025)	
Start-up*COVID-19 prevalence		-1.294**			-1.667***	
		(0.551)			(0.602)	
Scale-up			-0.0542**			-0.0676***
			(0.026)			(0.025)
Scale-up*COVID-19 prevalence			-1.304**			-1.620***
			(0.562)			(0.608)

Continued on the next page

	1	2	3	4	5	6
Variables	**GDP Growth Deceleration 1**			**GDP Growth Deceleration 1**		
	Stand-up	**Start-up**	**Scale-up**	**Stand-up**	**Start-up**	**Scale-up**
Mobility reduction	0.0255	0.0231	0.0248	0.0112	0.00803	0.0104
	(0.021)	(0.021)	(0.020)	(0.023)	(0.024)	(0.023)
Stringency Index	0.0094	0.00958	0.0104	0.0386	0.0387	0.040
	(0.045)	(0.044)	(0.044)	(0.045)	(0.045)	(0.044)
Trade openness	0.631	0.652	0.623	0.873	0.903	0.862
	(0.507)	(0.508)	(0.491)	(0.054)	(0.055)	(0.053)
Services share	0.146**	0.147**	0.149**	0.203**	0.205**	0.206**
	(0.061)	(0.062)	(0.061)	(0.081)	(0.083)	(0.081)
Past GDP per capita growth	0.0956	0.117	0.0958	-0.381	-0.356	-0.38
	(0.200)	(0.201)	(0.200)	(0.236)	(0.239)	(0.236)
Advanced economies	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
Emerging markets and developing economies	-1.180	-1.326	-1.272	0.101	-0.087	0.000
	(1.100)	(1.124)	(1.075)	(1.181)	(1.161)	(1.153)
Constant	-0.0374	-0.0193	0.0643	-3.291	-3.274	-3.181
	(3.633)	(3.636)	(3.584)	(4.676)	(4.683)	(4.616)
Number of observations	100	100	100	100	100	100
R-squared	0.2761	0.2436	0.2824	0.3531	0.3441	0.36
Adjusted R-squared	0.204	0.177	0.211	0.288	0.279	0.296
F statistics	5.288	4.796	5.427	5.309	4.997	5.532

COVID-19 = coronavirus disease, GDP = gross domestic product, GIDES = Global Index of Digital Entrepreneurship Systems.
Note: Columns 1, 2, and 3 (columns 4, 5, and 6) show the estimation results of Eq 6, Eq 7, and Eq 8, respectively. Robust standard errors are reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.
Source: Authors' estimates.

Table 8 exhibits the findings of stand-up, start-up, and scale-up. Broadly, the results display a consistent relationship across the three types of entrepreneurship: COVID-19 prevalence and sub-index show significant and predictable relationships with GDP growth deceleration. Interaction terms are significant, indicating that the effect of COVID-19 prevalence on economic deceleration depends on the levels of sub-dynamics. A closer inspection reveals that the impact of the interaction effect is most pronounced and significant for stand-up while weakest for start-up, from both an economic and statistical perspective. When considering the stand-up and using GDPDEC1 as an

example, we observe an interaction term coefficient of -1.398. This finding suggests that a one-standard deviation increase in stand-up reduces the impact of a one-unit rise in COVID-19 prevalence on GDP growth deceleration by 0.574 units (–1.398 x 0.02 x 20.514). In contrast, the impact is substantially lower for start-up and scale-up, measuring at 0.021 and 0.022 units, respectively. This finding somewhat corroborates Autio and Acs (2010), underscoring the necessity of examining the various developmental stages of entrepreneurship. By recognizing the differences in impacts associated with each stage, policymakers can align their support mechanism accordingly and prioritize targeted assistance for the development of the stand-up or prospective entrepreneurs.

5. Conclusion

ICT or digital technology helped entrepreneurs survive COVID-19. For instance, they shifted to online sales in the face of stringent lockdowns and mobility restrictions. The enhanced resilience of entrepreneurs, in turn, contributed to the resilience of the broader economy. The central objective of our study is to empirically analyze the relationship between the quality of a country's digital entrepreneurial ecosystem, measured by the GIDES, and its economic performance during the pandemic. At the same time, the existing literature does not contain such an empirical analysis, so the empirical analysis is also our main original contribution to the literature. Based on a cross-country analysis of 100 global economies, we find a positive association between GIDES and economic performance during COVID-19. This suggests that the quality of a country's environment for digital entrepreneurs can strengthen its economic resilience even in the face of major shocks.

Our empirical analysis yields a number of key findings. To reiterate, our primary finding is that countries with better digital entrepreneurship systems showed more resilience during COVID-19. More precisely, countries that provided better environments for digital entrepreneurs, as measured by GIDES, suffered a smaller unexpected reduction in GDP growth during the pandemic. Our analysis also yields two additional findings. First, digital entrepreneurial conditions have a more pronounced influence on promoting economic resilience compared to non-digital entrepreneurial conditions. This is consistent with the large and growing influence of ICT on entrepreneurship. Second, the environment facing digital entrepreneurship stand-ups has a more pronounced effect in mitigating the negative economic impact of the pandemic. This underscores the importance of supporting early-stage entrepreneurs in enhancing economic resilience and recovery. An interesting area of future research would be to re-visit the GIDES-resilience at a later time to gain a better understanding of the dynamics over a longer time horizon.

Appendix: **Sample Countries**

Advanced Economies	**Emerging Markets and Developing Economies**	
Australia	Argentina	Mali
Austria	Bahrain	Mauritius
Belgium	Bangladesh	Mexico
Canada	Benin	Mongolia
Czech Republic	Bolivia	Morocco
Denmark	Bosnia and Herzegovina	Mozambique
Estonia	Botswana	Namibia
Finland	Brazil	Nepal
France	Bulgaria	Nigeria
Germany	Burkina Faso	Oman
Greece	Cambodia	Pakistan
Ireland	Cameroon	Panama
Israel	Chile	Paraguay
Italy	China, People's Republic of	Peru
Japan	Colombia	Philippines
Korea, Republic of	Costa Rica	Poland
Latvia	Croatia	Qatar
Lithuania	Dominican Republic	Romania
Luxembourg	Ecuador	Russian Federation
Netherlands	Egypt, Arab Rep.	Rwanda
New Zealand	El Salvador	Saudi Arabia
Norway	Georgia	Senegal
Portugal	Ghana	Serbia
Singapore	Guatemala	South Africa
Slovak Republic	Honduras	Sri Lanka
Slovenia	Hungary	Tajikistan
Spain	India	Thailand
Sweden	Indonesia	Türkiye
Switzerland	Jordan	Uganda
United Kingdom	Kazakhstan	United Arab Emirates
United States	Kenya	Uruguay
	Kuwait	Viet Nam
	Kyrgyz Republic	Zambia
	Lebanon	Zimbabwe
	Malaysia	

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The Nexus between Digitalization, Entrepreneurial Ecosystem Quality, and Economic Resilience

A Cross-Country Analysis during the COVID-19 Pandemic

This study explores the relationship between the quality of a country's digital entrepreneurial ecosystem, measured by the Global Index of Digital Entrepreneurship Systems (GIDES), and its economic performance during the COVID-19 pandemic. Based on a cross-country analysis of 100 global economies, we find a positive association between GIDES and economic performance during the pandemic. This suggests that the quality of a country's environment for digital entrepreneurs can strengthen its economic resilience even in the face of major shocks.

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