Financial Innovation

RESEARCH Open Access

Investigating sustainable entrepreneurship: unforeseen effect of financial action task force (FATF) beneficial ownership policy through quasi-natural experiments

Shama Urooj[1,3], Guang Luo[1], Atta Ullah[2*] and Jun Cai[1*]

*Correspondence:
attaullah142@gmail.com;
juncai@hust.edu.cn

[1] School of Management, Huazhong University of Science and Technology (HUST), Wuhan 430074, China
[2] Digital Economy Research Center, School of Economics and Management, Wenhua College, Wuhan, 43007, China
[3] Department of Management Sciences, Lahore Garrison University, Lahore, Pakistan

Abstract

Ensuring transparency in business operations has become critical for promoting sustainable entrepreneurship (SE). Previous studies highlight the importance of regulatory measures; however, their direct impact remains unknown. This study employs a quasi-natural experiment using the difference-in-differences (DID) method to analyze the levels of sustainable entrepreneurship in response to the financial action task force (FATF) beneficial ownership (BO) recommendation of 2014, using panel data from the global entrepreneurship monitoring and World Bank Development Indicator from 2011 to 2022. The current study is the first to investigate how global regulatory measures aimed at enhancing beneficial ownership transparency influence SE. By utilizing a standardized index for sustainable entrepreneurship, our analysis reveals a significant increase in the level of sustainable entrepreneurship among countries that implemented the 2014 FATF BO recommendation. To address potential endogeneity and selection bias issues, kernel propensity score matching (KPSM-DID) and two-stage least squares regression are used. The KPSM-DID helps match the treatment and control groups on the basis of their features, ensuring a fair comparison. These techniques increase the validity of our findings by ensuring that the estimates are precise and unbiased. Our findings suggest that the FATF recommendation is a positive shock for countries that adopt beneficial ownership transparency. Enhanced transparency can foster a trusting atmosphere for investors and entrepreneurs that promotes collaboration, moral conduct, and long-term investments in sustainable entrepreneurship by reassuring investors about their alignment with sustainability goals.

Keywords: Sustainable entrepreneurship, Financial action task force (FATF), Beneficial ownership, Difference-in-differences

JEL Classification: Q01, L26, G28, C23

Introduction

Businesses, governments, and international communities are being forced to reconsider conventional business models due to social and environmental issues, such as income inequality, climate change, and environmental degradation (Wirba 2023). The UN

General Assembly has emphasized the importance of entrepreneurship in tackling these issues, highlighting its contributions to economic expansion, the reduction of unemployment, and the enhancement of living standards (Mugione and Farinelli 2017). In emerging economies, entrepreneurship accounts for 50% of global employment and 40% of national income (Cavoli et al. 2024). As the field of entrepreneurship has grown over the last two decades, interest has shifted from solely focusing on individual entrepreneurs to addressing a broader global concern.

Historically, researchers have emphasized the need for entrepreneurs to manage the triple bottom line: people, planet, and profit to thrive (Schaltegger and Wagner 2011; Terán-Yépez et al. 2020). However, Harvard University's extended view of entrepreneurship highlights the importance of being dynamic, innovative, and eco-friendly, extending beyond new ventures and startups (Eisenmann 2013). Sustainable enterprises frequently adopt new technologies and adapt to evolving market conditions, an aspect that has been previously overlooked (Rosário et al. 2022). Entrepreneurship thrives in a large ecosystem and is not an isolated endeavor. Ecosystems that support sustainable entrepreneurship (SE) can be shaped and fostered over time through entrepreneurial activities. Building the capacity to innovate, adapt, and continuously replenish resources is essential for SE growth (Gu and Wang 2022).

The 2030 agenda for sustainable development, encompassing 17 UN global goals (SDGs), promotes sustainable entrepreneurship by focusing on environmental protection, reducing inequality, and fostering innovation (Jha et al. 2022). Achieving these goals requires an ecosystem in which enterprises can function ethically, transparently, and following global standards. A key element in creating this ecosystem is the role of good governance and trust in the financial system, which are critical components. Scholars (Watson et al. 2023) and practitioners (UNCTAD 2017) have urged a deeper comprehension of the importance of policies and regulations in sustainable entrepreneurship. The FATF's beneficial ownership recommendation is crucial in ensuring that all types of corporate entities, including companies, trusts, foundations, partnerships, legal professions, and sole businesses, engage in commercial and entrepreneurial activities uphold transparency regarding their legal and beneficial ownership (FATF 2014). By mandating the disclosure of legal and beneficial ownership, these regulations foster accountability and trust, which are essential for the growth of sustainable entrepreneurship. Thus, the FATF has a substantial effect on enrolled countries and their financial systems because it introduces significant changes to the regulatory framework, compliance requirements, market dynamics, and international relations. The FATF itself claimed in its reports the unanticipated consequences of its standards for the financial system (FATF 2021).

The primary purpose of this study is to investigate four key aspects: (1) sustainable entrepreneurship as a multidimensional factor; (2) the impact of FATF policy regarding beneficial ownership as a shock for countries; (3) other control factors, such as digital financial capability (DFC), trade openness, financial soundness, market dynamics, and government support, that may influence SE; and (4) an assessment of the pre- and post-FATF policy effects on SE within both the treatment group and the control group.

This study assesses the influence of the FATF beneficial ownership policy on sustainable entrepreneurship by conducting an empirical analysis on panel data from 100 countries covering the period from 2011 to 2022. The 2011–2022 timeframe was selected

to analyze the long-term effects of the 2014 FATF BO policy by capturing sustainable entrepreneurship trends both before and after. Additionally, this timeframe corresponds to stable data availability in all 100 nations. This study contributes to literature in the following ways. First, it uniquely integrates transparency regulations with international regulatory pressure to influence sustainable entrepreneurship. This study is the first to assess whether the beneficial FATF ownership policy has unanticipated consequences for the business sector, especially sustainable entrepreneurship. Unlike prior research that focused solely on the determinants of entrepreneurship and linked sustainability with entrepreneurship, which focused on economic, social, and governance (ESG) parameters without acknowledging international regulatory influences (Cohen et al. 2008; Hall et al. 2010; Shahid et al. 2023), this study fills the crucial gap in the literature by shedding light on the nuanced consequences of international regulatory governance frameworks on entrepreneurial endeavors, particularly those geared toward the long term.

Second, quasi natural experiments provide empirical causal evidence on the real-world implications of the FATF BO recommendation. This study aims to examine sustainable entrepreneurship in countries that have implemented FATF BO regulations. By evaluating the effectiveness of these policies, this study seeks to contribute to our understanding of the relationship between regulatory frameworks and entrepreneurial activities, particularly in the context of promoting transparency and accountability in business practices. The current study will assess the implementation process and its results to identify any challenges or weaknesses that can prevent the full realization of the desired advantages of beneficial ownership regulations. This study provides empirical evidence on the impact of international regulatory measures on sustainable entrepreneurship via rigorous analyses, such as quasi natural experiments, including advanced econometric techniques, that is, difference in differences and propensity score matching.

Furthermore, to address potential sample selectivity bias, this study employs a propensity score matching (PSM) approach to pair treated countries with untreated countries. The findings of the study hold true after a series of robustness tests, including parallel trend assumption and dynamic effects, are performed. This approach addresses the pressing global policy concern, aiming to quantify policy interventions related to sustainable entrepreneurial practices.

The literature review is the focus of the following section of the study. The econometric model, data, and study design are included in the third section. The next section covers the findings and analysis. The final section focuses on the conclusion, suggested policies, and future directions.

Literature survey and research gap

The concept of sustainable entrepreneurship

In the past, entrepreneurship focused primarily on generating wealth and economic development (Ziemnowicz 1942). Environmental and social concerns were mainly ignored. According to Nave and Franco (2019) and Muñoz and Cohen (2018), entrepreneurship has evolved from focusing primarily on wealth generation to sustainable entrepreneurship because sustainable development has become a global priority. Therefore, entrepreneurship must be founded on social and environmental efforts and economic

goals that effectively and efficiently address the requirements and wants of today's economy. According to Fong et al. (2022), a growing number of businesses and entrepreneurs are curious about the effects of their ventures on the environment and society as a whole. Value creation in terms of financial results is no longer the primary focus of entrepreneurship; it has evolved over time to include noneconomic rewards. Sustainable entrepreneurship necessitates a secure business environment comprising stable regulatory frameworks, resource accessibility, supportive infrastructure, and an innovation ethos that integrates societal and environmental considerations (Weidinger 2013).

Sustainable development and entrepreneurship are connected through sustainable entrepreneurship (SE) (Jha and Pande 2024). The foundation work of Cohen et al. (2008) created a thorough understanding of the impact of entrepreneurship. They laid the groundwork for sustainable entrepreneurship by developing an entrepreneurship typology that considers triple bottom-line factors (economic, social, and environmental). However, the relevance of the findings is limited by their concentration on studies published in a single journal, the Journal of Business Venture, between 1998 and 2003. This timeframe overlooks recent developments in digitalization and innovation that are essential for understanding sustainable entrepreneurship today. Building on this, Schaltegger and Wagner (2011) offered a typology that incorporates social innovation and institutional entrepreneurship but ignores environmental aspects. Other studies, such as Mansouri and Momtaz (2022) and Hummels and Argyrou (2021), emphasize sustainability advancements at the micro level but tend to ignore broader macroeconomic elements such as economic development that may have an impact on the wider effects of entrepreneurship on social and economic sustainability. Moreover, researchers have explored the linkage between the SDGs and SE, but there is a significant lack of empirical findings in this domain (Shahid et al. 2023).

The research compiled in Table 1 links sustainability with entrepreneurship, emphasizing the growing significance of this connection and elaborating on the definition of sustainable entrepreneurship. Nonetheless, several limitations may be found, each of which uniquely affects the outcomes. However, there is no widely recognized metric for measuring sustainable entrepreneurship that considers its time-varying characteristics (Gu and Zheng 2021; Huang et al. 2023; Moya-Clemente et al. 2021). This work advances the body of knowledge by offering a new comprehensive index to gauge sustainable entrepreneurship, founded on the sustainable development concept of the triple bottom line with time-varying characteristics such as innovation, intentions, investments, infrastructure, and established businesses related to sustainable entrepreneurship.

Literature matrix

Graphical depiction of the sustainable entrepreneurship level across the world

Despite its relative novelty, sustainable entrepreneurship has evolved rapidly over the past two decades. Figure 1 illustrates a graphical depiction of sustainable entrepreneurship from the last decade, showing a rising trend worldwide. We created this graph on the basis of the values of the sustainable entrepreneurship index derived from principal component analysis (PCA). Interestingly, the graph reveals two distinct trends: from 2011 to 2015, there was a downward trend, followed by a steep slope, indicating a rising trend from 2015 to 2022. In 2012, 2014, and 2016, the UN General Assembly established

Table 1 Contribution to sustainable entrepreneurship development

Authors	Objective	Contributions	Limitations
Cohen et al. (2008)	Present a comprehensive picture of the effects of entrepreneurship by expanding entrepreneurship research to include economic, environmental, and social value	A typology of value creation for entrepreneurship that considers economic, social, and environmental aspects was developed with TBL in mind	The highly specific results limit the generalizability of the findings. The study focused on articles from 1998 to 2003 from specific journal, excludes insights on digitalization, and further limits the generalizability of the results
Schaltegger and Wagner (2011)	Provide a framework that clarifies the relationship between sustainability innovation and sustainable entrepreneurship	A typology of SE by incorporating social and institutional entrepreneurship	The main limitation lies in the exclusive focus on social and institutional entrepreneurship and the overlooking of environmental aspects and empirical findings
Hummels and Argyrou (2021)	Analyze sustainable entrepreneurship at a micro level	A framework of SE focuses on businesses making progress toward environmental responsibility, customers making modest changes to their purchasing habits, and governments having, to some extent, enforced legislative requirements	Ignoring the macro prospects of SE is more problematic. Ignoring macro factors like economic development missing SE impacts on economic and social sustainability
Mansouri and Momtaz (2022)	Focus on economic, society, and governance (ESG) properties for SE	A framework of startups' ESG properties	Empirical findings do not support the conceptual framework due to the use of a machine learning approach to use ESG ratings. It presents possible discrepancies that might cause the framework and the outcomes misaligned
Gu and Wang (2022)	The index creation of sustainable entrepreneurship is based on TBL and the characteristics of entrepreneurship, including innovation and investment	Considers social, economic, and environmental perspectives and innovation and investment	Based on a single country, empirical support is insufficient
Shahid et al. (2023)	Linkage between SDGs goals and Sustainable development and no. of startups	The study considers several SDGs and links them with sustainable development	No empirical findings are available
Jha and Pande (2024)	Develop Sustainable entrepreneurship by integrating three new sustainability dimensions	Social metabolism, sustainability orientation, and enabling cadence to form sustainable entrepreneurship	This study is based on firm-level factors and ignores country-level factors

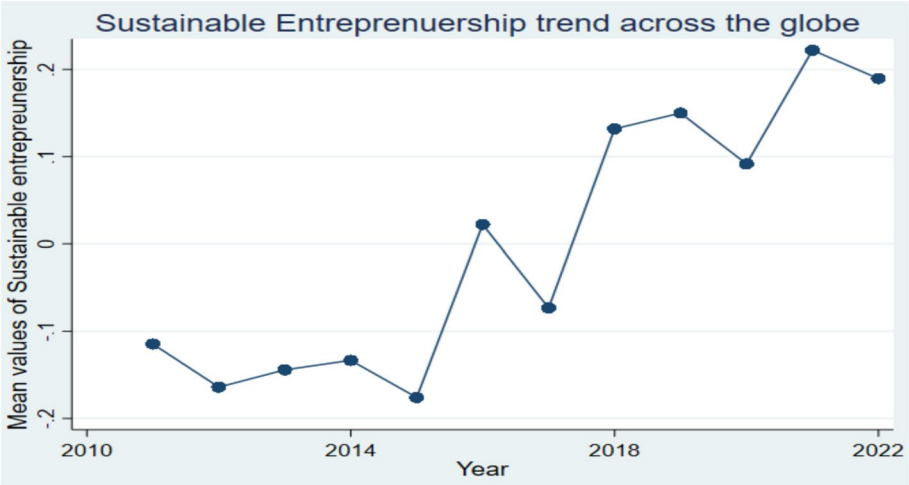


Fig. 1 Sustainable entrepreneurship levels across the world

the necessity of pursuing entrepreneurship with vigor at its sixty-seventh, sixty-ninth, and seventy-first sessions (Mugione and Farinelli 2017). The adoption of Sustainable Development Goals in 2015 has increased the demand for a change in the way startups conduct business around the world. Since 2015, the level of sustainable entrepreneurship has rapidly increased.

Policy-oriented literature

FATF policies regarding beneficial ownership and entrepreneurship

Legal regulations have traditionally been viewed as limiting factors. For certain actions such as entrepreneurship, these frames can be seen as restrictive. This notion is even more pertinent because entrepreneurs are frequently affected by these laws and policies. There are contradictory findings about the relationship between laws and entrepreneurship; some studies have shown that legal rules can stifle innovation, whereas other researchers have found that some regulatory policies can promote the growth of entrepreneurship (Serafimovska and Sotiroski 2014; Verbivska et al. 2022).

The Financial Action Task Force (FATF) is an intergovernmental organization that has developed globally recognized guidelines for governments to follow in combating financial crimes. The FATF has helped countries identify domestic vulnerabilities to financial crimes, despite the slow adoption of financial compliance laws (Shaffer 2024). Importantly, the FATF promotes beneficial ownership transparency by urging corporate entities engaged in commercial and entrepreneurial activities to confirm the identities of clients and their financial transactions through the "Customer Due Diligence" (CDD) procedure and to ensure that reporting obligations are fulfilled (Gilmour 2020). The European Union has also imposed a law on its member states to maintain digital registers of beneficial owners as one of the steps being taken to improve beneficial ownership transparency (Martinez 2021). Even in the U.S., millions of startups and small businesses are required to submit a report regarding beneficial ownership information to the financial crime enforcement network. Several researchers have studied FATF regulations aimed at controlling money laundering and terrorism financing crimes, which

affect economic growth (Ofoeda 2022; Pradhan et al. 2018; Urooj 2024). However, the costs and influence of financial crimes extend beyond financial and economic growth. Sustainable entrepreneurship encompasses economic, social, and environmental sustainability, making it broader than economic growth.

Countries should ensure that sufficient, timely, and accurate information on legal entities' beneficial ownership and control is available to competent authorities to access or receive (Fernando and Berkhout 2022). On the basis of the FATF assessment rating, it is evident that not every country has implemented Recommendation 24, introduced in 2014, concerning the beneficial ownership of legal persons (FATF 2024). In Fig. 2, the level of compliance indicates that most countries' shortcomings are minor and moderate and are labeled largely compliant (LC) and partially compliant (PC), respectively. In comparison, countries with major shortcomings are labeled noncompliant 'NCs.' Importantly, the significant drawback is that very few countries have implemented these recommendations with full compliance 'C.'

The formal G-20 conversation with the business sector, known as B-20, took place in October 2020. The guidelines of the G-20 align with a global movement toward more beneficial ownership disclosure. The revised beneficial ownership recommendation introduced by the FATF in 2021, which includes the development of public registers, aims to create more transparency around beneficial ownership (International 2021).

Transparent ownership structures foster greater accountability within companies, aligning with the principles of sustainable entrepreneurship, which emphasize ethical business practices and social responsibility. Transparent beneficial ownership practices support broader efforts toward achieving development goals by fostering economic stability, reducing financial crime, and promoting inclusive and responsible business practices. FATF's efforts to reduce financial crime play a crucial role in fostering sustainability and economic growth by promoting transparency, integrity, and trust in the financial system (Gueddari et al. 2024).

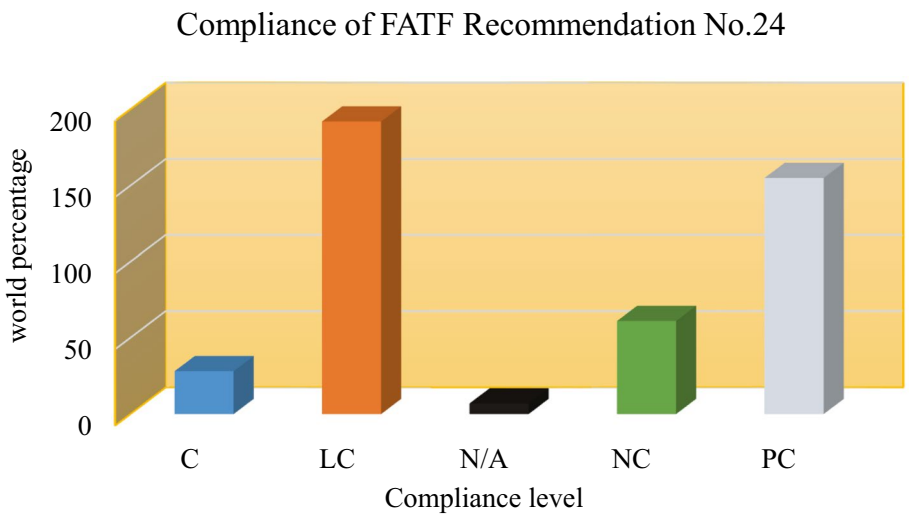


Fig. 2 FATF: Technical Compliance Recommendation 24. *Source*: TI based on FATF Mutual Evaluation Reviews, July 2021. *Note*: LC, largely compliant; PC, partially compliant; NC, noncompliant; C, compliant; NA, nonapplicable

H1

The FATF beneficial ownership recommendation 2014 positively influences sustainable entrepreneurship by increasing transparency and reducing illicit financial activity.

Other factors affecting sustainable entrepreneurship

In the past, the governments of the majority of nations, particularly developing nations, dedicated a significant amount of time and financial resources to creating policies meant to encourage entrepreneurship (Akçomak 2009). A comparative study of the impacts of government support and policies on the U.S. and Africa concluded that both nations have entrepreneurial intentions, but the development of entrepreneurship is much lower in Africa because of insufficient infrastructure and a lack of policies regarding business licensing and information (Ajayi-Nifise et al. 2024). A recent study by Faria et al. (2023) on government investments and entrepreneurship revealed that development in entrepreneurship and the SME sector does not require government support and investments. Development requires location and highly skilled workers as human capital for entrepreneurial ventures.

As more people work independently under temporary contracts in the gig economy, there is a growing need for them to handle their money more responsibly throughout their careers. At the same time, digital technology is expanding rapidly in financial services. To prevent fraud and guarantee access to financial services, users need to become more tech-savvy. Consequently, it is essential to comprehend the new requirements for financial capacity in the digital age and acknowledge the increasing significance of digital financial capability (DFC) (Urooj et al. 2025).

Several researchers have previously reviewed trade openness and entrepreneurship relationships, and their findings have shown that trade openness gives budding entrepreneurs more chances by providing them with access to a greater range of products and input markets (Abdeljaber et al. 2021; Asongu and Nwachukwu 2018; Audretsch et al. 2012; Rahman et al. 2023). Dilanchiev and Sekreter (2015) conducted research in Georgia and reported that the government of Georgia has been promoting trade openness as a means of conducting business. However, the relationship between trade openness and entrepreneurship development remains complex. For example, Audretsch et al. (2012) find that trade openness between nations increases competition, which lowers incentives and raises hurdles to entry for potential entrepreneurs. It is thus necessary to note that trade openness requires the fulfillment of international trade standards, which may not normally prioritize sustainability goals.

Market dynamics create many opportunities for entrepreneurship (Kreiterling 2023). In advanced countries, market dynamics and consumer preferences are continuously changing, creating opportunities for entrepreneurs to innovate. Wu et al. (2021) concluded that entrepreneurs need to develop sustainable products, processes, and business models to meet changing market trends.

Building on the literature review, we draw attention to crucial gaps in this area and the noteworthy contributions of our work to address these gaps. First, this study is one of the pioneering works to draw attention to sustainable entrepreneurship's dynamic

capabilities in line with Harvard University's guidelines. Second, this study is the first to use FATF beneficial ownership as a shock for countries to check sustainable entrepreneurship levels. Third, our study conducts a comparative analysis between the control and treatment groups, leveraging digitalization to gauge their respective impacts on the sustainability of entrepreneurial ventures.

Methodological approach

This study examines the FATF policy shock of the beneficial ownership recommendation and its effect on sustainable entrepreneurship while considering digital financial capabilities, trade openness, financial soundness, market dynamics, and government support concerning pre- and post-FATF policy period. This sample study focuses on 100 countries in the treatment and control groups.

Data sources and measurement

The dataset used in this study was obtained from the Global Entrepreneurship Monitoring (GEM) database. According to the study by Burchi et al. (2021), the GEM is the most accurate proxy for measuring sustainable entrepreneurship. In place of missing data, we employed the variables' overall historical trends when available in the GEM database. The best available sample-based data from one hundred countries span from 2011 to 2022. This year (2011), the World Bank launched its financial inclusion database, with data collected starting in 2011. By examining this timeframe, we can examine the effects on sustainable entrepreneurship both before and after implementation, guaranteeing a thorough grasp of the long-term effects. The sample is divided into two groups: countries that have implemented FATF beneficial ownership recommendations and twenty-four countries with minor and moderate shortcomings, which are considered the treatment group. In contrast, countries with significant shortcomings and not applying the FATF recommendation are considered the control group according to the FATF Mutual Assessment Report (FATF 2024). Details of the sample countries are shown in Appendix A. The triple-bottom-line (TBL) sustainability approach is used to measure the dependent variable, sustainable entrepreneurship. It includes CO_2 emissions as an environmental factor, education and reduced equality as social metrics, and GDP per capita as an economic metric (Dhahri and Omri 2018; Sadiq et al. 2022). Harvard University asserts that entrepreneurship is best suited to the dynamic capacity of ventures and is not limited to early start-ups or new businesses. These qualities include innovation, investment, the entrepreneurial mindset, the number of entrepreneurial activities, established firms, and infrastructure. This study examines the best indicators of sustainable entrepreneurship, including dynamic capabilities measurement and triple-bottom-line indicators. The Winsor2 test was applied to normalize the data before running the model. We assigned the normalization process (1, 99) Winsor cut following the World Bank criteria. The measurement of the variables used in the study is shown in Appendix B. The applicability of FATF regulations is illustrated in Fig. 3.

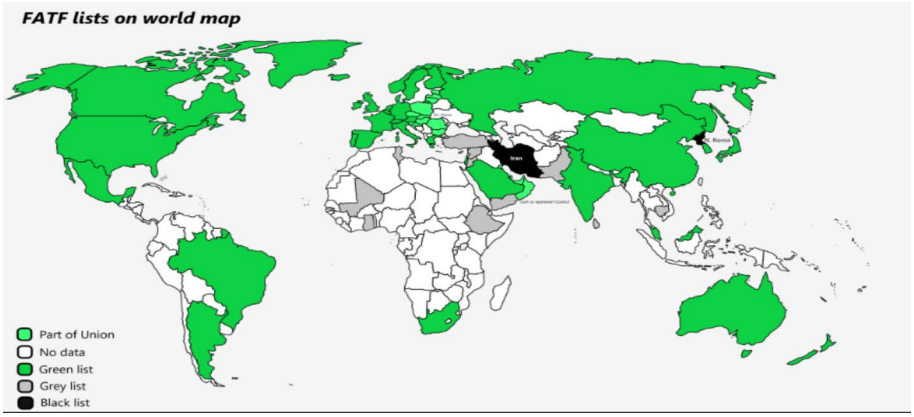


Fig. 3 FATF around the world Source: FATF website

Index construction and principal component analysis evaluation outcomes

Index construction process

As a continuation of conventional entrepreneurship, the idea of sustainable entrepreneurship is based on the triple bottom-line principle, which considers social, ecological, and economic growth. To prepare for a thorough examination of the impact of the FATF policy on sustainable entrepreneurship, this research attempts to quantify it. Three sets of variables—X_{it}, Y_{it}, and Z_{it}—represent observable factors linked to social, ecological, and economic development, respectively, and are assumed in this study. A_{it} is the main time-varying factor in entrepreneurship, whereas $Entr_{it}$ is the unobservable variable associated with sustainable entrepreneurship. It considers metrics such as investment, intentions, expectations, female entrepreneurial activities, infrastructure, and innovation, which are considered the soul of entrepreneurship.

Where $Entr_{it} = \sum w_t * A_{it}$ is the formula used to calculate the sustainability entrepreneurship index, where wt. represents the weights allocated to the individual indicators and where A_{it} is the main time-varying factor in entrepreneurship.

We create the sustainable entrepreneurship index following Gu and Wang (2022) by assigning factors that affect entrepreneurship weights. For any variable, this may be represented as $\Theta_{kt} = \frac{\beta_{kj}t}{\sum_{j=1}3\beta_{kj}t}$ We then compute wt. as the sum of $\alpha_k\theta_{kt}$. One can estimate the viability of sustainable entrepreneurship $Entr_{it}$, where α_k is a set of weights that measure social, ecological, and economic values. These weights were established via factor analysis. In summary, $Entr_{it} = \sum w_t A_{it} = \sum_k \sum_t \alpha_k \theta_{kt} A_{it}$ is the theoretical model built for the sustainable entrepreneurship index.

The social, economic, and environmental variables that create sustainable entrepreneurship along with time-varying factors include innovation, decision mindset, expectations and infrastructure, startups, female startups, and intentions.

The following is the weight formula for each element obtained from the factor analysis performed on the time-varying indicators and other sets classified as economic, ecological, and social factors:

Table 2 KMO and Bartlett tests

Bartlett test of sphericity	***p* value = 0.000**
	H_0: variables are not intercorrelated
Kaiser–Meyer–Olkin Measure of Sampling Adequacy	KMO *p* value = 0.589

Table 3 PCA results of the sustainable entrepreneurship (SE) Index

Component	Eigenvalue	Difference	Proportion	Cumulative
Innovation	2.294	0.919	0.191	0.191
Female Entrepreneurial Activities	1.375	0.157	0.115	0.306
Expectations	1.218	0.108	0.102	0.407
Entrepreneurial Business	1.110	0.034	0.092	0.500
Entrepreneurial Activities	1.076	0.129	0.090	0.590
Entrepreneurial Intentions	0.947	0.059	0.079	0.668
Reduced Inequality	0.888	0.070	0.074	0.742
Education	0.817	0.091	0.068	0.810
Physical Infrastructure	0.727	0.050	0.060	0.871
Economic Conditions	0.677	0.056	0.056	0.927
Environment	0.621	0.371	0.052	0.979
Decision Spirit	0.250		0.021	1.000

$$\alpha_k = \frac{F_k \; Variance \; contribution}{\sum_{i=1}^{3} F_k \; Variance \; contribution \; rate} \tag{1}$$

To verify whether the indicators used to develop the sustainable entrepreneurship index are interrelated, we employ the KMO and Bartlett tests. The test results are listed in Table 2. The p- value of Bartlett's test is less than 0.05, which implies rejecting the null hypothesis H_0 and not rejecting the alternate hypothesis H_1, indicating that the variables are indeed intercorrelated. Therefore, we justified the use of PCA.

The principal component approach yielded factor loading and contribution findings. Table 3 displays the sustainable entrepreneurship PCA. The results show that a substantial portion of innovation, which is the sole spirit of entrepreneurship, contributes to sustainable entrepreneurship ventures. The first PCA explained the majority of the variation in SE, as shown in Table 3. Female entrepreneurial activities are also important for sustainable entrepreneurship and cannot be ignored. This finding is important, as previous studies ignored the dynamic or time-varying characteristics and computed the SEI on the basis of the triple bottom line only.

Empirical strategy and econometric technique

Difference-in-differences (DID) method

The FATF recommendations regarding beneficial ownership, in their original version from 2014 using digital public registers, are regarded as crucial advancements for the world. They serve as natural policy experiments on which we can apply the difference-in-differences (DID) method to assess any improvements in sustainable

entrepreneurship (SE) levels. Comparing the changes in outcomes over time between a treatment group (countries that adopted the recommendations) and a control group (countries that did not implement the recommendations or had substantial inadequacies) makes this technique especially appropriate. This method helps to account for unidentified factors that might influence the development of sustainable entrepreneurship by comparing data collected before and after the recommendations were put into practice.

The original recommendations specifically target corporate entities, such as companies, trusts, foundations, partnerships, legal professions, and sole registered businesses, which are engaged in commercial and entrepreneurial activities, uphold transparency regarding their legal and beneficial ownership, including the development of digital public registers and adequate substitutes to enable authorities to determine the ultimate owner or controller of a company (FATF 2014). These measures aim to secure a business environment, thereby preventing financial crimes. Out of eighty-one jurisdictions globally, legislation mandating the registration of beneficial ownership with a governmental body has been enacted. Surprisingly, only 11 of these jurisdictions belong to the G20 group. Even the USA and China exhibit significant shortcomings, labeled noncomplaint 'NC' in their level of compliance with Recommendation 24. These regulations, aligned with the FATF recommendations, are some of the most widespread international standards concerning beneficial ownership transparency (Sam Eastwood 2021).

Given the circumstances described, it is deduced that recommendation twenty-four is affected by those groups who can afford it. To perform pre-post intervention analysis, we essentially have two groups: those treated by the policy intervention (i.e., policy-implemented groups) and those not treated (policy-excluded groups), who serve as a control. A difference-in-differences method was used to achieve the principal goal. If country 'i' has implemented FATF policy recommendation 24 with minor and moderate shortcomings, then treated = 1; otherwise, treated = 0. If time period t >= 2014, then post = 1; otherwise, post = 0. Therefore, according to the principle of the DID technique, we use the interaction term $treated_i x post_t$ to identify the impact of the FATF beneficial ownership policy on sustainable entrepreneurship.

Moreover, to fulfill the primary objective of this study, the sustainable entrepreneurship index includes triple bottom line economic, environment, and society characteristics and time-varying characteristics, such as innovation, number of start-ups, established businesses, infrastructure, decision-making spirit, and entrepreneurial intentions. The DID technique offers a method that mitigates various potential biases. DID helps minimize biases that remain constant over time. DID analyzes outcome variations to address time-varying issues that comparably impact both groups. Furthermore, since difference-in-differences (DID) analysis assumes that both groups would have experienced similar trends in outcomes if the intervention had not occurred, researchers are likely to attribute any observed differences after the intervention to the intervention itself rather than to preexisting trends. This is known as the parallel trend assumption. To ensure this assumption, several control variables are used, such as digital financial capability, trade openness, financial soundness, market dynamics, and government support and policies, adequately informed by the body

of research, both theoretical and empirical, to serve as baseline determinants of SE. The DID technique provides a robust framework for estimating causal interference by addressing potential sources of bias commonly encountered in observational studies.

The DID model used to check the FATF policy effect on sustainable entrepreneurship is as follows:

$$\tau^{DID} = E(Y^T - Y^C \mid T = 1) - E(Y^T - Y^C \mid T = 0) \tag{2}$$

where $T = 1$ refers to the time when countries implemented the FATF policy in 2014 and where $T = 0$ refers to the time when none of the countries implemented the policy and exhibited significant deficiencies. Y^T denotes treatment countries, and Y^C denotes control countries. To address the concerns of parallel trend assumptions, we use different control variables, integrating this limitation with Eq. 2.

$$Y_{it} = \alpha + \beta Treat_i + \gamma post_t + \delta(Treat_i * post_t) + \eta X_{it} + \varepsilon_{it} \tag{3}$$

where y is a dependent variable, sustainable entrepreneurship. $Treat_i$ is the treated group of countries that have implemented a policy with full compliance or minor and moderate shortcomings; $post_t$ is the dummy time period (1 for postpolicy, i.e., from 2014 onward, and 0 for prepolicy, i.e., before 2014); X are the control variables. γ represents the shared time trend between the two distinct groups.δ is the estimated effect of the treatment variable, and η shows the influence of the control variables.

Robustness kernel propensity score matching (KPSM-DID) and 2SLS regression

While the difference-in-differences method offers a reliable approach to analyzing policy impact, it does not address selection bias and pretreatment difference issues. To address these concerns, we employ the kernel propensity score matching technique. We confirmed any parallel trend by using KPSM to match the treatment and control groups on an array of measurable and observable features. Propensity score matching (PSM) is a natural way to match people between the treatment and control groups. Finding a control group of respondents comparable to the treatment group in all pertinent initial attributes aims to enable observational studies to imitate the experimental research design (Rosenbaum and Rubin 2023). By pairing the member states of the FATF with nonmembers who are as similar as possible in terms of pertinent baseline attributes, the unobserved counterfactual result is imputed. By assigning a positive weight to every observation in the neighborhood and only utilizing control data within a predetermined hood, kernel matching creates a counterfactual. The KPSM calculates the average impact of the intervention (FATF beneficial ownership 2014) and is expressed as

$$ATT = E(\Delta|X, T = 1) = E\Big(Y^1 - Y^0|X, T = 1\Big) = E\Big(Y^1|X, T = 1\Big) - E(Y^0|X, T = 1) \tag{4}$$

where X is the same set of pretreatment control variables and ATT is the average impact of the intervention on the treated. The counterfactual outcome, denoted by the formula $E(Y^0|X, T = 1)$, is not observed. However, KPSM statistically generates this counterfactual outcome for the treated group by producing the likelihood of using the intervention form (FATF Policy, 2014). The member countries and nonmembers with comparable

propensity ratings are then matched by creating a statistical comparison group on the basis of the likelihood of being an implemented policy country, T, conditional on the observed characteristics, X, as indicated by the propensity score: $P(X) = P_r(T = 1/X)$ (Sakyi-Nyarko et al. 2022).

Unlike traditional regression techniques, the KPSM generates low-bias and reliable estimates. If the treatment and control groups were derived from the same data source, they were subjected to similar economic conditions. Additionally, certain variables can help explain variations in the outcome variable and identify self-selection in the program or use of the intervention.

To address the endogeneity problem, this study employs two-stage least squares (2SLS) to examine the robustness of the results. An extension of ordinary least squares (OLS) regression, two-stage least squares regression, uses an instrumental variable to solve endogeneity concerns and, under specific circumstances, produces causal estimates. The general form of 2SLS-IV regression is.

The equation for the first stage is

$$X_1 = \pi_0 + \pi_1 Z + \varepsilon \tag{5}$$

where X is the endogenous variable, Z is the instrumental variable, π_0, π_1 represents the estimated parameters and ε is the error term. The second-stage equation is

$$Y = \beta_0 + \beta_1 X^{\wedge} + \beta_2 W + \epsilon \tag{6}$$

where $X^{\wedge}$ is the predicted value of the endogenous variable from the first stage and W represents the exogenous variables. Y is the dependent variable, and ϵ is the error term.

Results and analysis

Baseline results

Our analysis uses a multidimensional index to measure sustainable entrepreneurship, as discussed in section "Index construction and principal component analysis evaluation outcomes". The descriptive statistics of the overall sample are shown in Table 4. Tests using descriptive statistics are helpful for describing, evaluating, and interpreting the datasets. The table shows the values of the mean, standard deviation, maximum, and minimum. The mean displays the central tendency of the data. The standard deviation measures the dispersion of the values around the mean. The total number of observations is 1200.

Table 4 Descriptive statistics

Variable	Obs	Mean	Std. Dev	Min	Max
SE	1199	0.250	1.000	− 1.371	2.937
DFC	1200	0.120	1.000	− 1.265	3.647
Trade openness	1200	2.797	1.064	0.147	6.257
Fin sound	1200	0.241	1.271	− 5.589	3.952
Mark dynamics	1200	22.115	21.983	− 7.030	96.665
Govt. support	1200	4.308	1.140	0.010	6.525

Table 5 Pairwise Correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	VIF
(1) SE	1.000						1.03
(2) DFC	0.260*	1.000					1.01
(3) Trade openness	− 0.137*	− 0.011	1.000				1.01
(4) Financial sound	0.082*	0.319*	0.245*	1.000			1.01
(5) Mark dynamics	0.153*	0.110*	0.098*	− 0.154*	1.000		1.00
(6) Govt. support	− 0.108*	− 0.124*	− 0.013	− 0.247*	− 0.030	1.000	1.01
Total VIF							**1.01**

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

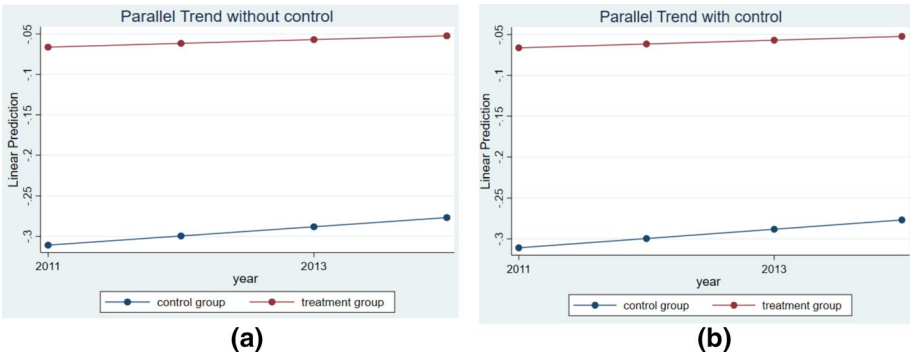


Fig. 4 **a** Parallel trend assumption without controls. **b** With control variables

Table 5 depicts the relationship between sustainable entrepreneurship and its covariants in the full sample. A correlation analysis is carried out when two or more variables are used in the investigation. The main goal of analyzing the correlation result is to identify any multicollinearity issues that could provide biased regression findings. The variables should have a correlation of less than 70% (Ullah et al. 2020). The results in Table 5 indicate that most of the variables used in the study have a positive relationship with sustainable entrepreneurship at the 10% significance level, except for trade openness and government support. The VIF values show that all values are less than the threshold of three, so there is no multicollinearity issue.

Parallel trend assumption of the DID technique.

To verify the parallel trend assumption, which states that the treatment group and the control group must have the same temporal trend before the policy's adoption for the DID model to function correctly, we utilize Fig. 4a, b to assess this hypothesis. The study examines data from both the control and treatment groups before and after the policy implementation period to assess whether the trends in both groups would have been similar in the absence of policy intervention. This approach helps ensure the validity of the assumption and strengthens the analysis. Figure 4a, b are plotted according to the estimated coefficient βs derived from the regression findings. Among these, Fig. 4a illustrates how the FATF's beneficial ownership policy affects sustainable entrepreneurship in the absence of other control factors. The regression results with the control variables are shown in Fig. 4b. As shown, from 2011 to 2014, the

Table 6 Mean of the scores for SE

Treatment group	FATF policy BO 2014		Total
	0	1	
0	− .40431109	− .45776725	− .44440321
1	− .00525686	.30751664	.22922441
Total	− .1409353	.04703069	− 9.983e-10

Table 7 The impact of FATF BO 2014 on sustainable entrepreneurship

Dependent variable SE	Without covariates (I)	With covariates (II)
FATF BO policy (1 vs 0)	0.366*** (0.133)	0.446*** (0.130)
DFC		0.166*** (0.029)
Trade openness		− 0.210 (0.071)
Financial soundness		0.078*** (0.021)
Govt. support		− 0.076*** (0.023)
Market dynamics		0.003*** (0.001)
Constant	− 0.404*** (0.093)	0.178 (0.150)
Country FE	YES	YES
Year FE	YES	YES
F	18.36	12.99
Total Observations	1,199	1,199
R-squared	0.114	0.159

Standard errors in parentheses ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

predicted coefficient βs was not significant prior to the execution of the policy. This suggests that there is strong comparability between the treatment and control groups, further supporting the above common trend hypothesis. Figure 5 shows the simulated trends before and after the 2014 FATF BO recommendation. Figure 5 indicates that after 2014, the broader gap between the treated and control groups suggests that the FATF policy affected the treatment group. The estimated coefficients βs lacked significance from 2011 to 2014 prior to policy implementation. However, in 2015, following the onset of policy implementation, they began to exhibit significance. This suggests that the treatment and control groups are comparably balanced and further validates the common trend hypothesis. A graphical and statistical proof of the parallel trend assumption is shown in Appendices C and D.

Table 6 displays the mean scores of sustainable entrepreneurship before and after the policy intervention in 2014 for both the control and treatment groups. Our findings reveal that the control and treated groups presented low levels of sustainable entrepreneurship before the FATF policy was implemented. However, following policy implementation, the treated groups demonstrated a significant increase in the mean SE score.

Table 8 Balance test of the PSM

		Mean		t test		VT/VC
Variable	Treated	Control	% bias	T	P>t	
SE	0.548	0.545	1.3	0.84	0.400	1.05
DFC	− 0.055	− 0.025	− 3.0	1.17	0.240	1.21*
GS	0.331	0.342	1.1	− 0.67	0.502	1.26*
MD	18.96	19.73	− 3.5	1.12	0.264	0.80*
FS	10.388	6.114	3.9	0.09	0.929	0.98
TO	22.451	22.469	− 1.14	− 0.11	0.912	1.10*

SE sustainable entrepreneurship, *DFC* digital financial capability, *GS* government support and policies, *MD* market dynamics, *FS* financial soundness, *TO* trade openness

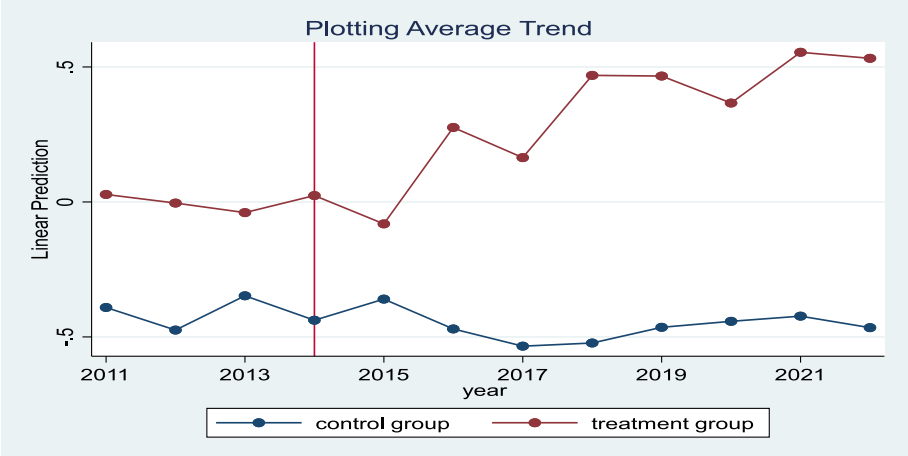


Fig. 5 Simulated trends before and after the policy intervention

Main model DID results

Column (I) of Table 7 presents the DID results for the 2014 FATF policy, with a focus on beneficial ownership. This analysis compared the SEs of the control and treated groups. Our findings indicate that following the policy intervention, the sustainable entrepreneurship of the treated group is approximately 36% greater than that of the control group, as shown in column (I) of Table 7.

Given the results concerning the parallel trend assumptions outlined above, we aim to investigate the outcome achieved when employing more precise control variables. This approach ensures the fulfillment of the conditional independence assumption. Column (II) of Table 7 shows the results of the difference-in-differences technique of the FATF (2014) policy. The Diff-in-Diff results reveal that policy implementation notably affects SE within a treated group. The findings suggest that the level of SE within the treatment group increased by 46.6% compared with that in the control group after the policy implementation. Digital financial capability (DFC) plays a significant role in uplifting sustainable entrepreneurial ventures throughout the sample. An increase in digital financial tools and platform usage can lead to a 16.6% increase in SE. The findings highlight clear patterns of the positive impact of financial soundness and market dynamics on SE at the 1% significance level. Notably, a one

percent improvement in institutions' financial stability correlates with a substantial 7.89% rise in SE. Interestingly, the study reveals contrasting findings regarding the impact of government support and policy, and trade openness on SE. Trade openness is negatively related to SE, whereas government support and policy harm it. The R-squared value indicates that 15.9% of the variation in sustainable entrepreneurship is explained by the FATF policy and other control variables used in the main results.

Robustness check

PSM analysis

The variables corresponding to matching country characteristics include sustainable entrepreneurship (SE), digital financial capability (DFC), financial soundness (FS), market dynamics (MD), trade openness (TO), and government support (GS). A 1:1 k-nearest neighbor match is the matching technique employed here. After the matching process is complete, a balance test is used to confirm the matching efficiency. The basic hypothesis of the balancing test asserts that the treated and control groups do not differ consistently from one another. Table 8 displays the results of the PSM balancing test, which shows that all covariate p values are greater than 5%, suggesting that the initial hypothesis cannot be denied. Moreover, Fig. 6 illustrates the balanced distribution of the matched forms by showing that the majority of the variables are closer to the vertical line with a zero standard error after matching. Therefore, it is confirmed that the matched sample meets the criteria for performing additional regression analysis.

KPSM-DID

We estimate Eq. (4) via the KPSM-DID technique, given the estimated propensity scores and under the basic assumption, i.e., conditional independence, independent and identically distributed data, and joint support. To meet the requirement of common support,

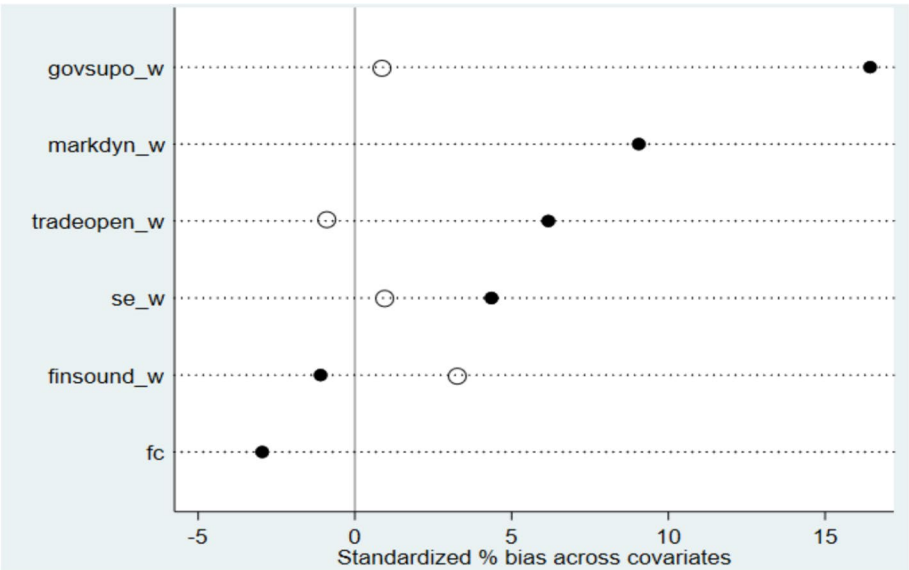


Fig. 6 Bias of control and treated before and after matching

countries whose propensity score was beyond the range of overlap between the treated and control groups were eliminated. Figure 7 shows the distribution.

Propensity score matching difference-in-differences (PSM-DID) is a combination of statistical methods used in observational research to improve the accuracy of causal impact estimates. This approach combines the advantages of difference-in-differences (DID) and propensity score matching (PSM) to account for confounding factors and other biases. Column (I) of Table 9 displays the results, showing that the average treatment effect on the treated (ATT) is significant, indicating that the average impact of the FATF policy on the SE levels of the countries that implemented it is substantial. The number of observations in column (I) indicates that only eight observations are treated off support and have been eliminated. Several covariates, such as DFC, financial soundness, and market dynamics, have positive significant relationships with SE. Conversely, trade openness is negatively insignificant, and government support is negatively significant with SE.

Counterfactual tests

This study adjusts the FATF BO policy period in the treatment group to 2013 to account for its early implementation. It examines the impact of the dummy variable $treat_i * post_t$ on sustainable entrepreneurship in the absence of the FATF BO recommendation. This method was used to check the robustness of the results. If the interaction variable $treat_i * post_t$ is insignificant, it proves that sustainable entrepreneurship is not affected by any other factors.

Table 10 shows the counterfactual test results of the FATF BO policy in advance of 2013. The regression coefficients of the interaction variable are small and insignificant (0.043), suggesting that sustainable entrepreneurship is likely unaffected by any other factor.

Table 9 Results of the KPSM DID

Dep variable SE	KPSM DID (I)
ATT	0.436***
	(0.091)
DFC	0.917***
	(0.077)
Trade open	− 0.001
	(0.007)
Financial soundness	0.113*
	(0.064)
Govt. support	− 0.279***
	(0.064)
Mark dynamics	0.020***
	(0.003)
Constant	− 0.444***
	(0.046)
Observations	1,191
R-squared	0.102

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 10 Counterfactual test results

Dep variable SE	KPSM DID
Treat*post-2013	0.043
	(0.228)
Control	Yes
Constant	− 0.583***
	(0.075)
Fixed effects	Yes
Observations	1,199
R-squared	0.082

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 11 IV estimation results: robustness check

Dep variable SE	1st Stage regression (I)	2SLS regression(II)
FATF BO(1 vs. 0)		0.391***
		(0.145)
V&A-IV	0.028***	
	(0.008)	
DFC	0.379***	0.466***
	(0.026)	(0.064)
Trade open	− 0.008	− 0.076
	(0.034)	(0.070)
Financial soundness	0.049**	0.116**
	(0.022)	(0.045)
Govt. support	− 0.072***	− 0.013***
	(0.023)	(0.003)
Mark dynamics	0.007***	0.099**
	(0.001)	(0.043)
Constant	− 0.480***	− 2.888***
	(0.108)	(0.836)
Observations	1,199	1,199
Sargan-Hensen value		0.202
Year effect	YES	
Country effect	YES	
F-statistics	11.87	
R-squared		0.248

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

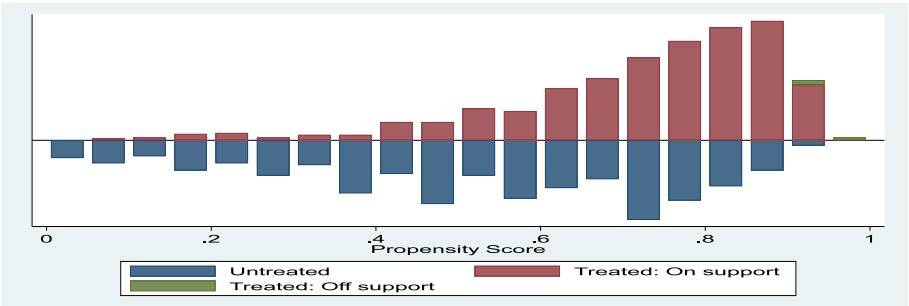


Fig. 7 Propensity score matching between the treatment and control groups for sustainable entrepreneurship

2SLS-IV regression

The analysis additionally incorporates a 2SLS regression to eliminate endogeneity and guarantee the robustness of the results, proving that the results align with the primary model. The 'FATF beneficial ownership policy' is replaced with voice and accountability (V&A) from the World Governance Indicator (WGI) as an instrumental variable (IV) to better convey the idea of transparency. V&A demonstrates the extent to which citizens express their freedom of opinion, demand accountability from the government and business institutions, and report corruption. V&A is crucial for implementing successful rules such as the beneficial ownership of the FATF. The first stage of 2SLS's F test score of 11.87 (F score > 10) shown in column (I) of Table 11 indicates that V&A and FATF BO have a strong enough correlation.

In Table 11, Columns (I) and (II) present the results of the 2SLS regression, showing that all the variables except trade openness are significantly related to sustainable entrepreneurship. Column (I) presents the first-stage least square regression results, reflecting that, except for trade openness and govt. support, all other variables positively and significantly influence sustainable entrepreneurship. Govt. support is negatively significant with SE at the 1% significance level, and trade openness is negatively insignificant. The coefficient of 2SLS FATF BO (0.391) is close to the original estimate of FATF BO (0.446), indicating that the robustness of the results and potential endogeneity issues are eliminated. The validity of the primary model results and the reliability of the 2SLS estimation methodology for 100 countries are demonstrated by the 2SLS diagnostic test in Column (II). V&A is a legitimate instrumental variable, has no endogeneity issues, and is uncorrelated with the error term, according to its Hensen value of 0.202. The model fits, as evidenced by R2, which takes the number of variables into consideration.

Discussion of key findings

This study investigates the impact of the 2014 FATF Beneficial Ownership (BO) recommendation on sustainable entrepreneurship from 2011 to 2022. This study uses a difference-in-differences (DID) approach to examine policy impacts via a quasi natural experimental design. The study categorizes countries into two groups: those that have applied the FATF BO recommendations with only minor to moderate shortcomings and those that have either not applied the recommendations or exhibit significant deficiencies according to the FATF mutual assessment report. The model validates that the DID methodology effectively specifies the conditions necessary to assess a policy's impact on sustainable entrepreneurship.

The findings indicate that sustainable entrepreneurship levels notably increased after the 2014 FATF Beneficial Ownership Recommendation was implemented in the treatment group. This substantial growth underscores the critical role of a secure and transparent business environment in fostering entrepreneurial activities, as corroborated by Rasiah et al. (2024). The results of the present study revealed that in countries that implemented the 2014 FATF BO recommendation, levels of sustainable entrepreneurship significantly increased by 46.6%. This finding supports H1. FATF Recommendation 24 enhances transparency through initiatives such as digital public registers, which help reduce information asymmetry and build trust among stakeholders. This is consistent with Kreiterling (2023), who reported that 35–40% of business innovation is attributed

to digitalization and a secure environment. FATF policies are based on a risk-based approach, but countries that implement them without assessing their risk analysis necessitate additional cost burdens, indicating a need for refinement in policy implementation (Ofoeda 2022).

The findings show that digital financial capability (DFC) enhances sustainable entrepreneurship by 16.6% and substantially contributes to the sustainability of entrepreneurial endeavors worldwide. The strong connection between DFC and SE supports the ecological theory of sustainable entrepreneurship. Similar findings were reported by Luo et al. (2021), who demonstrated that DFC supports Chinese entrepreneurs in maximizing resource management, reducing waste, and better utilizing available financial resources. Similarly, Kenya's M-Pesa case enables small business owners to prosper in environmentally friendly industries (Van Hove and Dubus 2019). Trade openness and SE are negatively insignificant. Market dynamics are important for advancing SE. The findings indicate that competitive market conditions, such as innovation and consumer demand, create an environment conducive to SE. These findings align with those of Schindehutte et al. (2008), who find a favorable connection between entrepreneurship and the market's competitive dynamics. Government support and policy negatively impact SE at the 1% significance level in both the main and robust results. The study outcomes are supported by Ajayi-Nifise et al. (2024), who find an inverse substantial link between government policies and entrepreneurship. Government initiatives to encourage entrepreneurship in Nigeria are inadequate because of corruption, political instability, and bureaucratic inefficiencies. One of the difficulties faced by entrepreneurs in developing nations is inconsistent government policies.

Furthermore, the findings highlight that financial soundness and SE are positively related at the 1% significance level. According to the findings, financially stable institutions increased SE by 7.8%. Financial soundness likely provides a conducive environment for entrepreneurs to innovate and invest in sustainable practices, as it reduces risk and enhances access to capital. These results are endorsed by Babajide et al. (2020), who demonstrate that East African countries have contributed to entrepreneurship growth through their responsiveness to changes in financial soundness, governance, and economic progress. Figure 8 depicts a summary of the results of the study.

Conclusion, recommendations and policy implications

By utilizing the global entrepreneurship monitoring database from 2011 to 2022 to assess sustainable entrepreneurship as a multidimensional factor, we examine how FATF policy has unanticipated effects on the SE levels of countries. The key findings offer new and compelling evidence that the FATF policy of beneficial ownership in 2014 created a secure business environment and that its implementation had a notable effect on sustainable entrepreneurship levels. Other control variables, such as digital financial capability, market dynamics, and financial soundness, play significant positive roles in uplifting entrepreneurial ventures. However, government support and policy negatively impact SE because of political unrest and corruption. Moreover, trade openness is negatively insignificant.

Government support and policies have a negative effect on SE. This is compounded by political instability and corruption in most countries; approximately 68% of countries are

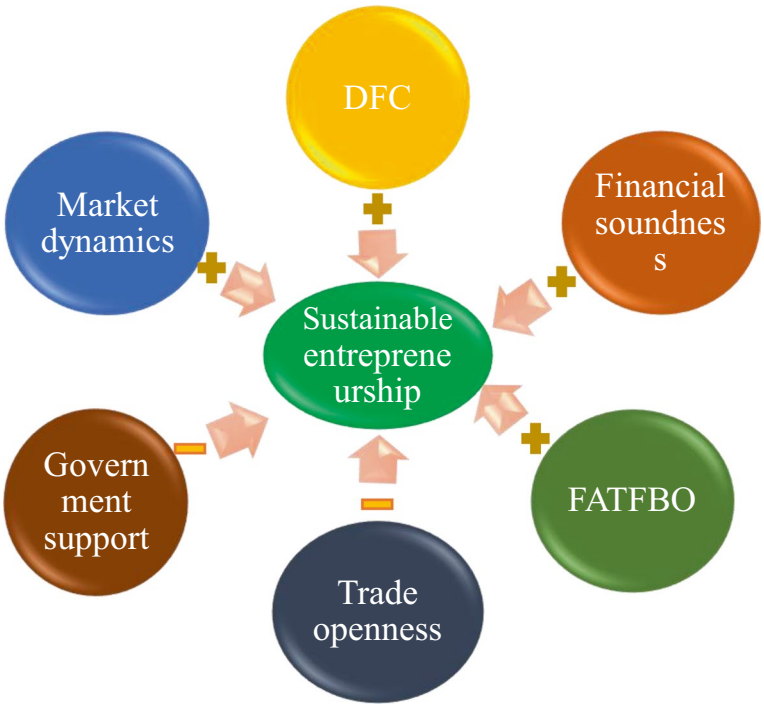


Fig. 8 Summary of the relationships between SE and other variables

politically unstable, and the global average for governmental corruption is 43%. Addressing these challenges through FATF regulations requires substantial effort to foster a more supportive environment for sustainable entrepreneurship. The expansion of entrepreneurship in most regions shows high adaptability to shifts in concerns about financial soundness and dynamic market policy.

With respect to policy implications, two results stand out: transparency in business operations can create a level playing field for entrepreneurs, reduce corruption and illicit financial activities, and ultimately put environmental preservation over short-term gains. The FATF has acknowledged that its standards may lead to unintended consequences, implying that its policies can negatively and positively affect countries. According to the FATF's mutual evaluations, nations that employed a multifaceted strategy outperformed those that employed a single strategy in avoiding the exploitation of legal persons for illicit activities and guaranteeing beneficial ownership transparency. Policymakers in advanced economies should strengthen enforcement and guarantee that transparency laws are implemented effectively to reduce financial crime and encourage sustainable entrepreneurship. The emphasis in emerging and developing economies should be on progressively establishing beneficial ownership legislation and strengthening institutional capability. Policymakers should cooperate internationally, exchange best practices, and coordinate regulatory efforts to effectively combat financial crime. Greater accountability inside businesses is fostered by transparent ownership structures, which is consistent with sustainable entrepreneurship's tenets of moral corporate conduct and social responsibility. This transparency increases public confidence and encourages community support for sustainability and environmental projects. Control group countries should note the strategies of treatment groups and what they are doing differently to

promote sustainable entrepreneurship initiatives and implement these policies in their areas.

The limitations of this analysis lie in the data availability and time span. The low comparability of entrepreneurial measures between developed nations and developing nations is one of the shortcomings of GEM entrepreneurship-related measures (Audretsch et al. 2022). However, it is important to highlight that we used country-level fixed effects to account for time-invariant systematic measurement errors, which helps mitigate concerns about these measurements. Future research should incorporate regional variations in data, different levels of adherence to the FATF's BO policy, and unobserved elements that could impact sustainable entrepreneurship, such as informal economic and cultural pressures. To gain a better understanding of how beneficial ownership policies promote sustainable entrepreneurship, further research should overcome these constraints by examining longer-term benefits and regional or sector-specific effects and merging quantitative data with qualitative case studies.

Appendix A: List of sample countries

#	Country	#	Country
1	Algeria	51	Korea, Rep
2	Angola*	52	Kuwait
3	Argentina	53	Kyrgyz Republic
4	Armenia	54	Latvia
5	Australia	55	Lesotho
6	Austria	56	Lithuania
7	Belarus	57	Luxembourg
8	Belgium	58	Madagascar*
9	Belize	59	Malaysia
10	Botswana*	60	Mexico
11	Brazil	61	Morocco
12	Bulgaria	62	Mozambique*
13	Cambodia	63	Namibia
14	Cameroon*	64	Netherlands
15	Canada	65	New Zealand
16	Chile	66	Niger*
17	China*	67	Nigeria*
18	Colombia	68	North Macedonia
19	Congo, Rep*	69	Norway
20	Costa Rica	70	Oman
21	Croatia	71	Pakistan*
22	Cyprus	72	Panama
23	Denmark	73	Philippines
24	Dominican Republic*	74	Portugal
25	Ecuador	75	Qatar
26	Egypt, Arab Rep	76	Romania
27	El Salvador*	77	Russian Federation*
28	England	78	Saudi Arabia
29	Estonia	79	Senegal*

#	Country	#	Country
30	Finland	80	Serbia
31	France	81	Singapore
32	Gabon	82	Slovak Republic*
33	Gambia, the	83	Slovenia
34	Georgia	84	South Africa
35	Germany	85	South Sudan*
36	Ghana	86	Spain
37	Greece	87	Sudan*
38	Guatemala	88	Sweden
39	Hong Kong SAR, China	89	Switzerland
40	Hungary	90	Syria*
41	Iceland	91	Thailand
42	India	92	Togo*
43	Indonesia	93	Tunisia*
44	Iran*	94	Turkey
45	Ireland	95	Uganda*
46	Israel	96	Ukraine
47	Italy	97	Uruguay
48	Jamaica	98	USA*
49	Japan	99	Vietnam
50	Jordon	100	Zimbabwe*

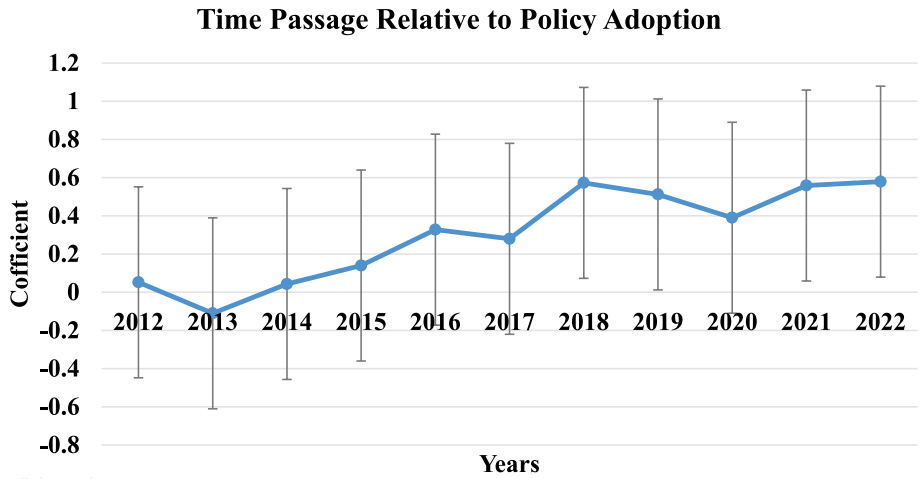
*Shows control group

Appendix B: Variable description and measurement

Variable	Description	Data source
Sustainable Entrepreneurship	Utilizes TBL approach, economic dimension is measured by GDP per capita, education and inequality rate reflects social measure, CO2 emission as the environmental indicator and dynamic capabilities we use innovation, decision spirit, established business, entrepreneurial intentions, infrastructure, expectations, no of startups. These indicators combined to create PCA	Global entrepreneurship monitoring database, World Bank Enterprise survey and WDI
Digital Financial capability (DFC) *1) Digital Financial literacy* *2) Financial behavior (financial inclusion)* *3) Financial environment (financial inclusion)*	PCA generates a composite index using digital financial literacy, behavior and environment Made and receive digital payments Credit cards payments, insurance coverage, mobile account, mobile and bank savings Self-service banking includes number of ATMs and bank branches	Global findex database Global findex database Global findex database
Trade openness	Exports and Imports Ratio to GDP	WDI
Market dynamics	Level of Annual market fluctuations	GEM
Government support FATF policy dummy zero for the year in which there is no policy(2011–3013) and one for in which there is a policy (2014 onward)	Level of worldwide policy support for entrepreneurship	GEM
Financial Soundness	Z score of bank's return on assets and return on equity	GFD

Author's own work

Appendix C



Parallel trend assumption

Appendix D: Table statistical test of parallel trend assumption

	DID results SE
YEARS	
D_3	0.0519
	(0.280)
D_2	− 0.110
	(0.280)
D_1	0.0432
	(0.280)
D_0 (2014)	0.328
	(0.280)
D1	0.419**
	(0.198)
D2	0.280
	(0.280)
D3	0.573**
	(0.280)
D4	0.512*
	(0.280)
D5	0.390
	(0.280)
D6	0.559**
	(0.280)
D7	0.579**
	(0.280)
D8	0.391**
	(0.161)
Observations	1.199
R-squared	0.138

Standard errors in parentheses ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

D stands for policy year 2014

Acknowledgements
The authors acknowledge the editor and anonymous reviewers support throughout the process.

Author contributions
All Authors contributed conceptually, formally and in original drafting. All the authors contributed. Responsibilities are as follows; SU: conceptualization; formal analysis; methodology; writing—original draft preparation, revision. GL: supervision; funding acquisition; writing—review and editing. AU: conceptualization; methodology; results validation; writing—review and editing. JC: Validation; formal analysis; Methodology; Writing—review and editing.

Funding
This research support Professor Guang Luo by School of Management, Huazhong University of Science and Technology, Wuhan China. The paper is supported by the liberal arts double world-class project of Huazhong University of Science and Technology (The major discipline platform construction Rural Development Research Center of Huazhong University of Science and Technology). Jun Cai acknowledges financial support from the Fundamental Research Funds for the Central Universities (HUST:2024WKYXQN031).

Availability of data and materials
Data available upon request.

Declarations

Ethics approval and consent to participate
All authors participated in the process of draft completion. All authors have read and agreed to the published version of the manuscript. The study did not use any data which needed approval.

Consent for publication
All authors agree to publish.

Competing interests
The authors reported no potential competing interests concerning the research, authorship, and/or publication of this article.

Received: 18 June 2024 Accepted: 16 October 2025
Published online: 19 January 2026

References

Abdeljaber O, Al-masaeed S, Azam SF, Ab Yajid MS, ALSoud AR, Johar M (2021) The role of trade integration and cross-border entrepreneurship in international relations: a moderating role of it infrastructure. Croat Int Relat Rev 27(87):63–94
Ajayi-Nifise AO, Tula ST, Asuzu OF, Mhlongo NZ, Olatoye FO, Ibeh CV (2024) The role of government policy in fostering entrepreneurship: a USA and Africa review. Int J Manag Entrep Res 6(2):352–367
Akçomak İS (2009) Incubators as tools for entrepreneurship promotion in developing countries. Entrepreneurship, Innovation and Economic Development, 228–264
Asongu SA, Nwachukwu JC (2018) Openness, ICT and entrepreneurship in sub-Saharan Africa. Inf Technol People 31(1):278–303. https://doi.org/10.1108/ITP-02-2017-0033
Audretsch DB, Belitski M, Chowdhury F, Desai S (2022) Necessity or opportunity? Government size, tax policy, corruption, and implications for entrepreneurship. Small Bus Econ 58(4):2025–2042. https://doi.org/10.1007/s11187-021-00497-2
Audretsch DB, Sanders M, Zhang L (2012) How exports matter: trade patterns over development stages. CEPR Discussion Paper No. DP8815. https://ssrn.com/abstract=2013806
Babajide A, Lawal A, Asaleye A, Okafor T, Osuma G (2020) Financial stability and entrepreneurship development in sub-Sahara Africa: implications for sustainable development goals. Cogent Soc Sci 6(1):1798330
Burchi A, Włodarczyk B, Szturo M, Martelli D (2021) The effects of financial literacy on sustainable entrepreneurship. Sustainability 13(9):5070
Cavoli T, Christian D, Shrestha R (2024) SMEs, trade finance markets and instruments: a review of the issues with reference to Asia. World Bank Res Obs. https://doi.org/10.1093/wbro/lkae006
Cohen B, Smith B, Mitchell R (2008) Toward a sustainable conceptualization of dependent variables in entrepreneurship research. Bus Strateg Environ 17(2):107–119
Dhahri S, Omri A (2018) Entrepreneurship contribution to the three pillars of sustainable development: what does the evidence really say? World Dev 106:64–77. https://doi.org/10.1016/j.worlddev.2018.01.008
Dilanchiev A, Sekreter A (2015) Measuring the effect of trade openness on entrepreneurship development in case of Georgia. Int J Recent Sci Res 6(10):6990–6993
Eisenmann TR (2013) Entrepreneurship: a working definition. Harv Bus Rev 10(5):1–3
Faria JR, Ogura L, Prado M, Boudreaux CJ (2023) Government investments and entrepreneurship. Small Bus Econ 61(4):1657–1670
FATF (2014) Guidance on transparency and beneficial ownership. FATF/OECD. www.fatf-gafi.org
FATF (2021) Mitigating the unintended consequences of the FATF standards. https://www.fatf-gafi.org/en/publications/Financialinclusionandnpoissues/Unintended-consequences-project.html

FATF (2024) Consolidated assessment ratings. https://www.fatf-gafi.org/en/publications/Mutualevaluations/Assessment-ratings.html
Fernando F, Berkhout MR (2022) Unmasking control: a guide to beneficial ownership transparency. International Monetary Fund, Washington
Fong CW, Yen YY, Ramasamy S (2022) Sustainable entrepreneurship in SMEs. GATR J Bus Econ Rev 7(1):92–102
Gilmour PM (2020) Lifting the veil on beneficial ownership. J Money Laund Control 23(4):717–734. https://doi.org/10.1108/JMLC-02-2020-0014
Gu W, Wang J (2022) Research on index construction of sustainable entrepreneurship and its impact on economic growth. J Bus Res 142:266–276. https://doi.org/10.1016/j.jbusres.2021.12.060
Gu W, Zheng X (2021) An empirical study on the impact of sustainable entrepreneurship: based on the environmental Kuznets model. J Bus Res 123:613–624
Gueddari A, Saafi S, Nouira R (2024) Is money laundering a hurdle to achieving sustainable development goals? J Money Laund Control 27(2):242–261
Hall JK, Daneke GA, Lenox MJ (2010) Sustainable development and entrepreneurship: past contributions and future directions. J Bus Ventur 25(5):439–448. https://doi.org/10.1016/j.jbusvent.2010.01.002
Huang Y, Li P, Bu Y, Zhao G (2023) What entrepreneurial ecosystem elements promote sustainable entrepreneurship? J Clean Prod 422:138459
Hummels H, Argyrou A (2021) Planetary demands: redefining sustainable development and sustainable entrepreneurship. J Clean Prod 278:123804. https://doi.org/10.1016/j.jclepro.2020.123804
International T (2021) A-new-global-standard-on-beneficial-ownership-transparency-response-to-FATF-consultation. https://www.transparency.org/en/campaigns/global-standards-fatf-beneficial-ownership-transparency
Jha A, Sindhwani R, Dwivedi A, Saddikuti V (2022) Sustainable recovery for digital entrepreneurs with shared resources: enablers, challenges and solutions. J Asia Bus Stud 16(3):515–537. https://doi.org/10.1108/JABS-05-2021-0214
Jha VK, Pande AS (2024) Making sustainable development happen: does sustainable entrepreneurship make nations more sustainable? J Clean Prod 440:140849. https://doi.org/10.1016/j.jclepro.2024.140849
Kreiterling C (2023) Digital innovation and entrepreneurship: a review of challenges in competitive markets. J Innov Entrep 12(1):49. https://doi.org/10.1186/s13731-023-00320-0
Luo Y, Peng Y, Zeng L (2021) Digital financial capability and entrepreneurial performance. Int Rev Econ Finance 76:55–74. https://doi.org/10.1016/j.iref.2021.05.010
Mansouri S, Momtaz PP (2022) Financing sustainable entrepreneurship: ESG measurement, valuation, and performance. J Bus Ventur 37(6):106258. https://doi.org/10.1016/j.jbusvent.2022.106258
Martinez AL (2021) Beneficial ownership transparency: accomplishment and obstacles. Available at SSRN 3820479
Moya-Clemente I, Ribes-Giner G, Chaves-Vargas JC (2021) Sustainable entrepreneurship: an approach from bibliometric analysis. J Bus Econ Manag 22(2):297–319
Mugione F, Farinelli F (2017) Promoting entrepreneurship for development. Small and Medium-Sized Enterprises in International Economic Law 339
Muñoz P, Cohen B (2018) Sustainable entrepreneurship research: taking stock and looking ahead. Bus Strategy Environ 27(3):300–322
Nave A, Franco M (2019) University-firm cooperation as a way to promote sustainability practices: a sustainable entrepreneurship perspective. J Clean Prod 230:1188–1196. https://doi.org/10.1016/j.jclepro.2019.05.195
Ofoeda I (2022) Anti-money laundering regulations and financial inclusion: empirical evidence across the globe. J Financ Regul Compl 30(5):646–664
Pradhan RP, Arvin MB, Nair M, Bennett SE, Hall JH (2018) The dynamics between energy consumption patterns, financial sector development and economic growth in Financial Action Task Force (FATF) countries. Energy 159:42–53
Rahman MM, Deb BC, Rahman MS, Uddin MM, Ramzan M, Hossain MJ, Uddin G (2023) Does trade openness affect global entrepreneurship development? Evidence from BRICS countries. Ann Financ Econ 18(03):2350001
Rasiah R, Ng YK, Cheong KC (2024) Mediating and moderating effects of social networks and business environment on the relationship between entrepreneurial orientation and sustainable competitive advantage among small and medium Malaysian firms in Cambodia. Asian J Technol Innov 32(1):182–203
Rosário AT, Raimundo RJ, Cruz SP (2022) Sustainable entrepreneurship: a literature review. Sustainability 14(9):5556
Rosenbaum PR, Rubin DB (2023) Propensity scores in the design of observational studies for causal effects. Biometrika 110(1):1–13. https://doi.org/10.1093/biomet/asac054
Sadiq M, Nonthapot S, Mohamad S, Chee Keong O, Ehsanullah S, Iqbal N (2022) Does green finance matter for sustainable entrepreneurship and environmental corporate social responsibility during COVID-19? China Finance Rev Int 12(2):317–333
Sakyi-Nyarko C, Ahmad AH, Green CJ (2022) The gender-differential effect of financial inclusion on household financial resilience. J Dev Stud 58(4):692–712. https://doi.org/10.1080/00220388.2021.2013467
Sam Eastwood CR, Leveson DJ (2021) Beneficial ownership transparency: a spotlight on international beneficial ownership registration. Global. https://www.mayerbrown.com/en/insights/publications/2020/12/beneficial-ownership-transparency-a-spotlight-on-international-beneficial-ownership-registration
Schaltegger S, Wagner M (2011) Sustainable entrepreneurship and sustainability innovation: categories and interactions. Bus Strategy Environ 20(4):222–237
Schindehutte M, Morris MH, Kocak A (2008) Understanding market-driving behavior: the role of entrepreneurship. J Small Bus Manag 46(1):4–26
Serafimovska H, Sotiroski L (2014) Implications of the legal framework for the development of entrepreneurship. Int Rev Soc Sci Human 7(1):263–273
Shaffer Y (2024) The FATF criminalization of money laundering–much room for improvement. J Money Laund Control 27(2):225–227
Shahid MS, Hossain M, Shahid S, Anwar T (2023) Frugal innovation as a source of sustainable entrepreneurship to tackle social and environmental challenges. J Clean Prod 406:137050. https://doi.org/10.1016/j.jclepro.2023.137050

Terán-Yépez E, Marín-Carrillo GM, del Pilar Casado-Belmonte M, de las Merces Capobianco-Uriarte M (2020) Sustainable entrepreneurship: review of its evolution and new trends. J Clean Prod 252:119742
Ullah A, Pinglu C, Ullah S, Zaman M, Hashmi SH (2020) The nexus between capital structure, firm-specific factors, macroeconomic factors and financial performance in the textile sector of Pakistan. Heliyon. https://doi.org/10.1016/j.heliyon.2020.e04741
UNCTAD (2017) UNCTAD annual report 2017. UNO. https://unctad.org/publication/unctad-annual-report-2017
Urooj S (2024) A dynamic threshold analysis of effect of Financial Action Task Force (FATF) measures on financial inclusion: evidence from the world. J Money Laund Control 27(4):696–709
Urooj S, Luo G, Ullah A (2025) Illuminating pandemic shadows: digital financial capability and sustainable entrepreneurship across developed and emerging economies. J Int Entrep. https://doi.org/10.1007/s10843-025-00380-1
Van Hove L, Dubus A (2019) M-PESA and financial inclusion in Kenya: of paying comes saving? Sustainability. https://doi.org/10.3390/su11030568
Verbivska L, Lagodiienko V, Filyppova S, Papaika O, Malin O, Neustroiev Y (2022) Regulatory policy of the entrepreneurship development as a dominant of economic security of the national economy. Int J Saf Secur Eng 12(5):543
Watson R, Nielsen KR, Wilson HN, Macdonald EK, Mera C, Reisch L (2023) Policy for sustainable entrepreneurship: a crowdsourced framework. J Clean Prod 383:135234
Weidinger C (2013) Business success through sustainability. In: Sustainable entrepreneurship: business success through sustainability. Springer, pp 287–301
Wirba AV (2023) Corporate social responsibility (CSR): the role of government in promoting CSR. J Knowl Econ. https://doi.org/10.1007/s13132-023-01185-0
Wu W, Wang H, Wu YJ (2021) Internal and external networks, and incubatees' performance in dynamic environments: entrepreneurial learning's mediating effect. J Technol Transf 46(6):1707–1733
Ziemnowicz C (1942) Joseph A. Schumpeter and innovation. Soc Democr 2(1):2–4

Publisher's Note