# The path analysis of entrepreneurship impacts on circular economy in emerging markets: a mediating role of digital technology

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## Abstract

**Purpose** – The purpose of this article is to explore the impact of the firm's entrepreneurship for the transformation of circular economy (CE). The role of entrepreneurship is thought to be important for the process of four Rs in the CE, and the authors have tried to study the role and impact path of entrepreneurship in CE.

**Design/methodology/approach** – Empirical data from Chinese listed firms are collected, and a measure of digital technology is constructed by text mining method. Mediation analysis method is used to test the proposed hypothesis.

**Findings** – The results show that the innovation entrepreneurship has a significant positive impact upon the CE and digital technology is playing a mediating role in the impact path. However, the business entrepreneurship is negatively affecting the CE adoption. Also, the proportion of shares hold by the institution has a heterogenous influence for the innovation entrepreneurship.

**Practical implications** – This study guides policy makers about the role of entrepreneurship and the mediating effect of digital technology and to encourage the adoption of CE for firms.

**Originality/value** – This study reveals the mediation effect of digital technology in the impact of entrepreneurship on CE in the emerging market. The heterogeneity of the proportion of shares hold by the institutions is also analyzed in the empirical study.

**Keywords** Entrepreneurship, Digital technology, Mediation effect, Circular economy

**Paper type** Original article

## 1. Introduction

In the past decade, the whole world is getting more focus on the circular economy (CE) since the severe industrial pollutions and scarcity of the natural resources. The CE, as the improvement of the traditional linear economy, emphasizes on the four R principles of reduce, reuse, recycle and recover. Compared with the take, use and disposal way in the linear economy the four Rs are now regarded as the key points to achieve the sustainable development for the human society. Here, we would like to explore the CE in a microscopic perspective, i.e. in a firm level which factors are leading to the transformation of CE.

Although the CE is attracting both academic and practitioner's attentions the explicit and detailed meaning is not easy to define (Kirchherr *et al.*, 2017). As pointed in Korhonen *et al.* (2018),

the scientific and research content of the CE concept is superficial and unorganized. How to realize the CE remains a tough question even conceptually and theoretically (Angelis, 2021). The realization path of CE has academic debates like whether a closed loop of material can be done (Mathews and Tan, 2011; Korhonen *et al.*, 2018), whether the long life of final product is the way for CE (Korhonen *et al.*, 2018). Millar *et al.* (2019) claimed that there is no consensus as to how best to implement the CE nor how all stakeholders can be equally incorporated. However, it is generally agreed that CE is a restorative business model that extends product life by using minimum need of raw materials, reducing waste, and optimizing reuse and recovery by ecosystem (Ellen MacArthur Foundation, 2017; Webster, 2015; Stahel, 2016). With these concepts, the industrials are struggling for the adoption of CE since each firm needs to think about the way to fulfill the conceptual purposes. In literature, CE has been studied in various ways like mediator factors, challenges, organizational sustainability identity, measurements and prospects (Bouncken *et al.*, 2022; Chien, 2022; Guo *et al.*, 2022; Sarfraz *et al.*, 2023; Sharma *et al.*, 2019; Xie *et al.*, 2022).

The relation between innovation and CE has been discussed in the literature recently. Yang (2017) analyzed the adoption of CE through the innovation of value chain circulation of plastic package by a case study in the Netherlands. Nathalia *et al.* (2021) pointed out that it is important to consider both inside and outside factors in the innovation process for CE and ecology innovation is primary for the CE. Tan *et al.* (2022) discussed how the risk adverse level of high mangers in the firm impacts the business model innovation toward CE. Eivind *et al.* (2020) and Usama *et al.* (2020) pointed out the digital technology and industrial 4.0 concept together with artificial intelligence (AI) would leads to the adoption of CE for firms. The entrepreneurship ties closely with business activities and plays an important role in innovation and sustainability (Al-Mamary and Alshallaqi, 2022; Andati *et al.*, 2022; Botella-Carrubi *et al.*, 2022; Vasilescu *et al.*, 2022). Factors like infrastructure and geographical location (Chien, 2022; Dana *et al.*, 2022), social relationship (Goduscheit *et al.*, 2021) and gender (Huang *et al.*, 2022) are thought to influence the entrepreneurship activities. As the entrepreneurship is the essential force for the firm to make the technology innovation and develop the new business model (Ye, 2000; Gu *et al.*, 2018; Gu and Qian, 2019). A natural question will be proposed: whether and how the entrepreneurship influences the CE?

Innovation and risk-taking characteristics of entrepreneurship are considered as the main driven force here since there are both scientifical barrier and organizational barrier to implement the CE. In this paper, we would like to discuss the relationship between entrepreneurship and CE and investigate the possible paths of entrepreneurship influence CE. Considering the wide use of digital technology, we would like to know whether digital technology plays a role in the paths of entrepreneurship influence CE and find one of the possible ways for the fulfillment of CE to some extends through the empirical study.

While the studies so far are mainly macroeconomic and qualitative, we would like to do a micro economic investigation with the firm level data in the China listed firms. China has started its economic reform only forty years ago and has a wide consumer market, which stands for a typical case for the emerging market. This paper analyzes the impact of entrepreneurship of firms upon the adoption of CE together with the mediating role of digital technology and contributes the literature as following: First, exploring the impact path of entrepreneurship upon the adoption of CE in the firm level, which enriches the literature of the empirical analysis for the possible implementation way of CE. Second, China is an immature market with investment distortions and government control, and it provides a typical case for the study of emerging market. The study on the China firms here provides another perspective of the literature aiding the study of emerging economies.

The rest of this paper is organized into six sections. Following the introduction, the second section is the theoretical framework. The third section describes the variable selection and the methodology. The fourth section provides empirical results and robust checking results.

In the next section, we discuss the importance of the study. At last, we draw the conclusions based on our findings.

## 2. Theoretical framework

When firms are considering the adoption of CE, the challenges are not only the technology gap but also the high risk for the change of business model in the competition market. Angelis (2021) pointed that new business models are highlighted as a critical building block for successful implementation of CE, and a competitive advantage can be obtained by implementing innovative business models enhancing resource efficiency and customers' value along the entire lifetime of a product. The innovation and new business models are regarded as important ways to reduce resource depletion and have competitive advantage for the risk management (Jørgensen and Pedersen, 2018; Gu *et al.*, 2022). So, it is essential to have the abilities to do the innovation and grasp the business opportunity in the competition market, which are exactly the attributes of the entrepreneurship. In fact, the entrepreneurship is usually considered as finding new combination of production factors, such as the advanced technology, low price labor, existing energy and new utilizing methods, to lower production cost and find the opportunity to meet new market demands and identify the business opportunities (Gu *et al.*, 2018; Gu and Wang, 2022). Therefore we propose the first hypothesis.

*H1.* The entrepreneurship is positively impacting on the adoption of CE of firms.

The technology innovation is the key for the entrepreneurs to occupy and expand the market in the competition for developing their firms (Shane and Venkataraman, 2000; Gu *et al.*, 2018). Nageshwaran *et al.* (2021) summarized the role of digital technologies. In the past decade, the digital technology is boomed up rapidly and its influence on economy draws attention from both the academic and practitioners. Pagoropoulos *et al.* (2017) discussed the technologies for big data analysis and pointed out those technologies would foster the CE. Emilia *et al.* (2019) found that the Internet of Things (IoT) was important for the strategy of 4 Rs in CE. Konstantinos and Daskalakis (2020) pointed that information communication technology (ICT) was essential for the adoption of CE and IoT and AI were the most welcome technologies in ICT solutions. Fossen and Sorgner (2022) discussed the heterogeneous effects of digital technology upon employment. The digital technology is summarized to have the following advantages: First, it increases both the production and organizational efficiency and reduce the cost. Second, it has a better social network building for outside channels to get more information and reduce the financial constraints. Third, it helps to do the new business model, especially the open innovation with other firms in different industrials (Pagoropoulos *et al.*, 2017; Andres *et al.*, 2019; Ece *et al.*, 2020).

In this study, we measure the level of digital technology through text mining technology. By using python and machine learning algorithms such as classification and clustering, we extract all digital technology-related terms from the text data of all annual financial reports and news reports of listed companies during the sample period on the website of East Money and build a concise dictionary of digital technology. Therefore, the frequency of the words in the dictionary built above in the annual report of the listed firm is used to measure the digital technology level for the firm (Zhao *et al.*, 2021). More specifically, by dividing the number of digital technology words appearing in Company A's 2018 annual report by the number of words in the dictionary, the number obtained is word frequency, which is used to measure digital technology. Thus, we propose the second hypothesis:

*H2.* Digital technology is playing a mediating role in the impact path of entrepreneurship on CE adoption.

The severe competition of the market is usually the driving force for the firms to do the innovation. By the effective supervision hypothesis of the institution share ratio, the

institutions will have a good perception for the market developing and will monitor the firm managers to take proper strategies for the business (Parthiban and Rahul, 1996). If the institution share ratio is high it is more likely that the firm will do better in the technology development and synergy innovation. However, there are competing theories about the institution such as strategic alliance hypothesis that has the opposite opinion as above. Thus, it is interesting to see whether and how the institution share ratio will influence the entrepreneurship and affect the impact path upon the adoption of CE.

*H3.* The institution share ratio has heterogenous effects for the impact of entrepreneurship on CE adoption.

## 3. The data and methodology

### 3.1 Data description
The empirical study is applied on the China's A-share listed companies from 2010 to 2020. The samples are then selected as follows: (1) exclude samples from the financial and insurance industry; (2) exclude Special Treatment (ST) firms; and (3) exclude the company with missing data. All the firms not excluded in the above steps are remained and 3,804 firms are finally retained. The data are mainly come from the Wind database of China, and the annual reports of listed firms.

### 3.2 Variable selection and measurement construction
The measurement of CE in the firm level is very difficult to construct due to following two reasons: (1) There is still no common agreement on the detailed definition of CE (Kirchherr *et al.*, 2017). (2) While some measurements of 4 Rs are available for macroeconomic level, like the recycling rate of wastes of the country and province, it is usually not available for the firm level. In order to get the measurement for each firm, we use the ESG index (in Wind) here for the proxy variable. The ESG means the environment, social and governance and is a popular evaluation index nowadays for the firms under the sustainable development goals. Although it seems the E part of ESG is even more relevant to the CE measurement, the data with the individual E score in the database unfortunately not enough (only 2 years). Notice that the sustainable development is highly connected to the CE (Millar *et al.* (2019)), the ESG should represent the level of CE to some extends.

The measurement of digital technology (Digit) in firm level is also difficult due to the availability of the data since it is not required to report in the quarterly or annual reports. In this paper, we construct the measure of digital technology by text mining technique. The detailed steps are as follows: First, collecting the firm news from growth enterprise market of listed firms. The time span is from 2010 to 2020. Second, do a manual labeling to find the key words from the media that will indicate that digital technology is used. Among this procedure four graduate students from applied statistics and economics are asked to perform the labeling task. Then, when obtaining the word dictionary of digital technology, we also combine it with the existing dictionary from other researcher in China (Zhao *et al.*, 2021) and form the final dictionary for this study. At last, the frequency of the words in the dictionary built above in the annual report of the listed firm is used to measure the digital technology level for the firm.

Following Gu *et al.* (2021), the entrepreneurship mainly consists of innovation entrepreneurship (IE) and business entrepreneurship (BE). The IE is usually measured by the number of patents or applications of patents of a firm. Here we use patents (lOpatent) in the main panel data analysis and applications of patents are used for the robust checking of the model. The BE is usually refereeing to the adventure and risk-taking spirits for the

entrepreneurs. This paper uses two measures, the first way is to use the asset–liability ratio deviation (Levd) to measure the risk-taking spirit in BE, which is the absolute value of the firm asset–liability ratio minus the average asset–liability ratio of the industry (Tong and Wei, 2010; Xie and Chang, 2017). The second measure is the ratio of risk investment and total asset (risk), which is also used for the robust checking in this paper.

The institution share ratio (insti) measured by the proportion of shares held by banks, insurance companies, and investment trust companies in the company. The sample mean is applied for the division of the two levels (high and low). In this paper, the institution share ratio is high if the ratio is higher than the mean.

Following the existing literature, the control variables used are as follows. Management fee (Mfee) is the ratio between management fee and the total income. ROA is the return of the asset. SIZE is the scale effect of the firm which is measured by the total asset. EPS is the earnings per share of the firm. Growth is the sales growth rate since the previous year. At the same time, the dummy variables year is set up to control the fixed effects of year.

### 3.3 Testing models
The main methodology used here for testing the hypothesis is by the panel data analysis. The role of mediating effect is following the mediating effect analysis framework (Jiang *et al.*, 2012; Gu *et al.*, 2022; Guo *et al.*, 2022). The panel regression model is established as follows:

$$ESG_{i,t} = \alpha_i + \lambda_1 entrepi_{i,t} + \sum control_{i,t} + Year_t + \varepsilon_{i,t} \tag{1}$$

where $entrepi_i$ is the variable of entrepreneurship, either IE (lOpatent) or BE (Levd). ESG is the proxy variable for the measure of CE level.

For the relationship between the entrepreneurship and digital technology (Digit),

$$Digit_{i,t} = \alpha_i + \lambda_1 entrepi_{i,t} + \sum control_{i,t} + Year_t + \varepsilon_{i,t} \tag{2}$$

where $Digit_i$ is the measure of digital technology by the text mining techniques.

For the mediating effects of digital technology, the following regression model is also needed,

$$ESG_i = \alpha_i + \lambda_1 entrepi_{i,t} + \lambda_2 Digit_{i,t} + \sum control_{i,t} + Year_t + \varepsilon_{i,t} \tag{3}$$

By the significance and the sign of independent variables' coefficients, we can check the hypotheses in the previous section. For the heterogenous effects of the institutional share ratio, the above panel models are compared within the two levels of the institutional share ratio.

## 4. Empirical results
### 4.1 Descriptive statistical analysis and correlation analysis
Table 1 shows the results of descriptive statistics of the variables used in the models. The Mfee, SIZE and ROA vary widely for different firms.

According to Pearson correlation coefficient, the correlation level is less than 0.8, so there does not exist multicollinearity for the covariates in the panel models (see Table 2).

### 4.2 Panel regression analysis
Table 3 is the results of the panel regression models for IE, where columns 1, 2 and 3 are the estimated results of the Eqs (1–3) respectively. Coefficients of lOpatent and Digit are all significantly positive at the level of 1%. This leads to two conclusions, the first is that the IE

| Variable | Mean | Median | Sd | Min | Max |
|---|---|---|---|---|---|
| HZesg | 4.081 | 4 | 1.088 | 1 | 8 |
| lOpatent | 0.799 | 0 | 1.089 | 0 | 8.037 |
| digit | 2.093 | 1.609 | 1.951 | 0 | 9.848 |
| lAI | 1.263 | 1.099 | 1.060 | 0 | 5.288 |
| Growth | 33.90 | 10.41 | 2,605 | −122.3 | 437,434 |
| EPS | 0.390 | 0.290 | 0.726 | −10.71 | 21.98 |
| Mfee | 12.93 | 8.995 | 285.1 | 0.0742 | 47,848 |
| SIZE | 12.86 | 12.68 | 1.278 | 8.431 | 18.75 |
| ROA | 6.002 | 5.707 | 7.974 | −184.0 | 104.6 |
| Levd | 16.26 | 14.80 | 11.24 | 3.05e-09 | 157.7 |

**Note(s):** Variable data comes from Wind database and manual sorting

**Table 1.**
Descriptive statistics

| | lOpatent | digit | Growth | EPS | Mfee | SIZE | ROA | risk2 |
|---|---|---|---|---|---|---|---|---|
| lOpatent | 1 | | | | | | | |
| digit | 0.215 | 1 | | | | | | |
| Growth | 0.00390 | −0.00620 | 1 | | | | | |
| EPS | 0.0936 | 0.0427 | −0.0106 | 1 | | | | |
| Mfee | 0.00280 | −0.00110 | 0.00660 | −0.0154 | 1 | | | |
| SIZE | 0.189 | 0.0975 | −0.00220 | 0.110 | −0.0116 | 1 | | |
| ROA | 0.0461 | −0.0275 | −0.0235 | 0.717 | −0.0248 | 0.0196 | 1 | |
| Levd | −0.0392 | −0.0804 | 0.000200 | −0.118 | 0.00870 | 0.00860 | −0.150 | 1 |

**Note(s):** Pearson correlation coefficient analysis was carried out for variables

**Table 2.**
Correlation table

| | (1) ESG | (2) Digit | (3) ESG |
|---|---|---|---|
| lOpatent | 0.0414*** | 0.0588*** | 0.0395*** |
| | (0.0108) | (0.0147) | (0.0108) |
| Digit | | | 0.0340*** |
| | | | (0.0072) |
| EPS | 0.1365*** | 0.0105 | 0.1362*** |
| | (0.0289) | (0.0249) | (0.0288) |
| Mfee | −0.0003 | 0.0005 | −0.0003 |
| | (0.0010) | (0.0007) | (0.0010) |
| SIZE | 0.1292*** | 0.4259*** | 0.1148*** |
| | (0.0194) | (0.0331) | (0.0197) |
| ROA | 0.0026 | 0.0011 | 0.0026 |
| | (0.0019) | (0.0019) | (0.0019) |
| _cons | 2.3691*** | −4.3718*** | 2.5181*** |
| | (0.2365) | (0.4037) | (0.2398) |
| Year effect | Yes | Yes | Yes |
| N | 27,841 | 28,270 | 27,841 |
| F | 25.1381 | 296.0742 | 25.0694 |
| p | 0.0000 | 0.0000 | 0.0000 |

**Note(s):** Standard errors in parentheses, $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. When the **entrepi** is IE (lOpatent), regression is conducted

**Table 3.**
Impact analysis of IE

positively impacts the CE level of the firm and the second is that the digital technology does have a mediating role in the impact path. The mediating effect here is incomplete since the coefficient of lOpatent in the last column is also significant. Notice that all the key coefficients are significant, and the sobel test is not necessary here. The results imply that the firms' IE will improve the CE adoption level of the firms by focusing on the innovation and more specifically by boosting the digital technology. It is because innovations can increase productivity technology, improve the efficiency of resource use, weaken the pollution of production on the environment and fulfill the 4 Rs of CE. Our results here are consistent with the similar study of innovation and sustainable development (Lorente and Alvarez-Herranz, 2016; Gu *et al.*, 2022). And the results here verify the Hypothesis 1 and 2.

Table 4 shows the panel regression results for BE. The coefficients of Levd and Digit are both significant, which means the mediating effect of the digital technology is obvious here again. However, the BE here have a negative effect for both the digital technology level and adoption of CE level of firm. The negative impact of BE on CE is a bit surprising since we usually think the risk-taking sprit and business opportunity-seeking ability might lead to a more circular business model and have a positive inference (Sánchez-Ortiz *et al.*, 2020; Nathalia *et al.*, 2021). The negative effect here possibly due to the following reasons: (1) The circular business model is not the only new business model, and the complex conceptualization and technology gap might hinder the entrepreneur to choose the CE option (Angelis, 2021). (2) Since the measure is built on the asset debt level, there might be a traditional under investment problem (Myers, 1977), which will limit the firm to invest in CE business model building. (3) Since China is an emerging market, the entrepreneurs are more inclined to the relative simpler and high short-term rate of return business opportunities.

The significant negative effect of BE on Digit is also interesting here. As Hanelt *et al.* (2021) pointed, the digital transformation of firm is not a conventional organization change in relation to IT but a shift toward malleable organizational designs that enable continuous

| | (1) ESG | (2) Digit | (3) ESG2 |
|---|---|---|---|
| Levd | −0.0032*** | −0.0028** | −0.0031*** |
| | (0.0009) | (0.0014) | (0.0009) |
| Digit | | | 0.0342*** |
| | | | (0.0072) |
| Growth | −0.0001** | −0.0000 | −0.0001** |
| | (0.0000) | (0.0000) | (0.0000) |
| EPS | 0.1335*** | 0.0075 | 0.1333*** |
| | (0.0287) | (0.0248) | (0.0286) |
| Mfee | −0.0002 | 0.0006 | −0.0002 |
| | (0.0010) | (0.0007) | (0.0010) |
| SIZE | 0.1325*** | 0.4305*** | 0.1178*** |
| | (0.0194) | (0.0330) | (0.0197) |
| ROA | 0.0021 | 0.0006 | 0.0020 |
| | (0.0019) | (0.0020) | (0.0019) |
| _cons | 2.4064*** | −4.3481*** | 2.5557*** |
| | (0.2375) | (0.4051) | (0.2409) |
| Year effect | Yes | Yes | Yes |
| N | 27,841 | 28,270 | 27,841 |
| F | 25.2309 | 293.7887 | 25.1038 |
| p | 0.0000 | 0.0000 | 0.0000 |

**Table 4.**
Impact analysis of BE

**Note(s):** Standard errors in parentheses, *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. When the **entrepi** is BE (Levd), regression is conducted

adaptation. Thus, the complex digital transformation might also bring a cost that may prevent the entrepreneurs, especially in emerging market like China, to employ the digital transformation. And our finding here is partially consistent with Guo and Xu (2021), which stated the digital transformation is in a U-shaped relationship with the profit-based financial performance for firms in China.

### 4.3 Heterogenous effects of institution share ratio

This paper further explores that whether the institutional ownership will affect the influence path of entrepreneurship on CE adoption level of firms. By the traditional theory the institutional investors have relative more professional ability and more abundant resource of the market, and they are able to help the corporate governance and business strategy management (Shleifer and Vishny, 1986). This is called the effective supervision hypothesis of the institutional ownership. However, there are debates about the effectiveness and the competing hypotheses are also given as negative effect (Pound, 1988) or ineffective (Bhide, 1993).

Tables 5 and 6 show the results of IE and BE panel regression with high and low levels of institution share ratio. For the high institutional share ratio with IE, the results are the same as the whole sample. But with the low institutional share ratio, the IE is not significant for the CE adoption. These results are consistent with the effective supervision hypothesis of the institutional ownership. The institutional investors have a positive effect to encourage firms to do innovations that can lead to CE. For the BE, the results of regression (3) and (6) in Table 6 are the same, and the institutional ownership is not taking any effect here, which is consistent with the ineffective hypothesis. Therefore, the institutional ownership behaves differently on the IE and BE in our empirical analysis, these mixed results imply a more complicated situation for improvement suggestions and policy makers.

| | High ISR | | | Low ISR | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | r1 | r2 | r3 | r4 | r5 | r6 |
| lOpatent | 0.044*** | 0.045** | 0.043*** | 0.009 | 0.058*** | 0.007 |
| | (0.015) | (0.021) | (0.015) | (0.017) | (0.020) | (0.017) |
| Digit | | | 0.031*** | | | 0.039*** |
| | | | (0.010) | | | (0.011) |
| Growth | −0.000** | −0.000 | −0.000** | −0.000 | −0.000** | −0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| EPS | 0.113*** | 0.011 | 0.112*** | 0.107** | 0.007 | 0.107** |
| | (0.027) | (0.040) | (0.027) | (0.044) | (0.033) | (0.044) |
| Mfee | −0.003* | 0.001 | −0.003* | 0.001 | 0.000 | 0.001 |
| | (0.001) | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) |
| SIZE | 0.163*** | 0.396*** | 0.150*** | 0.141*** | 0.432*** | 0.124*** |
| | (0.026) | (0.045) | (0.026) | (0.030) | (0.048) | (0.031) |
| ROA | −0.001 | 0.003 | −0.001 | 0.004* | 0.001 | 0.004 |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.002) | (0.003) |
| _cons | 1.879*** | −4.242*** | 2.010*** | 2.455*** | −4.178*** | 2.619*** |
| | (0.328) | (0.573) | (0.329) | (0.348) | (0.558) | (0.354) |
| N | 14,299 | 14,327 | 14,299 | 13,542 | 13,943 | 13,542 |
| F | 14.472 | 162.509 | 14.213 | 16.905 | 114.796 | 17.160 |
| p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Note(s):** Standard errors in parentheses, $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. When the **entrepi** is IE (lOpatent), regression is conducted in low and high ISR (Institution Share Ratio)

**Table 5.** Heterogeneous effect of institutional ownership on IE

| | High ISR | | | Low ISR | | |
| --- | --- | --- | --- | --- | --- | --- |
| | (1) r1 | (2) r2 | (3) r3 | (4) r4 | (5) r5 | (6) r6 |
| Levd | $-0.005^{***}$ | $-0.005^{***}$ | $-0.005^{***}$ | $-0.003^{**}$ | $-0.001$ | $-0.003^{**}$ |
| | (0.001) | (0.002) | (0.001) | (0.001) | (0.002) | (0.001) |
| Digit | | | $0.030^{***}$ | | | $0.039^{***}$ |
| | | | (0.010) | | | (0.011) |
| Growth | $-0.000^{*}$ | 0.000 | $-0.000^{*}$ | $-0.000$ | $-0.000^{**}$ | $-0.000$ |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| EPS | $0.103^{***}$ | 0.002 | $0.103^{***}$ | $0.107^{**}$ | 0.006 | $0.107^{**}$ |
| | (0.027) | (0.039) | (0.027) | (0.044) | (0.033) | (0.043) |
| Mfee | $-0.002$ | 0.002 | $-0.002$ | 0.001 | 0.000 | 0.001 |
| | (0.001) | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) |
| SIZE | $0.170^{***}$ | $0.404^{***}$ | $0.158^{***}$ | $0.140^{***}$ | $0.435^{***}$ | $0.123^{***}$ |
| | (0.026) | (0.045) | (0.026) | (0.030) | (0.047) | (0.031) |
| ROA | $-0.002$ | 0.002 | $-0.002$ | 0.004 | 0.001 | 0.004 |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.002) | (0.003) |
| _cons | $1.887^{***}$ | $-4.229^{***}$ | $2.015^{***}$ | $2.540^{***}$ | $-4.174^{***}$ | $2.704^{***}$ |
| | (0.329) | (0.574) | (0.329) | (0.353) | (0.562) | (0.359) |
| N | 14,299 | 14,327 | 14,299 | 13,542 | 13,943 | 13,542 |
| F | 14.805 | 161.194 | 14.436 | 17.265 | 113.751 | 17.459 |
| p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Table 6.**
Heterogeneous effect of institutional ownership on BE

**Note(s):** Standard errors in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. When the ***entrepi*** is BE (Levd), regression is conducted in low and high ISR (Institution Share Ratio)

*4.4 Endogeneity and robust checking*
In the panel regression model, we might face the endogeneity problem since it is possible that the reversal effect of CE adoption level on entrepreneurship exists. We apply the instrument variable method by using the one period lag of the entrepreneurship proxy variables. For the robust checking, we replace the measure of patents by the applications of the patents for IE and replace the firm liability deviation by the risk investment of the firm for BE. The risk investment is the long-term financial investment plus the accounts receivable, then divided by the total asset. The results are represented in Table 7.

Form Table 7 we can see the sign and significance levels are the same as our main regression results above, which validates our empirical results.

## 5. Discussion
In the past decade, CE has gained widespread attention since the severe industrial pollutions and scarcity of the natural resources. In firm level, entrepreneurship has a profound impact on the development and operation of the company, and the unclear relationship between entrepreneurship and the possible paths to achieve CE. We proposed a question: whether and how the entrepreneurship influences the CE? Considering the current dissemination and use of digital technology, we want to know whether digital technology will play a role as an intermediary factor in the influence path of entrepreneurship on CE.

In the present study, we investigated the role and effect path of the firm's entrepreneurship for the transformation of CE especially in emerging market. Specially, we proposed a mediation effect analysis method for the hypothesis test, and the endogeneity of the model was solved by endogeneity and robust checking. Through the regression results, we find the IE positively impacts on the CE adoption level of firms while BE is negative. This result is consistent with our hypothesis and previous studies, such as Hanelt *et al.* (2021).

| | (1) ESG | (2) ESG | (3) ESG | (4) ESG |
|---|---|---|---|---|
| lOpatent | 0.0928*** | | | |
| | (0.0268) | | | |
| Levd | | −0.0073*** | | |
| | | (0.0014) | | |
| lApatent | | | 0.0536*** | |
| | | | (0.0090) | |
| risk | | | | −0.4126*** |
| | | | | (0.1591) |
| digit | 0.0384*** | 0.0392*** | 0.0330*** | 0.0358*** |
| | (0.0058) | (0.0057) | (0.0072) | (0.0072) |
| Growth | −0.0000 | −0.0000 | −0.0001** | −0.0001** |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| EPS | 0.1105*** | 0.1008*** | 0.1338*** | 0.1285*** |
| | (0.0170) | (0.0170) | (0.0288) | (0.0284) |
| Mfee | −0.0002 | 0.0001 | −0.0003 | −0.0002 |
| | (0.0005) | (0.0005) | (0.0010) | (0.0010) |
| SIZE | 0.1271*** | 0.1367*** | 0.1136*** | 0.1148*** |
| | (0.0145) | (0.0144) | (0.0197) | (0.0198) |
| ROA | 0.0029** | 0.0018 | 0.0025 | 0.0026 |
| | (0.0013) | (0.0013) | (0.0019) | (0.0019) |
| _cons | 2.3875*** | 2.4584*** | 2.5059*** | 2.5881*** |
| | (0.1775) | (0.1781) | (0.2394) | (0.2441) |
| N | 24,159 | 24,159 | 27,841 | 27,841 |

**Note(s):** Standard errors in parentheses, $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. ESG with one stage lag is used as instrumental variable, lApatent and risk are used for robustness checking

**Table 7.**
Instrument variable regression and robust checking

In addition, IE promotes the technological progress of enterprises and further exacerbates the environment through the mediation effect of digital technological progress. The mediating effect of digital technology in BE's influence path is also significant although the impact of BE is negative on CE. Besides, the institutional investors positively affect the IE on firms' CE adoption levels.

### 5.1 Theoretical and practical implications

This paper makes theoretical contributions to the CE and entrepreneurship literature. First, our results confirmed that entrepreneurship ties closely with business activities and plays an important role in innovation and sustainability (Al-Mamary and Alshallaqi, 2022; Andati *et al.*, 2022; Botella-Carrubi *et al.*, 2022; Vasilescu *et al.*, 2022). We successfully provided another perspective of the role of entrepreneurship in the CE through the innovation and mediating role of digital technology. Second, we identified the different effects of IE and BE on CE and refine the research field. Inspired by Guo *et al.* (2022) and Nageshwaran *et al.* (2021), we use digital technology as an intermediary variable, which facilitates innovation research. Digital technology, by using our established measurement method, we believed that it is a mediating role in the path of entrepreneurship on CE. Thus, our study also expanded the criteria for measuring the level of digital technology adoption in companies. Besides, the study on the firms here provides another perspective of the literature aiding the study of emerging economies.

And our findings hold important practical implications. Gu *et al.* (2022) investigated in multiple countries how does the sustainable entrepreneurship work. Furthermore, this article focuses on entrepreneurship and CE in emerging markets, which extends the similar research

like Dana *et al.* (2022) to the firm level in the emerging market. Besides, the use of digital technology should be focused more and it might be essential in the entrepreneurs' decision-making of CE adoption.

### 5.2 Limitations

Notwithstanding these insights, our study is subject to some limitations. Measurement of digital technology created by text mining technique, although referring to Zhao *et al.* (2021), the effectiveness of this indicator might be further considered.

### 5.3 Future lines of research

We suggest the future research in the two directions: Firstly, a detailed sampling survey on the management of firms might be performed to help studying the companies' decision-making on CE adoption in terms of entrepreneurship through digital technology. Secondly, the measurement of the digital technology is a tough challenge and can be further studied.

## 6. Conclusion

In this paper, we investigated the role and effect path of the firm's entrepreneurship for the transformation of CE especially in emerging market. Specially, we devised a way to measure the level of digital technology and proposed a mediation effect analysis method for the hypothesis test, and the endogeneity of the model was tested by endogeneity and robust checking. Our results confirm the proposed hypothesis and the theory are tested. Innovative entrepreneurship has a significant positive impact on the CE, with digital technology mediating the impact path. However, BE has a negative effect on the adoption of CE. In addition, the proportion of shares held by institutions has a heterogeneous effect on innovative entrepreneurship.

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*Expression of concern:* The publisher of Management Decision is issuing an Expression of Concern for the following article "Gu, W., Li, L., Zhang, S. and Yi, M. (2023), "The path analysis of entrepreneurship impacts on circular economy in emerging markets: a mediating role of digital technology", *Management Decision*, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/MD-11-2022-1595", which was submitted to the guest-edited special issue 'Navigating the role of circular economy in entrepreneurship: Opportunities and challenges'. An investigation by the publisher found a number of articles with multiple concerns, including but not limited to compromised editorial handling and reviewing, undisclosed conflicts of interest, and lack of suitability for the scope of the journal. As a result of these concerns and as trust in the content is central to the integrity of the publication process, the Editor-in-Chief and publisher have taken the decision to publish an Expression of Concern for all articles within this special issue. The journal has not been able to confirm whether the authors were aware of these concerns. An investigation is ongoing and is currently unresolved. Further information will be provided by Management Decision as it becomes available.