Sitnicki, M. W., Serhiienko, R., Halynskyi, D., & Zhytar, M. (2026). Economic freedom and the dynamics of energy start-ups: Cross-country evidence on green and digital entrepreneurship and financing. *Journal of International Studies, 19*(1), 255-279. doi:10.14254/2071-8330.2026/19-1/14

Journal of International Studies

Centre of Sociological Research

Scientific Papers

Economic freedom and the dynamics of energy start-ups: Cross-country evidence on green and digital entrepreneurship and financing

Maksym W. Sitnicki*
West Virginia University, Department of Management, USA;
VIZJA University, School of Business, Poland;
Taras Shevchenko National University of Kyiv, Management of Innovation and Investment Activities Department, Ukraine
maksym.sitnicki@mail.wvu.edu
ORCID 0000-0002-0452-0404
** Corresponding Author*

Ruslan Serhiienko
University of Warsaw, Faculty of Management,
Poland
ruslan.r.serhiienko@gmail.com
ORCID 0009-0002-5056-1044

Dmytro Halynskyi
Sumy State University, Department of Financial Technologies and Entrepreneurship, Ukraine
vondarin@gmail.com
ORCID 0009-0004-9035-188X

Maksym Zhytar
National Aviation University, Faculty of Management, Finance and Marketing, Ukraine
maksym.zhytar@kai.edu.ua
ORCID 0000-0003-3614-0788

Abstract. The transition towards low-carbon, digitalised energy systems has heightened the importance of understanding how institutional environments shape entrepreneurial activity and investment in the energy sector. This study aims to assess the role of economic freedom and its subcomponents in shaping cross-country differences in the creation and financing of green and digital energy start-ups, with a focus on non-linear institutional effects and stage-specific investment dynamics. The analysis is based on a cross-country panel dataset combining start-up and funding data from the International Energy

Received: June, 2025
1st Revision: February, 2026
Accepted: March, 2026

DOI: 10.14254/2071-8330.2026/19-1/14

Agency with institutional indicators from the Fraser Institute, using two-way fixed effects models with Driscoll–Kraay standard errors and quadratic specifications. The results show that economic freedom has a weak, mostly negative effect on start-up formation, with coefficients of approximately −0.157 for green start-ups and −0.185 for digital start-ups. In contrast, its impact on financing is strong and consistently negative, with coefficients ranging from −5.2 to −5.6 across early- and later-stage funding models. Significant non-linear effects are identified for later-stage digital funding, with an inverted U-shaped relationship, a turning point of approximately 5.35. Subindex results indicate that trade freedom and sound money drive negative effects, while legal institutions exhibit threshold effects at approximately 7.6–8.6.

Keywords: economic freedom, energy start-ups, green entrepreneurship, digital entrepreneurship, entrepreneurial finance, non-linear effects, panel data, cross-country.

JEL Classification: L26, Q42, G24, C23

1. INTRODUCTION

The transformation of global energy systems has become a central priority for economic and environmental policy, particularly amid climate-neutrality targets and rising geopolitical uncertainty. The European Commission emphasises that achieving the objectives of the European Green Deal requires not only large-scale investments in clean technologies but also a dynamic ecosystem of innovative firms capable of developing and commercialising low-carbon solutions (European Commission, 2019, 2023). At the same time, recent energy crises linked to supply disruptions and the war in Ukraine have reinforced the strategic importance of energy security, diversification, and technological sovereignty within the European Union (European Commission, 2022). In this context, energy start-ups, particularly those operating in green and digital domains, are increasingly recognised as key actors in accelerating innovation, enhancing system flexibility, and supporting the decarbonisation of energy systems (European Commission, 2023).

From a global perspective, the International Energy Agency highlights that clean energy innovation must scale rapidly to support net-zero pathways, with early-stage ventures playing a critical role in developing breakthrough technologies across renewables, storage, hydrogen, and smart energy systems (IEA, 2023b). However, IEA reports also underline that investment in energy start-ups remains highly uneven across countries and is strongly influenced by institutional, financial, and regulatory conditions (IEA, 2023a). Similarly, the International Renewable Energy Agency stresses that while global investment in renewable energy has grown significantly, funding gaps persist, particularly in emerging markets and in early-stage innovation (IRENA, 2023). These disparities point to the importance of national institutional environments in shaping both the creation of start-ups and their ability to attract capital and scale (IRENA, 2022).

In parallel, the increasing digitalisation of the energy sector is reshaping the nature of entrepreneurship and investment. Reports by the Renewable Energy Test Center and international agencies emphasise the growing role of digital technologies, such as artificial intelligence, smart grids, and data-driven energy management, in improving efficiency, integrating renewable sources, and enabling new business models (RETC, 2023). This convergence of green and digital innovation creates new opportunities for start-ups but also introduces additional complexity, requiring access to advanced infrastructure, skilled human capital, and supportive institutional frameworks (IEA, 2023b; IRENA,

2023). As a result, the success of energy start-ups is increasingly dependent not only on technological capabilities but also on the broader economic and regulatory environment in which they operate.

Against this background, economic freedom emerges as a potentially important but insufficiently explored determinant of energy entrepreneurship. While higher levels of economic freedom are generally associated with improved market functioning, reduced barriers to entry, and enhanced investment conditions, recent evidence suggests that its effects may be non-linear and context-dependent, particularly in sectors characterised by high capital intensity, policy dependence, and long-term risk, such as energy (IEA, 2023a; IRENA, 2022). Reports from international organisations indicate that targeted public support, regulatory stability, and institutional quality often play a decisive role alongside market liberalisation (European Commission, 2023; IEA, 2023b). This raises an important research question: whether economic freedom uniformly promotes the development of green and digital energy start-ups, or whether its impact varies across stages of entrepreneurial activity and levels of institutional development, thereby necessitating a more nuanced, cross-country analysis.

2. LITERATURE REVIEW

The development of entrepreneurship, particularly in technologically intensive and sustainability-oriented sectors, is increasingly recognised as a multidimensional phenomenon shaped by individual, organisational, and institutional factors. Entrepreneurial orientation, leadership, and organisational capabilities are critical determinants of firm resilience and innovation performance, especially in turbulent socio-economic environments, where ambidexterity and adaptive capacity enhance long-term sustainability (Abu Taleb et al., 2025; Fitriningrum et al., 2025; Benabderrahmane & Benbouzid, 2025; Saba et al., 2025). At the same time, entrepreneurial success is strongly conditioned by ecosystem-level factors, including access to resources, competencies, and social capital, which facilitate opportunity recognition and business development across diverse institutional contexts (Bayoumy et al., 2025; Imo & Makanjuola, 2025; Iwara, 2025; Han et al., 2025). In addition, methodological approaches to assessing innovative entrepreneurship highlight the need for multidimensional evaluation frameworks capturing both qualitative and quantitative aspects of entrepreneurial activity (Bekzhanova et al., 2024). These insights highlight that entrepreneurship cannot be analysed in isolation from its broader economic and institutional environment.

The role of digitalisation and technological change further transforms entrepreneurial dynamics, particularly in emerging sectors such as energy. Digital tools, artificial intelligence, and advanced technologies are increasingly embedded in entrepreneurial processes, shaping value creation, business models, and competitive advantage (Balcerzak et al., 2025; Alzamel, 2024; Kajda & Karwot, 2026). At the same time, perceptions of entrepreneurial opportunities and barriers, especially among young and potential entrepreneurs, influence the decision to engage in start-up activity, reflecting behavioural and institutional constraints (Dorusincova et al., 2025). Digital entrepreneurial ecosystems and smart city environments create new opportunities for innovation, although their effects on start-up development may be complex and sometimes counterintuitive, reflecting trade-offs between technological advancement and ecosystem maturity (Khatami et al., 2024; Mursalov et al., 2023; Kuzior et al., 2025; Manolache et al., 2025). Furthermore, the integration of digital technologies into sectors such as healthcare, public management, and logistics demonstrates the cross-sectoral nature of digital transformation and its implications for entrepreneurial activity (Hart, 2025; Kuzior et al., 2024a; Behar Villegas et al., 2024). These developments underscore the importance of digital readiness and technological infrastructure in shaping modern entrepreneurship.

Within this broader context, energy entrepreneurship emerges as a distinct and increasingly important domain, closely linked to the global transition towards sustainability. The expansion of renewable energy

systems, the need to reduce environmental externalities, and the growing importance of sustainable finance create new opportunities and challenges for start-ups operating in this sector (Badreddine & Larbi Cherif, 2024; Balcerzak et al., 2024; Streimikiene et al., 2024). Energy start-ups are characterised by high capital intensity, long investment horizons, and significant regulatory dependence, which increase both risks and barriers to entry (Dobrovolska et al., 2024; Myroshnychenko et al., 2024). At the same time, recent EU climate policy developments impose new requirements and opportunities for entrepreneurs, particularly in the context of renewable energy expansion and regulatory transformation (Kawecka-Wyrzykowska, 2025). Infrastructure factors, such as reliable electricity grid connections, and policy instruments, including fiscal incentives and public support mechanisms, play a decisive role in enabling the development and scaling of renewable energy ventures (Lyeonov et al., 2025b; Raboshuk et al., 2025). These features distinguish energy entrepreneurship from other sectors and highlight the importance of institutional and policy frameworks.

The literature also emphasises the critical role of entrepreneurial ecosystems and governance structures in shaping start-up performance and innovation outcomes. University–industry collaboration, knowledge transfer mechanisms, and regional innovation systems are key drivers of start-up success, particularly in technology-intensive industries (Kuzior et al., 2024b; Jurgelevičius & Raišienė, 2025). Public administration and governance arrangements can act both as facilitators and barriers to entrepreneurship, depending on their efficiency, flexibility, and regulatory design (Rosiak et al., 2024; Oe et al., 2025). In addition, public–private partnerships and policy instruments aimed at promoting sustainability and circular economy practices contribute to the development of innovation ecosystems and entrepreneurial activity (Juracka et al., 2024; Burrell et al., 2025). At the same time, government technological readiness, particularly in artificial intelligence, is increasingly recognised as a factor influencing energy sector development and innovation capacity (Lyeonov et al., 2025a). However, governance paradoxes and institutional complexity may hinder entrepreneurial initiatives, particularly in highly regulated sectors such as energy (Rosiak et al., 2024).

Access to finance and investment conditions constitute another crucial dimension of entrepreneurial dynamics, especially in the context of energy and digital start-ups. Venture financing, risk perception, and financial market conditions significantly influence entrepreneurial behaviour and firms' ability to scale (Civelek et al., 2025; Tudor, 2024; Su et al., 2025). Empirical evidence indicates that access to credit, investor protection, and financial infrastructure are key determinants of start-up development in clean and digital energy sectors (Artyukhov et al., 2024; Podosynnikov et al., 2024). At the same time, broader macroeconomic factors, including business cycles, foreign direct investment, and institutional absorptive capacity, shape entrepreneurial opportunities and outcomes across countries (Bușu et al., 2024; Tarek & Albaqami, 2024). These findings suggest that financial and institutional environments jointly determine the dynamics of entrepreneurial finance.

Finally, the literature highlights the increasing importance of sustainability, environmental awareness, and institutional quality in shaping entrepreneurial activity and market outcomes. Green branding, environmental management practices, and consumer attitudes towards renewable energy influence both demand and entrepreneurial opportunities (Starchenko et al., 2021; Sardianou & Kougias, 2025). At the same time, regulatory frameworks, market design, and operational constraints in energy systems affect the viability and performance of renewable energy ventures (Pijarski et al., 2025; Delcea et al., 2024; Triantafyllidou et al., 2024). The interaction between digital capacity, collaborative governance, and regional development further reinforces the importance of institutional environments in shaping entrepreneurial ecosystems and economic outcomes (Zhuravka et al., 2025; Olortegui-Alcalde & Cordova-Buiza, 2025; Yassin et al., 2024; Korpysa & Judit, 2024).

The existing literature demonstrates that entrepreneurship in the energy sector is shaped by a complex interplay of technological, financial, and institutional factors, with increasing emphasis on sustainability and digitalisation. However, despite extensive research on entrepreneurial ecosystems and renewable energy development, the specific role of economic freedom and its subdimensions in influencing both start-up formation and financing dynamics remains insufficiently explored. This gap highlights the need for a comprehensive cross-country analysis that integrates institutional theory with the study of green and digital energy entrepreneurship.

This study aims to assess the role of economic freedom and its subcomponents in shaping cross-country differences in the creation and financing of green and digital energy start-ups, focusing on non-linear institutional effects and stage-specific investment dynamics.

3. METHODOLOGY

The empirical analysis is based on a cross-country panel dataset combining information on green entrepreneurial activity and institutional conditions. Data on start-up dynamics are obtained from the International Energy Agency Energy Start-up Data Explorer (IEA, n.d.), which provides harmonised information on energy-related start-ups across countries and years. This dataset enables the identification of green start-ups, particularly those operating in renewable energy, energy efficiency, and low-carbon technologies. The study employs a set of dependent variables capturing both the quantity of start-ups and the scale of financial support across different stages of development. Specifically, the dependent variables include: Energy and green start-ups (Number), Energy and digital start-ups (Number), Early-stage funding of energy and green start-ups (USD), Later-stage funding of energy and green start-ups (USD), Later-stage funding of energy and digital start-ups (USD), and Early-stage funding of energy and digital start-ups (USD). To ensure comparability across countries and mitigate skewness in the distribution, all count and monetary variables are transformed using natural logarithms.

Institutional quality is measured using the Economic Freedom of the World Index from the Fraser Institute (n.d.). Both the aggregate index and its key subcomponents are employed, including: (i) Size of Government, (ii) Legal System and Property Rights, (iii) Sound Money, (iv) Freedom to Trade Internationally, and (v) Regulation. These indicators reflect different dimensions of the institutional environment that may influence entrepreneurial incentives, market entry conditions, and access to capital. To explore potential non-linear relationships, squared terms of the economic freedom indicators are included in the model specification.

The empirical analysis is conducted using panel data covering the period from 2000 to 2023.

The empirical strategy relies on panel data econometric techniques to account for unobserved heterogeneity and temporal dynamics. Specifically, two-way fixed effects (TWFE) models are estimated, controlling for both country-specific and time-specific effects. This approach allows for isolating within-country variation over time while accounting for global shocks and structural differences across countries. The baseline specification can be expressed as follows:

$$log(Y\_it) = \beta_0 + \beta_1 \cdot EFI\_it + \beta_2 \cdot EFI\_it^2 + \gamma \cdot X\_it + \mu\_i + \lambda\_t + \varepsilon\_it$$

where Y_it represents each of the dependent variables, EFI denotes the economic freedom index (or its subcomponents), X_it is a vector of control variables, μ_i captures country fixed effects, λ_t represents year fixed effects, and ε_it is the error term. The inclusion of quadratic terms enables testing for potential inverted U-shaped or U-shaped relationships between institutional quality and green entrepreneurship.

To ensure robust inference in the presence of heteroskedasticity, serial correlation, and cross-sectional dependence, standard errors are estimated using Driscoll–Kraay corrections. This is particularly

relevant in macro-panel settings with a relatively large time dimension and interconnected economies. In addition, all continuous explanatory variables are centred before constructing interaction or quadratic terms to reduce multicollinearity and facilitate the interpretation of coefficients. All data processing, variable construction, and econometric estimation were conducted in the R programming environment, ensuring reproducibility and transparency of the analytical procedures.

Finally, turning points of the quadratic relationships are computed to identify threshold levels of economic freedom at which the marginal effect on green start-up activity changes sign. These turning points are compared with the observed data range to assess their economic relevance. This methodological framework enables a comprehensive assessment of both linear and non-linear institutional effects on green entrepreneurship across countries.

4. EMPIRICAL RESULTS AND DISCUSSION

The descriptive statistics indicate substantial cross-country and temporal heterogeneity in entrepreneurial activity within the energy sector. The average number of energy-related green start-ups amounts to 11.55, while digital start-ups are less frequent, with a mean of 5.71. However, the medians (3 and 2, respectively) are considerably lower than the means, and the distributions exhibit pronounced right skewness (skewness of 2.99 and 3.21), indicating that a limited number of countries account for a disproportionately large share of start-up activity. This pattern is even more pronounced for funding variables, where both early- and later-stage investments display extreme skewness and kurtosis, alongside median values equal to zero. These results suggest that venture financing in the energy domain is highly concentrated and episodic, with most country–year observations receiving no investment and a few observations experiencing exceptionally large inflows. Such distributional characteristics strongly support the use of count-data and non-linear modelling approaches, such as Poisson estimators, in subsequent empirical analysis.

In contrast, the Economic Freedom Index and its subcomponents display relatively moderate dispersion and more stable distributions across countries and years. The overall index has a mean of 7.44 with a standard deviation of 0.65, indicating limited but meaningful variation in institutional quality. Among the subindices, "Sound Money" and "Freedom to trade internationally" exhibit the highest average values (8.69 and 8.33, respectively), whereas "Size of Government" and "Regulation" show comparatively lower scores. The negative skewness observed for most institutional variables suggests that higher levels of economic freedom are more common in the sample, with fewer observations at the lower end of the distribution. Notably, the variability is greatest for the legal system and property rights component, indicating more pronounced cross-country differences in institutional enforcement and governance quality. The contrast between the highly skewed entrepreneurial and financing variables and the relatively stable institutional indicators provides a strong empirical basis for investigating how variations in economic freedom shape the emergence and scaling of green and digital start-ups across countries.

The Economic Freedom Index was mean-centred before estimation to reduce multicollinearity between the linear and quadratic terms and to improve the interpretability of the coefficients in models testing for non-linear effects. By expressing economic freedom as deviations from its sample mean, the coefficient on the linear term reflects the marginal effect at the average level of institutional quality. In contrast, the squared term captures the curvature of the relationship in a numerically stable way. At the same time, the dependent variables are log-transformed to address strong right-skewness, the presence of extreme values, and heteroskedasticity observed in the raw data, particularly for start-up counts and funding variables. This transformation compresses the influence of outliers, stabilises variance, and allows

estimated coefficients to be interpreted in approximate percentage terms, thereby enhancing both the robustness and economic interpretability of the results.

The results from the TWFE models (Table 1) indicate that the relationship between economic freedom and the number of start-ups is weak and statistically insignificant across most specifications. For green start-ups, neither the linear nor the quadratic term of the centred Economic Freedom Index is significant, and the very low within R^2 suggests that within-country changes in economic freedom explain only a minimal share of variation in entrepreneurial activity. A similar pattern is observed for digital start-ups, although the linear term is marginally significant at the 10% level and negative. Overall, these findings imply that short-term changes in economic freedom within countries do not appear to be a strong driver of the number of energy-related start-ups, once unobserved country characteristics and global time effects are controlled for.

Table 1

TWFE estimation results: Economic freedom and start-ups/funding

Variables	(1) Green start-ups	(2) Digital start-ups	(3) Early green funding	(4) Late green funding	(5) Late digital funding	(6) Early digital funding
c_efi	-0.157	-0.185†	-5.487***	-5.566***	-5.432***	-5.192***
	(0.114)	(0.103)	(1.570)	(1.589)	(1.484)	(1.594)
c_efi_sq	-0.018	-0.004	-0.502	-0.948†	-1.411**	-0.691
	(0.052)	(0.035)	(0.577)	(0.579)	(0.650)	(0.645)
Observations	871	871	871	871	871	871
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.879	0.850	0.581	0.477	0.441	0.564
Within R^2	0.005	0.010	0.056	0.060	0.057	0.047

Notes: Clustered standard errors (by country) in parentheses. Dependent variables are log-transformed. The Economic Freedom Index is mean-centred. Significance codes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$, † $p < 0.10$.
Source: authors' calculation in R Studio.

In contrast, a much stronger and statistically significant relationship emerges when analysing funding variables. For both early- and later-stage green financing, the linear term for economic freedom is negative and significant at the 1% level, indicating that increases in economic freedom (relative to a country's average level) are associated with lower funding levels. However, the quadratic terms are not statistically significant, suggesting no robust evidence of non-linear effects in green financing. This pattern may reflect the fact that investment dynamics in green sectors are influenced more by structural and policy-driven factors, such as subsidies or targeted programmes, rather than incremental changes in general economic freedom.

The most pronounced nonlinear effects are observed in later-stage digital start-up funding. Here, both the linear and quadratic terms are statistically significant, with negative coefficients, indicating an inverted U-shaped relationship between economic freedom and funding. This suggests that increases in economic freedom initially support the scaling of digital start-ups. Still, beyond a certain level, further liberalisation may reduce investment, potentially due to reduced regulatory protection, increased competition, or shifts in market structure. Importantly, the presence of a significant quadratic term confirms that the relationship is not monotonic and highlights the importance of considering non-linear institutional effects in explaining entrepreneurial finance.

For early-stage digital funding, the results mirror those observed for green financing: the linear term is negative and statistically significant, while the quadratic term remains insignificant. This indicates a predominantly linear relationship, where higher levels of economic freedom are associated with lower early-stage investment flows. Taken together, the results suggest that while economic freedom does not strongly influence the number of start-ups, it plays a more substantial and nuanced role in shaping funding dynamics, particularly in later stages of digital entrepreneurship, where non-linear effects become relevant.

The estimates obtained with DK SE (Table 2) provide more robust inference by accounting for cross-sectional dependence and serial correlation, and they reveal clearer patterns than those from the clustered specifications. For start-up activity, the linear term of the centred Economic Freedom Index is now statistically significant and negative for both green and digital start-ups. Specifically, a one-unit increase in economic freedom (relative to the country mean) is associated with a reduction in the log number of green and digital start-ups, while the quadratic terms remain insignificant. This indicates that the relationship between economic freedom and the number of start-ups is predominantly linear and negative, with no evidence supporting a U-shaped or inverted U-shaped pattern. Substantively, this suggests that short-term increases in economic freedom within countries may not stimulate the entry of new firms in the energy sector and may even coincide with reduced start-up formation.

Table 2

TWFE estimates with Driscoll–Kraay standard errors

Variables	(1) Green start-ups	(2) Digital start-ups	(3) Early green funding	(4) Late green funding	(5) Early digital funding	(6) Late digital funding
c_efi	-0.157***	-0.185**	-5.487***	-5.566***	-5.192***	-5.432***
	(0.055)	(0.074)	(1.117)	(1.189)	(0.926)	(1.101)
c_efi_sq	-0.018	-0.004	-0.502	-0.948**	-0.691	-1.411***
	(0.049)	(0.041)	(0.626)	(0.455)	(0.518)	(0.440)
Observations	871	871	871	871	871	871
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Driscoll–Kraay standard errors (lag length = 2) reported in parentheses. Dependent variables are log-transformed. The Economic Freedom Index is mean-centred. Significance codes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Source: authors' calculation in R Studio.

A much stronger and highly consistent relationship emerges for funding variables. Across all models, the coefficient on economic freedom is negative and statistically significant at the 1% level, indicating that higher economic freedom is associated with lower levels of both early- and later-stage investment in green and digital start-ups. The magnitude of these coefficients is substantial, reflecting the strong sensitivity of investment flows to institutional changes. This pattern may reflect the importance of targeted policy interventions, subsidies, and state involvement in supporting capital-intensive sectors such as energy, where purely market-driven environments may not provide sufficient investment incentives.

Importantly, non-linear effects become statistically significant in later-stage financing models. For both green and digital later-stage funding, the quadratic term is negative and statistically significant, indicating an inverted U-shaped relationship between economic freedom and investment. This implies that while initial increases in economic freedom may support the scaling of start-ups, beyond a certain threshold, further liberalisation is associated with declining investment levels. Such a pattern is consistent

with the idea that excessive deregulation or reduced institutional support may weaken investment conditions, particularly in sectors characterised by high uncertainty and long payback periods.

In contrast, no robust nonlinear effects are observed for early-stage funding, with the quadratic terms remaining statistically insignificant. This suggests that early-stage investment dynamics are primarily driven by a linear relationship with economic freedom, without clear threshold effects. Taken together, the findings highlight a nuanced role of economic freedom. While it does not appear to promote start-up entry and is negatively associated with overall funding, its impact on later-stage investment is non-linear, suggesting that an intermediate level of institutional development may be most conducive to scaling entrepreneurial ventures in the energy and digital domains.

The estimated turning points indicate that the relationship between economic freedom and later-stage funding is non-linear and characterised by an inverted U-shape. For green start-up late-stage funding, the turning point is approximately 4.50 on the original Economic Freedom Index scale, which lies very close to the lower bound of the observed range, suggesting that the positive effects of increasing economic freedom on funding are realised only at relatively low levels of institutional development and quickly diminish thereafter. In contrast, for digital start-up later-stage funding, the turning point is estimated at approximately 5.51, which is well within the sample range and therefore economically meaningful. This implies that moderate levels of economic freedom are most conducive to attracting later-stage investment in digital ventures, while further increases beyond this threshold are associated with declining funding. Overall, these findings highlight that the impact of economic freedom on investment is not monotonic and that optimal institutional conditions differ across sectors, with digital entrepreneurship exhibiting a more pronounced, policy-relevant nonlinearity.

The subindex-level results (Table B1, Appendix B) show that none of the institutional dimensions equally drives the previously identified negative association with economic freedom at the aggregate level. For start-up formation, most subareas do not exhibit robust effects after including country- and year-fixed effects. In the case of green start-ups, neither the size of government, the legal system, or property rights, nor regulation is statistically significant, and their quadratic terms are likewise insignificant. Only two dimensions stand out. First, sound money is negatively associated with green start-up activity at the 10% level, suggesting that within-country increases in monetary stability are linked to a modest decline in the number of new green ventures. Second, the freedom to trade internationally has a strong, statistically significant negative linear effect, with no significant quadratic pattern, indicating a predominantly monotonic relationship. For digital start-ups, the pattern is similar: freedom to trade internationally again displays a strong negative linear association, while the remaining subindices are generally insignificant. The only indication of non-linearity appears in the legal system and property rights, where the positive quadratic term is weakly significant, suggesting a possible U-shaped relationship; however, the absence of a significant linear term means this result should be interpreted cautiously.

A clearer and much more systematic pattern emerges for early-stage funding. Early green funding is negatively associated with government size, sound money, international trade freedom, and regulation, with the strongest linear effects observed for trade freedom and regulation. At the same time, several non-linearities appear. The size of government has a weakly significant negative quadratic term, and sound money also shows a negative, significant quadratic coefficient, suggesting an inverted U-shaped pattern in both cases. Most notably, the legal system and property rights subindex has a strongly positive quadratic term. At the same time, its linear coefficient is insignificant, indicating that the relationship is non-linear and becomes more favourable only at higher levels of institutional quality. This suggests that improvements in legal protection may not immediately stimulate early-stage green investment, but stronger institutional development may eventually become supportive. For early digital funding, the results broadly mirror those for green funding: sound money, freedom to trade internationally, and regulation all

show strong negative linear effects, while the legal system and property rights subindex again yields a weakly significant positive quadratic term, and sound money displays a negative quadratic term, reinforcing the idea that monetary stability may exert diminishing or adverse effects once it exceeds certain levels.

For later-stage green funding, the evidence suggests that institutional conditions matter even more strongly, but primarily through linear channels. Legal system and property rights, sound money, freedom to trade internationally, and regulation all display statistically significant negative linear coefficients, while the size of government is negative at the 10% level. However, only a limited degree of non-linearity is detected, as none of the quadratic terms is statistically significant. This implies that the scaling of green ventures is most consistently associated with monotonic changes in institutional subareas rather than with threshold effects. Later-stage digital funding shows a similar but slightly sharper pattern. The size of government, the legal system, property rights, sound money, freedom to trade internationally, and regulation all have negative, statistically significant linear effects. In addition, sound money exhibits a significant negative quadratic term, indicating an inverted U-shaped relationship. This suggests that moderate improvements in monetary conditions may initially be compatible with greater later-stage digital investment, but beyond a certain point, further increases are associated with declining funding.

These findings indicate that the negative association between economic freedom and entrepreneurial finance is not uniform across institutional dimensions but is most consistently driven by the freedom to trade internationally, sound money, and regulation. These three subareas repeatedly show statistically significant negative linear coefficients across both green and digital funding models, and, in the case of sound money, also display evidence of non-linearity. By contrast, the legal system and property rights dimension appears more complex: it is weakly or strongly relevant mainly for funding outcomes. It occasionally exhibits a U-shaped pattern, suggesting that institutional protection may become supportive only beyond a certain threshold. The start-up count models are clearly less responsive than the funding models, which implies that institutional changes may affect the scale and financing of ventures more strongly than their initial emergence. Overall, the appendix results reinforce the conclusion that economic freedom is most relevant for the financing environment of green and digital entrepreneurship. At the same time, its impact on firm entry is comparatively limited and more selective across institutional subareas.

The turning point analysis (Table 3) provides important additional insight into the non-linear relationships identified in the subindex models, revealing substantial heterogeneity across institutional dimensions and stages of entrepreneurial finance. For the legal system and property rights subindex, the results consistently indicate a U-shaped relationship. In the case of digital start-ups, the turning point is located at approximately 7.80, suggesting that improvements in legal institutions initially coincide with lower entrepreneurial activity, but beyond a relatively high threshold, stronger legal protection begins to foster start-up formation. A similar pattern is observed for early-stage green funding, where the turning point of approximately 7.47 implies that only sufficiently advanced legal frameworks support investment. This pattern becomes even more pronounced for early-stage digital funding, with a turning point of 8.56, indicating that the positive effects of legal institutions emerge only at very high levels of institutional quality. Overall, these findings suggest that legal infrastructure acts as a threshold condition, becoming supportive for entrepreneurship and investment only once a certain level of development is reached.

In contrast, the size of the government subindex for early-stage green funding exhibits an inverted U-shaped relationship, with a turning point at approximately 5.26, which lies well within the observed range. This indicates that moderate levels of government involvement are most conducive to early-stage green investment, while both lower and higher levels are associated with reduced funding. This result is consistent with the idea that some degree of public-sector involvement, through subsidies, coordination, or support mechanisms, is necessary in capital-intensive, policy-driven sectors such as green energy. Still, excessive government size may crowd out private investment or reduce efficiency.

The sound money subindex displays a more complex pattern. For early-stage green funding, the turning point is estimated at approximately 1.90, which lies close to the lower bound of the observed range, suggesting a weakly relevant inverted U-shape in which most observations fall on the downward-sloping segment. For early-stage digital funding, the turning point falls outside the observed range (approximately 0.47), suggesting that the relationship is effectively monotonic and negative in practice, despite the statistical significance of the quadratic term. In contrast, for later-stage digital funding, the turning point is approximately 2.15, within the sample range, indicating a meaningful inverted U-shaped relationship. This suggests that moderate levels of monetary stability may support the scaling of digital ventures, but further increases are associated with declining investment, possibly due to reduced risk-taking or tighter financial conditions.

Table 3

Turning points for economic freedom subindices (TWFE, DK SE)

Model	Subindex	β_1 (linear)	β_2 (quadratic)	Turning point (centred)	Turning point (original)	Range (min–max)	Within range
Digital start-ups	Legal system & property rights	-0.069	0.053	0.657	7.800	4.36–9.40	Yes
Early green funding	Size of government	-0.906	-0.526	-0.861	5.263	4.15–8.68	Yes
Early green funding	Legal system & property rights	-0.681	1.056	0.322	7.466	4.36–9.40	Yes
Early green funding	Sound money	-1.745	-0.128	-6.797	1.896	1.12–9.88	Yes
Early digital funding	Legal system & property rights	-1.532	0.540	1.417	8.561	4.36–9.40	Yes
Early digital funding	Sound money	-1.635	-0.099	-8.222	0.471	1.12–9.88	No
Late digital funding	Sound money	-1.046	-0.080	-6.545	2.147	1.12–9.88	Yes

Notes: Turning points are calculated as $-\beta_1/(2\beta_2)$. Subindices are mean-centred before estimation; original values are obtained by adding the sample mean. Driscoll–Kraay standard errors are used in all models. "Within range" indicates whether the turning point lies within the observed data range of the respective subindex.
Source: authors' calculation in R Studio.

The turning point analysis reinforces the conclusion that the effects of the economic freedom subindices are highly nonlinear and context-dependent. While legal institutions exhibit U-shaped dynamics with clear threshold effects at higher levels of development, government size and monetary stability tend to display inverted U-shaped relationships, where intermediate levels are most conducive to investment. Importantly, not all statistically significant quadratic terms translate into economically meaningful turning points, as demonstrated by the early digital funding model for sound money. These results highlight the importance of jointly considering statistical significance and the location of turning points within the observed data range when interpreting non-linear effects in panel data models.

The lagged specifications provide a substantially stronger and more credible basis for causal interpretation, as institutional conditions precede entrepreneurial outcomes. As shown in Table B2, the results indicate that the overall Economic Freedom Index (lagged) does not significantly affect green start-

up formation. In contrast, its effect on digital start-ups is weakly negative and marginally significant. Importantly, no evidence of non-linearity is observed in start-up counts, suggesting that institutional changes do not generate delayed threshold effects in firm entry. However, at the subindex level, freedom to trade internationally consistently shows a strong, statistically significant negative effect for both green and digital start-ups, indicating that increased trade openness in the previous period is associated with reduced domestic start-up activity in the energy sector. In addition, sound money shows a weak negative effect for green start-ups, suggesting that monetary stability may slightly dampen entrepreneurial entry, although this relationship remains only marginally significant.

In contrast, the funding models reveal a clearer, economically meaningful pattern. Across all specifications, the lagged Economic Freedom Index is strongly negative and highly significant for both early- and later-stage funding, indicating that increases in economic freedom are associated with lower subsequent investment in green and digital start-ups. This effect is particularly pronounced for later-stage funding, where the quadratic term is also negative and significant, implying an inverted U-shaped relationship. This suggests that while moderate levels of economic freedom may initially support investment, further increases beyond a certain threshold reduce funding availability. The presence of this non-linearity in lagged models strengthens the interpretation that institutional conditions influence investment dynamics over time rather than contemporaneously.

At the subindex level, the results highlight that trade freedom, regulation, and sound money are the primary drivers of the observed effects. Freedom to trade internationally consistently shows strong negative linear effects across all funding models, with no robust non-linearities, indicating a monotonic relationship. Regulation also exhibits strong negative and statistically significant effects across both green and digital funding, particularly at early stages, suggesting that reductions in regulatory constraints may not translate into increased investment in these sectors. Meanwhile, sound money shows significant linear and quadratic effects across several models, particularly for later-stage funding, confirming an inverted U-shaped relationship in which intermediate levels of monetary stability are most conducive to investment.

The legal system and property rights subindex presents a distinct pattern characterised by U-shaped relationships in several early-stage funding models. The positive and significant quadratic terms indicate that improvements in legal institutions only become supportive of investment beyond a certain threshold, reinforcing the idea that institutional quality must reach a sufficiently advanced stage before it fosters entrepreneurial finance. The lagged results reported in Table B2 confirm that institutional factors play a much stronger role in shaping funding dynamics than start-up formation, and that these effects are highly non-linear and dimension-specific. This provides robust evidence that the impact of economic freedom on green and digital entrepreneurship operates primarily through investment channels and unfolds over time.

The turning-point analysis substantially refines the interpretation of the lagged quadratic models by distinguishing between statistically estimated curvature and economically meaningful non-linearity. As reported in Tables B3 (Appendix B) and Table 4, many quadratic specifications produce turning points that lie outside the observed range of the relevant institutional variable, which means that, although a quadratic term may have been estimated, the implied U-shaped or inverted U-shaped relationship is not substantively relevant within the actual sample. This applies, for example, to the lagged overall Economic Freedom Index for green start-ups, digital start-ups, early green funding, early digital funding, and several subindex-based funding models. In such cases, the relationship should be interpreted as effectively monotonic over the observed data range, rather than as evidence of a genuine threshold effect.

In the formation of start-ups, the most meaningful nonlinearities emerge at the subindex level rather than at the aggregate index level. In the case of green start-ups, turning points fall within the observed range across all five subindices, although not all are supported by statistically significant quadratic terms. Substantively, the estimated turning point for the legal system and property rights is located at

approximately 8.37, suggesting that only relatively high levels of legal quality would be associated with a reversal from a negative to a positive relationship. For international trade freedom, the turning point is about 7.37, suggesting an inverted U-shaped pattern in which moderate-to-high levels of trade openness may be associated with the most favourable environment before the relationship becomes less supportive. For digital start-ups, the most notable meaningful turning points occur for legal system and property rights (around 7.90) and regulation (around 8.07), both consistent with a U-shaped pattern in which institutional improvements become favourable only at relatively advanced levels. By contrast, the turning points for sound money and trade freedom lie outside the observed range, so these relationships should not be interpreted as valid non-linear effects within the sample.

For early-stage funding, the turning-point results indicate a marked divergence across institutional dimensions. In early green funding, meaningful turning points are observed for the size of government (5.84), legal system and property rights (7.64), and sound money (1.75). The first and third of these are consistent with inverted U-shaped relationships, implying that moderate levels of government size and monetary stability are associated with the most favourable funding outcomes, whereas further increases coincide with declining investment. In contrast, the turning point for the legal system and property rights suggests a U-shaped relationship, meaning that the association becomes more supportive of early green finance only beyond a relatively high level of legal-institutional quality. For early digital funding, only the size of government (6.05) and legal system and property rights (7.89) yield turning points within the observed range, while the turning points for the overall Economic Freedom Index, sound money, trade freedom, and regulation fall outside the sample domain. This again indicates that early-stage funding responds to specific institutional thresholds rather than to broad changes in economic freedom.

The clearest and most policy-relevant threshold effects arise in later-stage funding, especially for digital ventures. As shown in Table 4, the lagged overall Economic Freedom Index shows a meaningful turning point for late-stage digital funding at approximately 5.35, indicating an inverted U-shaped relationship in which moderate levels of economic freedom are most conducive to late-stage investment. At the same time, further increases are associated with lower funding. Among the subindices, sound money and freedom to trade internationally also produce economically meaningful turning points for late digital funding, at about 2.52 and 6.39, respectively, both consistent with inverted U-shaped dynamics. For late green funding, only freedom to trade internationally yields a turning point within the observed range (around 6.10), again pointing to a meaningful inverted U-shaped pattern. Overall, the turning-point analysis confirms that truly relevant non-linearities are concentrated in selected subdimensions and in later-stage financing outcomes. In contrast, many apparent quadratic relationships are not economically meaningful once the observed data are taken into account. This is why the models with turning points inside the empirical range should receive the greatest interpretative emphasis in the main discussion. At the same time, the remaining estimates are better treated as evidence of broadly monotonic effects.

The findings of this study provide important insights into the role of institutional environments in shaping energy entrepreneurship, particularly by distinguishing between start-up formation and financing dynamics.

Table 4

Economically meaningful turning points only (turning points within the observed range)

Dependent variable	Institutional variable	β_1	β_2	Turning point (original scale)	Observed range	Implied shape
log_green_startups	Area 1: Size of Government	0.001	-0.017	6.149	4.15–8.68	Inverted U-shape
log_green_startups	Area 2: Legal System & Property Rights	-0.070	0.029	8.366	4.36–9.40	U-shape
log_green_startups	Area 3: Sound Money	-0.053	-0.005	3.418	1.12–9.88	Inverted U-shape
log_green_startups	Area 4: Freedom to trade internationally	-0.113	-0.059	7.368	5.88–9.64	Inverted U-shape
log_green_startups	Area 5: Regulation	-0.011	0.042	7.039	3.95–8.71	U-shape
log_digital_startups	Area 1: Size of Government	-0.040	-0.020	5.126	4.15–8.68	Inverted U-shape
log_digital_startups	Area 2: Legal System & Property Rights	-0.097	0.064	7.903	4.36–9.40	U-shape
log_digital_startups	Area 5: Regulation	-0.031	0.013	8.071	3.95–8.71	U-shape
log_early_green_fund	Area 1: Size of Government	-0.446	-0.793	5.843	4.15–8.68	Inverted U-shape
log_early_green_fund	Area 2: Legal System & Property Rights	-1.192	1.204	7.639	4.36–9.40	U-shape
log_early_green_fund	Area 3: Sound Money	-2.021	-0.146	1.748	1.12–9.88	Inverted U-shape
log_late_green_fund	Area 4: Freedom to trade internationally	-3.677	-0.825	6.098	5.88–9.64	Inverted U-shape
log_early_digital_fund	Area 1: Size of Government	-0.073	-0.465	6.046	4.15–8.68	Inverted U-shape
log_early_digital_fund	Area 2: Legal System & Property Rights	-1.280	0.858	7.889	4.36–9.40	U-shape
log_late_digital_fund	Economic freedom in all areas	-5.689	-1.365	5.354	4.41–8.74	Inverted U-shape
log_late_digital_fund	Area 3: Sound Money	-1.305	-0.106	2.521	1.12–9.88	Inverted U-shape
log_late_digital_fund	Area 4: Freedom to trade internationally	-2.942	-0.762	6.395	5.88–9.64	Inverted U-shape

Notes: Turning points are calculated as $-\beta_1/(2\beta_2)$. "Within range" indicates whether the turning point lies within the observed empirical range of the respective institutional variable. Only those cases should be interpreted as economically meaningful non-linear effects. U-shape is implied by $\beta_1 < 0$and $\beta_2 > 0$, while an inverted U-shape is implied by $\beta_1 > 0, \beta_2 < 0$ or, more generally, in practical interpretation here, by a negative quadratic coefficient with a turning point inside the data range.
Source: authors' calculation in R Studio.

The empirical results indicate that economic freedom does not significantly stimulate the creation of green and digital start-ups and, in several specifications, is negatively associated with entrepreneurial entry. This contrasts with the broader entrepreneurship literature, which often emphasises the positive role of

favourable institutional environments, entrepreneurial orientation, and ecosystem support in fostering firm creation (Abu Taleb et al., 2025; Imo & Makanjuola, 2025; Yassin et al., 2024). However, the results are consistent with studies highlighting that in highly regulated and capital-intensive sectors such as energy, structural factors, infrastructure availability, and policy frameworks may dominate over general market liberalisation in determining entry dynamics (Dobrovolska et al., 2024; Myroshnychenko et al., 2024; Lyeonov et al., 2025b). This suggests that energy entrepreneurship follows a different logic from that of more flexible sectors, where institutional liberalisation alone is insufficient to stimulate start-up formation.

A more pronounced and consistent pattern emerges for financing, where economic freedom exhibits strong negative effects across both early- and later-stage investment. The magnitude of these effects, with coefficients exceeding −5 in several models, indicates a high sensitivity of entrepreneurial finance to institutional changes. These findings challenge conventional expectations that liberal economic environments uniformly attract investment and instead support the argument that targeted policy instruments, public support mechanisms, and financial incentives play a critical role in enabling investment in sustainable and high-risk sectors (Streimikiene et al., 2024; Burrell et al., 2025; Artyukhov et al., 2024). In this context, the results align with evidence that access to credit, investor protection, and institutional support structures are more decisive for start-up financing than general economic liberalisation (Podosynnikov et al., 2024; Civelek et al., 2025). The negative association may reflect the reduced role of state intervention and subsidy schemes in more liberalised economies, which are particularly important for supporting early-stage and capital-intensive ventures in the energy domain.

The identification of non-linear effects further refines the interpretation of institutional influences on entrepreneurial finance. The inverted U-shaped relationship observed for later-stage digital funding, with a turning point around 5.35 on the economic freedom scale, indicates that moderate levels of institutional development are most conducive to scaling start-ups. This finding is consistent with the literature, which suggests that both insufficient and excessive regulation may hinder entrepreneurial performance, while balanced institutional frameworks provide optimal conditions for growth (Juracka et al., 2024; Oe et al., 2025). Similarly, the threshold effects identified for legal institutions, where positive impacts emerge only at higher levels of institutional quality, support the view that strong governance and property rights protection become effective only once a certain level of development is achieved (Kuzior et al., 2024b; Jurgelevičius & Raišienė, 2025). These results highlight that institutional quality operates in a non-linear and stage-specific manner, particularly in sectors characterised by technological complexity and long investment horizons.

Finally, the subindex-level analysis reveals that not all dimensions of economic freedom exert uniform effects, with trade freedom, sound money, and regulation emerging as the most influential factors. The consistently negative roles of trade openness and monetary stability may reflect increased exposure to international competition and reduced incentives for domestic investment in high-risk sectors, which align with findings on financial risk perception and investment behaviour under uncertainty (Civelek et al., 2025; Su et al., 2025). At the same time, the observed U-shaped effects for legal institutions confirm their role as a foundational condition for entrepreneurial development, particularly in ensuring investor confidence and long-term financing (Artyukhov et al., 2024). Overall, the results extend the existing literature by demonstrating that economic freedom influences energy entrepreneurship primarily through financing channels rather than start-up entry and that its effects are highly heterogeneous across institutional dimensions and stages of development.

Despite providing new cross-country evidence on the relationship between economic freedom and the dynamics of green and digital energy start-ups, this study has several limitations. First, the analysis relies on aggregated national-level data, which may mask important heterogeneity across regions, sectors,

and specific types of technologies, particularly within the broad categories of green and digital energy ventures. Second, the sample is constrained by the availability of comparable data from the IEA and Fraser Institute, which may limit the generalisability of the findings to countries with less developed statistical systems or missing observations. Third, although lagged specifications strengthen causal interpretation, the results still reflect associations rather than fully identified causal effects, as unobserved factors such as policy design, subsidy intensity, or innovation ecosystem characteristics may influence both institutional conditions and entrepreneurial outcomes. Fourth, the measurement of economic freedom captures broad institutional dimensions and may not fully reflect sector-specific regulatory frameworks that are particularly relevant for energy markets. Future research could address these limitations by incorporating more granular, firm-level or regional data, distinguishing between specific energy technologies, and explicitly modelling policy instruments such as subsidies or carbon pricing. Additionally, applying quasi-experimental approaches, such as policy-reform difference-in-differences designs, or integrating alternative institutional indicators, could further strengthen causal inference and provide deeper insights into the mechanisms linking institutional environments and energy entrepreneurship.

5. CONCLUSION

The study set out to evaluate how economic freedom and its institutional subdimensions influence the development of green and digital energy entrepreneurship across countries, with particular emphasis on differences between start-up formation and financing dynamics as well as the presence of non-linear institutional effects. In doing so, the analysis aimed to clarify whether more liberal economic environments systematically support the emergence and scaling of energy-related entrepreneurial activity or whether their effects vary across stages and institutional dimensions.

The empirical analysis was based on a cross-country panel dataset combining start-up and funding data from the International Energy Agency with institutional indicators from the Fraser Institute. The study employed two-way fixed effects models with country and year controls, complemented by Driscoll–Kraay standard errors to address cross-sectional dependence and serial correlation. Nonlinear effects were examined using quadratic specifications, and turning points were calculated to assess the economic relevance of the estimated relationships.

The results reveal that the relationship between economic freedom and start-up formation is generally weak and, when significant, negative, with coefficients of approximately −0.157 for green start-ups and −0.185 for digital start-ups in the most robust specifications. In contrast, the impact on financing is strong and consistently negative, with coefficients ranging from −5.2 to −5.6 for both early- and later-stage funding, indicating substantial sensitivity of investment flows to institutional changes. Non-linear effects are particularly pronounced in later-stage digital funding, where a significant inverted U-shaped relationship is observed, with a turning point at approximately 5.35 on the economic freedom scale. Subindex analysis further shows that freedom to trade internationally and sound money are the most consistent drivers of negative effects across models. At the same time, the legal system and property rights exhibit U-shaped relationships with turning points around 7.6–8.6, indicating threshold effects. Importantly, meaningful non-linearities are concentrated in financing rather than in start-up counts, suggesting that institutional conditions affect venture scaling more strongly than their initial emergence. Overall, the findings demonstrate that higher levels of economic freedom do not necessarily promote energy entrepreneurship and may even reduce funding beyond moderate levels.

These findings have several important policy implications. First, they suggest that a purely market-oriented approach may be insufficient to support green and digital energy entrepreneurship, particularly in capital-intensive sectors where long-term investment horizons and high uncertainty prevail. Governments should therefore complement economic liberalisation with targeted support instruments, including

subsidies, public–private co-investment schemes, and risk-sharing mechanisms, especially at early stages of venture development. Second, the presence of inverted U-shaped relationships indicates that an optimal, intermediate level of economic freedom may be more conducive to investment than either very low or very high levels, implying that policymakers should focus on balanced institutional design rather than maximising liberalisation per se. Third, the strong and consistent role of trade freedom, monetary stability, and regulation suggests that reforms in these areas should be carefully calibrated, as excessive liberalisation may unintentionally reduce domestic investment incentives. Fourth, the threshold effects observed for legal institutions highlight the importance of achieving sufficiently high levels of legal protection and enforcement before positive effects on entrepreneurial finance can materialise. Finally, policy strategies should differentiate between stages of entrepreneurial development, as the determinants of start-up entry and scaling differ substantially, requiring tailored institutional and financial support frameworks to foster sustainable energy innovation effectively.

REFERENCES

Abu Taleb, M., Tantawi, P. I., Ragheb, M. A., & Amara, D. (2025). Small and Medium-sized Enterprises' Resilience to Socioeconomic Challenges in Emerging Economies: The Impact of Entrepreneurial Orientation on Organisational Ambidexterity. *SocioEconomic Challenges, 9*(2), 156–179. https://doi.org/10.61093/sec.9(2).156-179.2025

Alzamel, S. (2024). Leveraging smart glasses for digital entrepreneurship: a conceptual model. *Polish Journal of Management Studies, 30*(2), 7–21. https://doi.org/10.17512/pjms.2024.30.2.01.

Artyukhov, A., Havrylenko, O., Churikanova, O., & Mohylna, K. (2024). Overcoming barriers to the development of clean and digital energy start-ups: access to credit and protection of minority investors' rights. *Financial Markets, Institutions and Risks, 8*(4), 226–248. https://doi.org/10.61093/fmir.8(4).226-248.2024

Badreddine, A., & Larbi Cherif, H. (2024). Public health improvement by reducing air pollution: A strategy for the transition to renewable energy. *Health Economics and Management Review, 5*(1), 1–14. https://doi.org/10.61093/hem.2024.1-01

Balcerzak, A. P., Škapa, S., & Zinecker, M. (2025). Start-ups and artificial intelligence: From application to value, and the five problems that shape effective implementation. *Oeconomia Copernicana, 16*(4), 1369–1376. https://doi.org/10.24136/oc.4057

Balcerzak, A., Uddin, G. S., Dutta, A., Pietrzak, M. B., & Igliński, B. (2024). Energy mix management: A new look at the utilization of renewable sources from the perspective of the global energy transition. *Equilibrium. Quarterly Journal of Economics and Economic Policy, 19*(2), 379–390. https://doi.org/10.24136/eq.3158

Bayoumy, M. S. A., Abou-Shouk, M., AL-Taii, A., Al-Leheabi, S. M. Z. M., & Youssef, E. (2025). The Contribution of Social Capital to Entrepreneurial Activities' Success: Across-Country Field Study in the Light of Social Capital Theory. *Journal of Tourism and Services, 16*(31), 65–89. https://doi.org/10.29036/3350h252

Behar Villegas, E., Goh, Z., & Horowitt, G. S. (2024). Designing a good story for better policies: Entrepreneurship at the crossroads of AI-powered visual storytelling and sensemaking. *Human Technology, 20*(3), 420–445. https://doi.org/10.14254/1795-6889.2024.20-3.1

Bekzhanova, T., Yeshpanova, D., Omarova, A., Vorobyeva, S., Shugaipova, Z., & Salzanova, Z. (2024). Methodology for assessing innovative entrepreneurship. *Montenegrin Journal of Economics, 20*(4), 239–249. https://doi.org/10.14254/1800-5845/2024.20-4.20

Benabderrahmane, N., & Benbouzid, K. (2025). Personal, Organizational, and External Determinants of Tourism Startups Success: Step-By-Step for Business Leadership. *Business Ethics and Leadership, 9*(1), 154–166. https://doi.org/10.61093/bel.9(1).154-166.2025

Burrell, D. N., Wansi, T., Morin, S. L., Rahim, E., Tessema, D. B., Alemu, B. A., Harris, N., & Conley, L. (2025). Harnessing Behavioral Economics, Green Promotions, and Financial Incentives as Catalysts for Sustainable Practices. *Green Transition and Sustainable Development, 1*(1), *1–16*. https://doi.org/10.61093/gtsd.1(1).1-16.2025

Bușu, M., Staicu, G., Gheorghe, M., Prinz, E. & Fonseca, L.M. (2024). Analysing the Effects of the Business Cycle on Renewable Energy Consumption and Sustainable Development: Evidence from EU Countries. *Amfiteatru Economic, 26* (Special Issue No. 18), pp. 1048–1064. https://doi.org/10.24818/EA/2024/S18/1048

Civelek, M., Ključnikov, A., Brezina, I., Procházková, L., & Folvarčná, A. (2025). Facing the financial risk, embracing the opportunity: How financial perceptions shape entrepreneurial behavior in recession periods. *Equilibrium. Quarterly Journal of Economics and Economic Policy, 20*(3), 1131–1164. https://doi.org/10.24136/eq.3877

Delcea, C., Oprea, S.-V., Dima, A. M., Domenteanu, A., Bara, A., & Cotfas, L.-A. (2024). Energy communities: Insights from scientific publications. *Oeconomia Copernicana, 15*(3), 1101–1155. https://doi.org/10.24136/oc.3137

Dobrovolska, O., Ortmanns, W., Podosynnikov, S., Halynskyi, D., & Miniailo, A. (2024). Start-Ups and Entrepreneurship in Renewable Energy: Investments and Risks. *Financial Markets, Institutions and Risks, 8*(2), 213–240. https://doi.org/10.61093/fmir.8(2).213-240.2024

Dorusincova, A., Belás, J., Streimikis, J., & Bencsik, A. (2025). The impact of perceived advantages and disadvantages on the start-up of entrepreneurship by university students. *Polish Journal of Management Studies, 32*(2), 39–55. https://doi.org/10.17512/pjms.2025.32.2.03

European Commission. (2019). *The European Green Deal* (COM(2019) 640 final). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640

European Commission. (2022). *REPowerEU plan* (COM(2022) 230 final). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022DC0230

European Commission. (2023). *Proposal for a regulation on establishing a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem (Net Zero Industry Act)* (COM(2023) 161). https://single-market-economy.ec.europa.eu/document/download/9446a7b1-0220-4b7b-91d2-11b7e27b9278_en

Fitriningrum, A., Cindyawan, F., & Pulungan, A. H. (2025). Entrepreneurial Orientation, Affective Commitment, and Transformational Leadership's Impacts on SMEs' Innovation Performance. *Business Ethics and Leadership, 9*(2), 145–159. https://doi.org/10.61093/bel.9(2).145-159.2025

Fraser Institute. (n.d.). Economic freedom data. https://www.fraserinstitute.org/categories/economic-freedom

Hart, G. (2025). Navigating AI Implementation in Healthcare Retail: A Case Study on Leadership, Workforce Adaptation, and Digital Transformation. *Health Economics and Management Review, 6*(3), 1–16. https://doi.org/10.61093/hem.2025.3-01

Han, T., Lorenzo, L. C., De Guzman Mallari, M. A., Zhang, Q., & SzabóSzentgróti, E. (2025). How business practices of social entrepreneurs shape brand resilience of retail company in Shanxi province, China. *Journal of International Studies, 18*(1), 254–283. https://doi.org/10.14254/2071-8330.2025/18-1/15

Imo, I. O., & Makanjuola, O. E. (2025). Ecosystem resources, entrepreneurial competencies, and startup success: a mediation analysis. *International Journal of Entrepreneurial Knowledge, 13*(2), 156–178. https://doi.org/10.37335/ijek.v13i2.350

International Energy Agency (IEA). (n. d.). *Energy Start-up Data Explorer – Data Tools - IEA*. https://www.iea.org/data-and-statistics/data-tools/energy-start-up-data-explorer

International Energy Agency (IEA). (2023a). Energy Technology Perspectives 2023, IEA, Paris https://www.iea.org/reports/energy-technology-perspectives-2023

International Energy Agency (IEA). (2023b). World Energy Outlook 2023, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2023

International Renewable Energy Agency (IRENA). (2022). World Energy Transitions Outlook 2022: 1.5°C Pathway, International Renewable Energy Agency, Abu Dhabi. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Mar/IRENA_World_Energy_Transitions_Outlook_2022.pdf

International Renewable Energy Agency (IRENA). (2023). World Energy Transitions Outlook 2023: 1.5°C Pathway, International Renewable Energy Agency, Abu Dhabi. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2023/Jun/IRENA_World_energy_transitions_outlook_2023.pdf

Iwara, I. O. (2025). Cross-examining entrepreneurial success traits across entrepreneur groups in a common ecosystem. *International Journal of Entrepreneurial Knowledge, 13*(2), 54–74. https://doi.org/10.37335/ijek.v13i2.337

Juracka, D., Valaskova, K., & Nica, E. (2024). Sustainable public policy instruments: revealing global interest in circular economy and eco-innovations. *Administratie si Management Public, 43,* 6–24. https://doi.org/10.24818/amp/2024.43-01

Jurgelevičius, A., & Raišienė, A.G. (2025). University entrepreneurial ecosystems: Start-up founders 'perspectives on critical factors for student start-up success. *Economics and Sociology, 18*(2), 221–245. https://doi.org/10.14254/2071-789X.2025/18-2/12

Kajda, K., & Karwot, J. (2026). AI-Driven Waste Classification and Smart Management in Poland's Industry 4.0 Framework: CNN-Based Solutions for Sustainable Municipal Systems. *Green Transition and Sustainable Development, 2*(1), 65–-87. https://doi.org/10.61093/gtsd.2(1).65-87.2026

Kawecka-Wyrzykowska, E. (2025). New EU climate goals in light of RES directive of 2023: Challenges for economic policy and entrepreneurs in Poland [Nowe cele klimatyczne UE w świetle dyrektywy o OZE z 2023 r. Wyzwania dla polityki gospodarczej. *Rynek Energii, 2025*(1), 3–15. https://rynek-energii.pl/pl/node/4736

Khatami, F., Ferraris, A., Palmucci, D. N., & Dabić, M. (2024). Impact Analysis of the Digital Entrepreneurial Ecosystem to Improve the Tourism Industry and Social Sustainability. *Journal of Tourism and Services, 15*(29), 176–205. https://doi.org/10.29036/jots.v15i29.831

Korpysa, J., & Judit, O. (2024). Startups' organizational resilience in post-COVID times. *International Journal of Management and Economics*, 60(1), 3-11.

Kuzior, A., Marhasova, V., Zozuľakova, V., Kočnerova, M., Koibichuk, V., Ryabushka, L., & Vasylieva, T. (2025). Smart city rankings and startup ecosystems: An empirical analysis of inverse correlation across 77 smart cities. *Problems and Perspectives in Management, 23*(2), 409–422. https://doi.org/10.21511/ppm.23(2).2025.29

Kuzior, A., Marszałek-Kotzur, I., Kurovska, Y., & Chvankin, Y. (2024a). The Role of Digital Economy in Transformation of Public Health: Modeling and Analysis. *Health Economics and Management Review, 5*(4), 91–109. https://doi.org/10.61093/hem.2024.4-06

Kuzior, A., Samoilikova, A., Valúch, M., & Bácsné Bába, E. (2024b). Impact of university-industry R&D collaboration on innovation transfer and startup performance. *Journal of International Studies, 17*(3), 164–181. https://doi.org/10.14254/2071- 8330.2024/17-3/9

Lyeonov, S., Mielczarek, L., Krawczyk, D., & Popp, J. (2025a). The role of government AI readiness in shaping renewable electricity capacity and output. *Human Technology, 21*(3), 668–693. https://doi.org/10.14254/1795-6889.2025.21-3.9

Lyeonov, S., Podosynnikov, S., & Strielkowski, W. (2025b). Does a reliable electricity grid connection matter for the development of European renewable energy startups? *Energy Policy, 206,* 114749. https://doi.org/10.1016/j.enpol.2025.114749

Manolache, S.B., Nechita, D., Zamfir, C.G. & Stanciu, S. (2025). Digital Ecosystems in Romania's Courier Market. *Amfiteatru Economic, 28*(71), pp. 202–218. https://doi.org/10.24818/EA/2026/71/202

Mursalov, M., Yarovenko, H., & Vasilyeva, T. (2023). Entrepreneurial Ecosystem and Digitalisation: Relationship and Synergy of Development. *Springer Proceedings in Business and Economics,* 109–127. https://doi.org/10.1007/978-3-031-28131-0_9

Myroshnychenko, I., Podosynnikov, S., Halynskyi, D., Ushkalov, M., & Chuhai, O. (2024). Regulatory Barriers For Entrepreneurship and Start-Ups In Renewable Energy: Bibliometric Analysis. *SocioEconomic Challenges, 8*(3), 181–210. https://doi.org/10.61093/sec.8(3).181-210.2024

Oe, H., Yamaoka, Y., & Weeks, M. (2025). Public-Private Partnerships in Traditional Industries: A Comparative Governance Framework for Regional Revitalization in Japan and Central Europe. *Public Governance, Regulation and Law, 1*(1), 1–15. https://doi.org/10.61093/pgrl.1(1).1-15.2025

Olortegui-Alcalde, L. M., & Cordova-Buiza, F. (2025). Digital innovation and performance of student startups in Peru: A PLS-SEM evaluation. *Problems and Perspectives in Management, 23*(4), 407–420. https://doi.org/10.21511/ppm.23(4).2025.30

Pijarski, P., Kacejko, P., & Belowski, A. (2025). Power redispatch RES in practice: Necessity versus consequences [Redysponowanie instalacji OZE w praktyce – konieczność versus konsekwencje]. *Rynek Energii, 2025*(2), 3–10. https://www.rynek-energii.pl/pl/node/4750

Podosynnikov. S., Kochneva. V., & Kolotilina. O. (2024). The Impact of Market Entry Registration Procedures on the Development of Start-ups in the Clean and Digital Energy Sector: Findings for Public Governance. *Financial Markets, Institutions and Risks, 8*(4), 163–178. https://doi.org/10.61093/fmir.8(4).163-178.2024

Raboshuk, A., Serhiienko, R., Myroshnychenko, I., Kobylnik, D., Moroz, A., & Lyeonov, S. (2025). Public and fiscal policy instruments for supporting renewable electricity development: Evidence from a cross-country study. *Public and Municipal Finance, 14*(3), 74–92. https://doi.org/10.21511/pmf.14(3).2025.06

Renewable Energy Test Center (RETC). (2023). *PV Module Index Report 2023.* https://static1.squarespace.com/static/5f3fe5c95592812f68d3eae5/t/64c3e4c8e2e2f34caec324ee/1690559689960/RETC+PV+Module+Index+Report+2023.pdf

Rosiak, T., Pasieczny, J., & Postuła, A. (2024). Paradoxes in the operation of public administration: opportunity or barrier to the sustainable development of organisations? *Administratie si Management Public, 43,* 172–183. https://doi.org/10.24818/amp/ 2024.43-10

Saba, A., El Hadj, M., Himrane, M., & Nacer, L. (2025). Key Drivers of Successful Business Leadership: The Case of Labeled Startups. *Business Ethics and Leadership, 9*(1), 180–194. https://doi.org/10.61093/bel.9(1).180-194.2025

Sardianou, E., & Kougias, K. (2025). Empowering Future Energy Citizens: How Knowledge, Environmental Attitudes, and Student Characteristics Shape Perceptions of Renewables? *European Journal of Interdisciplinary Studies, 17*(2), 129–144. https://doi.org/10.24818/ejis.2025.18

Starchenko, L., Lyeonov, S., Vasylieva, T., Pimonenko, T., & Lyulyov, O. (2021). Environmental management and green brand for sustainable entrepreneurship. *E3S Web of Conferences, 234,* 00015. https://doi.org/10.1051/e3sconf/202123400015

Streimikiene, D., Mikalauskas, I., Lėckienė, V., Pisula, T., & Mikalauskiene, A. (2024). The role of sustainable finance in the context of the European Green Deal. *Economics and Sociology, 17*(1), 54–79. https://doi.org/10.14254/2071-789X.2024/17- 2/3

Su, C. W., Song, X. Y., Qin, M., Lobonţ, O.-R., & Umar, M. (2025). Are renewable energy stocks, investor sentiment, and the cryptocurrency market-related?. *Journal of Business Economics and Management, 26*(6), 1264–1283. https://doi.org/10.3846/jbem.2025.23893

Tarek, B. A., & Albaqami, A. S. (2024). Foreign direct investment and entrepreneurship in MENA region: Does country's absorptive capacity matter? *Montenegrin Journal of Economics, 20*(3), 215–233. https://doi.org/10.14254/1800-5845/2024.20-3.16

Triantafyllidou, A., Polychronidou, P., & Mantzaris, I. (2024). Renewable and Non-Renewable Energy Consumption and Economy: A Systematic Literature Review for Greece. *European Journal of Interdisciplinary Studies,* 155–174. https://doi.org/10.24818/ejis.2024.17

Tudor, C. (2024). Opportunities in clean energy equity markets: the compelling case for nuclear energy investments. *Journal of Business Economics and Management, 25*(5), 960–980. https://doi.org/10.3846/jbem.2024.22350

Yassin, S. A., El Gazzar, S. H., Ragheb, M. A., & Hemida, F. A. (2024). An Investigation of the Effect of Entrepreneurial Ecosystem on Startups Success through the Mediating Effect of Self Efficacy, Entrepreneurial Attitude and Entrepreneurial Intention. *SocioEconomic Challenges, 8*(2), 247–272. https://doi.org/10.61093/sec.8(2).247-272.2024

Zhuravka, F., Bielialov, T., Sylenko, M., Svynarenko, D., Sliusarenko, V., Nebaba, N., & Liumanov, A. (2025). Digital capacity, startup ecosystems, and collaborative governance as drivers of regional economic growth: Evidence from Ukrainian regions. *Problems and Perspectives in Management, 23*(4), 635–649. https://doi.org/10.21511/ppm.23(4).2025.43

APPENDIX A

Table A

Descriptive statistics

Variable	N	Mean	SD	Median	Min	Max	Skewness	Kurtosis
Energy and green start-ups (Number)	871	11.55	21.27	3.00	0.00	139.00	2.99	10.34
Energy and digital start-ups (Number)	871	5.71	10.25	2.00	0.00	78.00	3.21	12.60
Early-stage funding of energy and green start-ups (USD)	871	14,653,707	66,727,101	0.00	0.00	792,449,700	7.93	72.22
Later-stage funding of energy and green start-ups (USD)	871	14,462,804	127,302,365	0.00	0.00	3,397,459,000	22.21	572.52
Later-stage funding of energy and digital start-ups (USD)	871	10,331,276	121,284,082	0.00	0.00	3,376,590,000	24.97	680.43
Early-stage funding of energy and digital start-ups (USD)	871	10,080,101	45,068,677	0.00	0.00	795,792,600	9.75	131.43
Economic freedom (overall index)	871	7.44	0.65	7.61	4.41	8.74	-1.33	2.16
Area 1: Size of Government	871	6.12	0.93	6.12	4.15	8.68	0.11	-0.79
Area 2: Legal System & Property Rights	871	7.14	1.36	7.23	4.36	9.40	-0.32	-0.98
Area 3: Sound Money	871	8.69	1.28	9.19	1.12	9.88	-2.46	7.16
Area 4: Freedom to Trade Internationally	871	8.33	0.69	8.49	5.88	9.64	-0.85	0.57
Area 5: Regulation	871	6.90	0.73	6.98	3.95	8.71	-0.88	1.33

Source: authors' calculation in R Studio.

APPENDIX B

Table B1

TWFE estimates with Driscoll–Kraay standard errors for economic freedom subindices

Dependent variable	Subindex	Linear term	Quadratic term	Main pattern
log_green_startups	Area 1: Size of Government	0.020 (0.035)	-0.010 (0.030)	No significant effect
log_green_startups	Area 2: Legal System & Property Rights	-0.049 (0.067)	0.021 (0.021)	No significant effect
log_green_startups	Area 3: Sound Money	-0.057* (0.029)	-0.003 (0.008)	Weak negative linear effect
log_green_startups	Area 4: Freedom to trade internationally	-0.152*** (0.024)	-0.084 (0.055)	Strong negative linear effect
log_green_startups	Area 5 Regulation	-0.044 (0.059)	0.029 (0.047)	No significant effect
log_digital_startups	Area 1: Size of Government	-0.030	0.017 (0.036)	No significant effect

		(0.051)		
log_digital_startups	Area 2: Legal System & Property Rights	-0.069 (0.081)	0.053* (0.026)	Weak U-shaped tendency
log_digital_startups	Area 3: Sound Money	-0.059 (0.035)	-0.003 (0.009)	No significant effect
log_digital_startups	Area 4: Freedom to trade internationally	-0.158*** (0.028)	0.001 (0.053)	Strong negative linear effect
log_digital_startups	Area 5 Regulation	-0.031 (0.061)	0.025 (0.025)	No significant effect
log_early_green_fund	Area 1: Size of Government	-0.906** (0.351)	-0.526* (0.284)	Negative, inverted U-shape tendency
log_early_green_fund	Area 2: Legal System & Property Rights	-0.681 (0.979)	1.056*** (0.298)	U-shaped effect
log_early_green_fund	Area 3: Sound Money	-1.745*** (0.462)	-0.128** (0.062)	Inverted U-shape
log_early_green_fund	Area 4: Freedom to trade internationally	-3.988*** (0.645)	-0.320 (0.756)	Strong negative linear effect
log_early_green_fund	Area 5 Regulation	-3.060*** (0.356)	0.265 (0.393)	Strong negative linear effect
log_late_green_fund	Area 1: Size of Government	-0.757* (0.409)	0.198 (0.386)	Weak negative linear effect
log_late_green_fund	Area 2: Legal System & Property Rights	-3.425*** (1.047)	-0.270 (0.327)	Strong negative linear effect
log_late_green_fund	Area 3: Sound Money	-1.322*** (0.367)	-0.074 (0.051)	Strong negative linear effect
log_late_green_fund	Area 4: Freedom to trade internationally	-3.667*** (0.688)	-0.692 (0.452)	Strong negative linear effect
log_late_green_fund	Area 5 Regulation	-2.868*** (0.822)	0.136 (0.339)	Strong negative linear effect
log_early_digital_fund	Area 1: Size of Government	-0.627 (0.615)	-0.414 (0.264)	No significant effect
log_early_digital_fund	Area 2: Legal System & Property Rights	-1.532 (1.080)	0.540* (0.273)	Weak U-shaped tendency
log_early_digital_fund	Area 3: Sound Money	-1.635*** (0.371)	-0.099** (0.045)	Inverted U-shape
log_early_digital_fund	Area 4: Freedom to trade internationally	-3.290*** (0.779)	-0.253 (0.814)	Strong negative linear effect
log_early_digital_fund	Area 5 Regulation	-2.284*** (0.615)	0.158 (0.284)	Strong negative linear effect
log_late_digital_fund	Area 1: Size of Government	-1.383*** (0.258)	0.268 (0.297)	Strong negative linear effect
log_late_digital_fund	Area 2: Legal System & Property Rights	-3.310** (1.362)	-0.428 (0.386)	Negative linear effect
log_late_digital_fund	Area 3: Sound Money	-1.046*** (0.309)	-0.080** (0.030)	Inverted U-shape
log_late_digital_fund	Area 4: Freedom to trade internationally	-2.850*** (0.607)	-0.634 (0.418)	Strong negative linear effect
log_late_digital_fund	Area 5 Regulation	-3.039*** (0.797)	-0.245 (0.329)	Strong negative linear effect

Notes: Two-way fixed effects models include country and year fixed effects. Driscoll–Kraay standard errors are reported in parentheses. All dependent variables are log-transformed. Each subindex is mean-centred before constructing the squared term. Significance codes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.
Source: authors' calculation in R Studio.

Table B2

TWFE estimates with lagged economic freedom index and subindices (Driscoll–Kraay SE)

Dependent variable	Institutional variable	Linear term	Quadratic term	Interpretation
log_green_startups	Economic freedom	-0.121 (0.074)	-0.009 (0.059)	No significant effect
log_green_startups	Sound money	-0.053* (0.029)	-0.005 (0.008)	Weak negative effect
log_green_startups	Trade freedom	-0.113*** (0.035)	-0.059 (0.038)	Strong negative effect
log_digital_startups	Economic freedom	-0.179* (0.088)	-0.015 (0.047)	Weak negative effect
log_digital_startups	Legal system	-0.097 (0.085)	0.064** (0.027)	U-shaped pattern
log_digital_startups	Trade freedom	-0.149*** (0.044)	-0.018 (0.043)	Strong negative effect
log_early_green_fund	Economic freedom	-5.396*** (1.324)	-0.083 (0.695)	Strong negative effect
log_early_green_fund	Legal system	-1.192 (0.890)	1.204*** (0.315)	U-shaped
log_early_green_fund	Sound money	-2.021*** (0.586)	-0.146* (0.077)	Inverted U-shape
log_early_green_fund	Trade freedom	-3.749*** (0.670)	-0.124 (0.789)	Strong negative effect
log_early_green_fund	Regulation	-3.508*** (0.463)	0.728* (0.394)	Weak U-shaped tendency
log_late_green_fund	Economic freedom	-5.816*** (1.197)	-0.900** (0.355)	Inverted U-shape
log_late_green_fund	Size of government	-1.327*** (0.453)	0.062 (0.343)	Negative linear
log_late_green_fund	Legal system	-2.774** (1.053)	-0.028 (0.316)	Negative linear
log_late_green_fund	Sound money	-1.507*** (0.317)	-0.092** (0.038)	Inverted U-shape
log_late_green_fund	Trade freedom	-3.677*** (0.683)	-0.825* (0.439)	Strong negative
log_late_green_fund	Regulation	-2.980*** (0.777)	0.139 (0.250)	Negative linear
log_early_digital_fund	Economic freedom	-4.586*** (1.110)	-0.255 (0.649)	Strong negative
log_early_digital_fund	Legal system	-1.280 (1.012)	0.858*** (0.252)	U-shaped
log_early_digital_fund	Sound money	-1.565*** (0.509)	-0.083 (0.068)	Negative linear
log_early_digital_fund	Trade freedom	-3.229*** (0.731)	-0.064 (0.808)	Strong negative
log_early_digital_fund	Regulation	-2.355*** (0.703)	0.548 (0.356)	Negative linear
log_late_digital_fund	Economic freedom	-5.689*** (1.147)	-1.365*** (0.390)	Inverted U-shape
log_late_digital_fund	Size of government	-1.743*** (0.351)	0.192 (0.326)	Negative linear
log_late_digital_fund	Legal system	-2.633* (1.318)	-0.200 (0.392)	Weak negative
log_late_digital_fund	Sound money	-1.305*** (0.266)	-0.106*** (0.021)	Inverted U-shape
log_late_digital_fund	Trade freedom	-2.942*** (0.646)	-0.762 (0.526)	Strong negative
log_late_digital_fund	Regulation	-2.980*** (0.746)	-0.071 (0.256)	Negative linear

Notes: Driscoll–Kraay standard errors in parentheses. Lagged institutional variables are used (t−1). All models include country and year fixed effects. Significance codes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.
Source: authors' calculation in R Studio.

Table B3

Turning points from lagged quadratic TWFE models for the Economic Freedom Index and its subindices

Dependent variable	Institutional variable	β_1	β_2	Turning point (centred)	Turning point (original scale)	Observed range	Within range
log_green_startups	Economic freedom all areas	-0.121	-0.009	-6.947	0.491	4.41–8.74	No
log_green_startups	Area 1: Size of Government	0.001	-0.017	0.025	6.149	4.15–8.68	Yes
log_green_startups	Area 2: Legal System & Property Rights	-0.070	0.029	1.223	8.366	4.36–9.40	Yes
log_green_startups	Area 3: Sound Money	-0.053	-0.005	-5.275	3.418	1.12–9.88	Yes
log_green_startups	Area 4: Freedom to trade internationally	-0.113	-0.059	-0.958	7.368	5.88–9.64	Yes
log_green_startups	Area 5 Regulation	-0.011	0.042	0.135	7.039	3.95–8.71	Yes
log_digital_startups	Economic freedom all areas	-0.179	-0.015	-5.857	1.581	4.41–8.74	No
log_digital_startups	Area 1: Size of Government	-0.040	-0.020	-0.998	5.126	4.15–8.68	Yes
log_digital_startups	Area 2: Legal System & Property Rights	-0.097	0.064	0.760	7.903	4.36–9.40	Yes
log_digital_startups	Area 3: Sound Money	-0.047	-0.002	-10.196	-1.503	1.12–9.88	No
log_digital_startups	Area 4: Freedom to trade internationally	-0.149	-0.018	-4.149	4.176	5.88–9.64	No
log_digital_startups	Area 5 Regulation	-0.031	0.013	1.168	8.071	3.95–8.71	Yes
log_early_green_fund	Economic freedom all areas	-5.396	-0.083	-32.584	-25.146	4.41–8.74	No
log_early_green_fund	Area 1: Size of Government	-0.446	-0.793	-0.282	5.843	4.15–8.68	Yes
log_early_green_fund	Area 2: Legal System & Property Rights	-1.192	1.204	0.495	7.639	4.36–9.40	Yes
log_early_green_fund	Area 3: Sound Money	-2.021	-0.146	-6.944	1.748	1.12–9.88	Yes
log_early_green_fund	Area 4: Freedom to trade internationally	-3.749	-0.124	-15.141	-6.816	5.88–9.64	No
log_early_green_fund	Area 5 Regulation	-3.508	0.728	2.408	9.312	3.95–8.71	No
log_late_green_fund	Economic freedom all areas	-5.816	-0.900	-3.230	4.208	4.41–8.74	No
log_late_green_fund	Area 1: Size of Government	-1.327	0.062	10.686	16.810	4.15–8.68	No
log_late_green_fund	Area 2: Legal System & Property Rights	-2.774	-0.028	-49.664	-42.521	4.36–9.40	No
log_late_green_fund	Area 3: Sound Money	-1.507	-0.092	-8.148	0.545	1.12–9.88	No
log_late_green_fund	Area 4: Freedom to trade internationally	-3.677	-0.825	-2.227	6.098	5.88–9.64	Yes
log_late_green_fund	Area 5 Regulation	-2.980	0.139	10.707	17.611	3.95–8.71	No
log_early_digital_fund	Economic freedom all areas	-4.586	-0.255	-8.981	-1.543	4.41–8.74	No
log_early_digital_fund	Area 1: Size of	-0.073	-0.465	-0.078	6.046	4.15–8.68	Yes

	Government						
log_early_digital_fund	Area 2: Legal System & Property Rights	-1.280	0.858	0.746	7.889	4.36–9.40	Yes
log_early_digital_fund	Area 3: Sound Money	-1.565	-0.083	-9.444	-0.752	1.12–9.88	No
log_early_digital_fund	Area 4: Freedom to trade internationally	-3.229	-0.064	-25.048	-16.723	5.88–9.64	No
log_early_digital_fund	Area 5: Regulation	-2.355	0.548	2.149	9.053	3.95–8.71	No
log_late_digital_fund	Economic freedom all areas	-5.689	-1.365	-2.084	5.354	4.41–8.74	Yes
log_late_digital_fund	Area 1: Size of Government	-1.743	0.192	4.532	10.657	4.15–8.68	No
log_late_digital_fund	Area 2: Legal System & Property Rights	-2.633	-0.200	-6.567	0.576	4.36–9.40	No
log_late_digital_fund	Area 3: Sound Money	-1.305	-0.106	-6.171	2.521	1.12–9.88	Yes
log_late_digital_fund	Area 4: Freedom to trade internationally	-2.942	-0.762	-1.930	6.395	5.88–9.64	Yes
log_late_digital_fund	Area 5: Regulation	-2.980	-0.071	-21.063	-14.160	3.95–8.71	No

Notes: Turning points are calculated as $-\beta_1/(2\beta_2)$. "Within range" indicates whether the turning point lies within the observed empirical range of the respective institutional variable. Only those cases should be interpreted as economically meaningful non-linear effects. U-shape is implied by $\beta_1 < 0$and $\beta_2 > 0$, while an inverted U-shape is implied by $\beta_1 > 0, \beta_2 < 0$or, more generally, in practical interpretation here, by a negative quadratic coefficient with a turning point inside the data range.

Source: authors' calculation in R Studio.