Forging organizational resilience through green value co‐creation: The role of green technology, green operations, and green transaction capabilities

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Forging organizational resilience

Abstract

The study assessed the mediating role of green organizational capabilities (green technology development, green operations, and green transactions), in the relationship between green value co-creation and organizational resilience among Chinese manufacturing firms. That is, firms' ability to build strong organizational resilience in response to the COVID-19 pandemic. It focused on manufacturing firms operating within Shenzhen, a coastal city located within the Guangdong province in south-eastern China. The sample comprised 234 firms. Data were analyzed using a covariance-based structural equation modelling. Findings revealed that green value co-creation had no direct effect on organizational resilience, rather, its effect was realized indirectly through green organizational capabilities. The study concludes that manufacturing companies can augment their organizational capabilities by leveraging the knowledge of their customers through green value co-creation to build strong organizational resilience. Theoretical and managerial implications have been provided.

Keywords: *Green value co-creation; organizational resilience; manufacturing firm; green technology; green operations; green transaction*

1. Introduction

The advent of the COVID-19 pandemic has led to a global economic meltdown, with every country having its share of the loss (UNDP, 2020). Consumption patterns were disrupted, especially in the year 2020, when consumers focused on the purchase of necessary goods. This caused a lot of firms to either reduce their workforce or fold up, with some also diversifying their production lines, to meet up with the new consumption trend in the market (Amankwah-Amoah et al., 2021). These radical changes in the business environment, call for firms to be resilient to remain in business. Building organizational resilience is essential for firms, to cope with an unexpected crisis such as the COVID-19 pandemic (Resilience Destinations, 2020). Resilient organizations can anticipate, cope with, and recover from business disruptions (Duchek, 2020; Wang et al., 2022). According to Witmer (2019), organizational resilience enables firms' ability to project a disruption, manage it when it occurs, and learn from it to prepare for future occurrences, without deviating from the core business objective. Discussions on how firms could build resilience are, however, inconclusive, as multiple variables have been identified to influence organizational resilience (Barasa et al., 2018).

China, one of the largest manufacturing hubs in the world, was one of the hardest hits by the COVID-19 pandemic (Shen et al., 2020). The coronavirus was first reported by China and followed up with strict measures in curbing the disease, including lockdowns, border closures, etc. When the virus spread to other countries, and consumer purchase patterns began to change, Chinese manufacturing firms which were not into the manufacturing of essential goods, began to see a decline in sales (Zhao et al., 2021). Some firms began diversifying into the production of COVID-19 Personal Protective Equipment (PPEs) (such as face masks, face shields, sanitisers, etc.) since that was in high demand globally (Addo et al., 2020). The COVID-19 pandemic has, however, not been all negative affair, but has also helped to point out the devastating effects of business operations on the ecological environment.

A study by Muhammad et al. (2020) demonstrated that the outbreak of the COVID-19 pandemic was a blessing in disguise, as they noted that during the periods of lockdown and less economic activities, environmental pollution was reduced by 30%. This being identified, external stakeholders (such as consumers, suppliers, media, governments, international organizations, etc.) are also becoming increasingly conscious of the devastating effects of natural resource depletion, thereby pressuring firms to inculcate environmental sustainability policies and strategies into their business operations, to reduce environmental impact (Taoketao et al., 2018). Adopting proactive environmental strategies by firms grants them favourable image and reputation, and enhances their market, financial and environmental performance, leading to an enhanced competitive advantage (Baah et al., 2021). Collaborating with key stakeholders such as consumers and suppliers is essential for the success of the firm's green initiatives. This study sought to therefore identify how green characteristics (such as green value co-creation and green capabilities) could enhance Chinese manufacturing firms' resilience amid business environmental turbulence and crisis.

The study aims to explore how manufacturing firms could forge organizational resilience through green value co-creation by leveraging capabilities in response to the pandemic (COVID-19). A model based on the Natural Resource-Based View (NRBV) is developed and tested with data from firms in one of the largest manufacturing hubs in the world (China). The rest of the paper covers the theoretical background and the hypotheses development. This is then followed by the methodology adopted for the study which highlights the research design and method of data collection and analysis. The results of the study are then presented and discussed with the paper concluding with implications and suggestions for future studies.

2. Theoretical Background and Hypotheses Development

The study is founded on the Natural Resource-Based View (NRBV), which proposes that firms could achieve a competitive advantage through their relationship with the environment (Hart, 1995). A firm's capability to consistently enhance and refine its production process could lead to reduced environmental pollution, lower costs in the long-term, and could also offer some first-mover advantages and a sustained customer base (Chen and Kim, 2021). NRBV also demonstrates that the resources needed by firms to achieve competitive advantage are not fully controlled by the keystone, but are also found in their interaction with other stakeholders (such as customers and suppliers) (Andersén, 2021). For example, Adidas and Nike partnered with environmental organizations (Parley and FieldTurf respectively), to help in recycling ocean plastics, used sportswear and production waste for the manufacturing of their sportswear (Borah et al., 2021). These firms tapped into the environmental knowledge of external firms such as Parley and FieldTurf, to achieve a competitive advantage through green production. Crasto et al. (2020) identified that, in 2018, Adidas sold 5 million pairs of shoes made from recycled ocean plastics. This suggests that Chinese manufacturing firms could achieve resilience, not only through their internal green capabilities (green development and green operations) but also through external networks like green value co-creation.

2.1 Green value co-creation and organizational resilience

Jensen et al. (2007) identified two approaches to national innovation systems, which are; codified and explicit knowledge derived from formal processes of R&D, and tacit knowledge derived from informal interactions within and between firms. This study focuses on generating tacit knowledge through firms' engagement with customers, to co-create value. Romero and Molina (2009) defined value co-creation as the process by which firms engage or involve their customers and business allies to jointly create value, with the aim of achieving competitive advantage. Co-creation is however, not limited to the joint value creation for existing products, but could also lead to the creation of innovative solutions to shared problems (Ferlie et al., 2019), such as the effects of COVID-19 pandemic. Value co-creation in general, has been identified to potentially contribute towards organizational resilient. In public governance, Morais et al. (2022) identified that co-creation helps public sector to achieve better results for society, including building strong resilience during turbulent times. Bethune et al. (2021) also studied how value co-creation could enhance destination resilience during disaster, using interconnected smart system. Resilient healthcare was also identified to be achieved through co-creation and collaborative learning (Bergerød et al., 2022). Value co-creation has been studied by many researchers (Tian et al., 2021; Das, 2020), however, inculcating green concepts into value co-creation has seen limited discussion among researchers (Chang, 2019; Li et al., 2020). With the rise in increased green consciousness and stakeholder pressure, it is essential to consider how green value co-creation could also enhance manufacturing firms' resilience.

Green environmental behaviour by firms has gained ground in literature for the past two decades. This is a reflection of the environmental consciousness of firms, as a result of the increasing stakeholder pressure for the implementation of environmentally-friendly practices by firms (Borah et al., 2022). In China's manufacturing industry, the adoption of green knowledge exchange between firms and their external stakeholders (especially customers) is very essential for their sustainability (Kong, 2016). Green value co-creation considers the exchange of environmental knowledge between the firm and its customers, during the process of production and the consumption stage (Yousaf, 2021). Green consciousness among consumers is pushing firms to adopt green practices. To satisfy consumers' green value demands, firms engage consumers (through the exchange of green knowledge), to co-create green value for their consumers.

Some prior studies have suggested that green initiatives enhanced organizational resilience. Ullah et al. (2022) found out that firms that engaged in green supply chain management, had their market prices recover much faster from business shocks and disruptions caused by the COVID-19 pandemic. Vargas-Hernández and Calderón-Campos (2022) identified that environmentally responsible enhanced organizational resilience. The findings from Yang and Xiao (2021) also revealed that green strategies improved the flexibility and stability of firms, by helping to reduce the stock volatility of the firms and increasing firm profitability. Findings from these studies thus suggest that green value co-creation could thus also enhance organizational resilience among Chinese manufacturing firms. It was therefore hypothesized that:

H1: Green value co-creation has a direct positive effect on organizational resilience among Chinese manufacturing firms.

2.2 Mediating role of green technology development capability

Based on the Natural Resource-Based View (NRBV), the organizational resilience of the firms represents the competitive advantage, whilst green value co-creation also relates with the environment (Hart, 1995). However, since firms' relationship with the environment can be achieved through interaction with their customers (through green value co-creation), the framework posits that for firms to achieve resilience, they have to do so through leveraging their internal green capabilities. Hence, we looked at how green capabilities could potentially intervene in the relationship between green value co-creation and organizational resilience among Chinese manufacturing firms. This study focused on three organizational capabilities (technology development, operations and transaction capabilities) identified in Zawislak et al.'s (2012) Capability-Based Model of firm innovation. This study inculcated green dimensions into these organizational capabilities. The role of organizational capabilities in general, in enhancing organizational resilience has been established by some researchers (Duchek, 2020; Witmer and Mellinger, 2016). However, the role of green organizational capabilities is not well established, especially, considering the individual dimensions enumerated above.

Eriksson et al. (2014) identified that co-creation is essential for technology business development, while Liwång (2022) also identified that co-creation contributes towards filling the gap between policy-makers and technology development. Within the semiconductor industry, co-creation has been identified as an innovative way for new technology development, through its risk-sharing potential (Banerjee & Sharma, 2015). Technology development (such as institutional system AI solutions), has also been found to improve organizational resilience, by making firms more responsive and effective (Lauri et al., 2023). Despite these findings, little is known of the relationships that exist between the green dimensions of these variables (green value co-creation, green technology development, and organizational resilience).

Green technology development is defined as firms' appreciation of nature or the natural environment, which influences firms' efficient use of resources for organizational expansion and profitability (Wang et al., 2021; Sahoo et al., 2022). Green technology development capability helps firms to grow within specific timelines, taking into consideration the environmental impact of its growth (Perruchas et al., 2020; Wicki and Hansen, 2019; del Río González, 2005). Firms' ability to grow without overly hurting the natural environment could be influenced by green value co-creation, and this could potentially lead to enhanced organizational resilience among Chinese manufacturing firms. It was therefore hypothesized that:

H2: Green technology development capability mediates the relationship between green value co-creation and organizational resilience among Chinese manufacturing firms.

2.3 Mediating role of green operations capability

Le and Zhu (2022) assessed digital operation management based on value co-creation, and found out that, in realizing overall value co-creation, supply chain management system combines the links of operation using information integration capability. Value co-creation through entanglements of identity and creation of experience is seen as critical ingredients for the success of church operation (Lugosi, 2014). Within the hospitality and catering sector, ideological, normative, and situational dimensions of value co-creation are deemed essential for shaping who participates in the production and consumption of hospitality (Lugosi, 2009). Sjödin et al. (2017) stated that value co-creation is a critical ingredient for the success of integrated product-service offerings. Despite these findings, little is known about the relationship between the green dimensions of value co-creation and operational capability, and how that could influence organizational resilience.

Green operations capability represents firms' ability to inculcate environmental practices such as eco-design, cleaner production, and recycling or reuse of materials, into its product development to the management of the whole product life cycle (Nunes and Bennett, 2010). Green operations capability focuses on reducing costs related to manufacturing, distribution, use, and disposal of end products, by protecting the environment (Wang, 2015). A firm's ability to engage in green operations could be determined by its engagement with customers for green value co-creation. Building a resilient organization is also dependent firm's ability to develop green products which will meet the needs of the ever-increasing green consumers. It was therefore hypothesized that:

H3: Green operations capability mediates the relationship between green value co-creation and organizational resilience among Chinese manufacturing firms.

2.4 Mediating role of green transaction capability

Studies such as Xiao et al. (2020) found that value co-creation enhanced transaction cost of firms. Similarly, Siaw and Sarpong (2021) found that exchange capabilities for value co-creation in ecosystems are essential for the maximization of resource potentials within firms. Schmidt et al. (2022) also assessed how firms could leverage emergent social interactions for value co-creation on transaction platforms. This notwithstanding, the relationship between green value co-creation and green transaction capability, and their subsequent effect on organizational resilience, has been underexplored.

Green transaction capability also represents a firm's ability to reduce transaction costs associated with outsourcing, marketing, bargaining, delivery and logistics, without compromising environmental protection (Fuerst and Shimizu, 2016; Zawislak et al., 2012). Transaction costs simply refer to the search costs, bargaining costs, contracting costs, and enforcement costs (Coase, 1960). Transaction cost analysis helps firms to make decisions regarding investments in distribution channels and international markets. A firm's ability to successfully execute these activities efficiently and effectively, with less destruction to the natural environment, is what we referred to as green transaction cost. This capability could help the firm achieve a sustainable competitive advantage (Chu et al., 2018). By exchanging environmental ideas with consumers through green value co-creation, manufacturing firms could be pushed to adopt green transaction costs, and this could subsequently lead to organizational resilience during the crisis. It was therefore hypothesized that:

H4: Green transaction capability mediates the relationship between green value co-creation and organizational resilience among Chinese manufacturing firms.

Figure 1. Conceptual Framework

3. Methods

3.1. Sample and Data Collection

The study focused on manufacturing firms operating within Shenzhen. Shenzhen is a coastal city located within the Guangdong province in south-eastern China and also borders Hong Kong. Shenzhen has over the years attracted many foreign direct investments and has become the hub for the world's telecommunications devices supply, with its port being one of the world's busiest (Zhang et al., 2020). With the advanced industrialization within the city, there are concerns for firms to operate under environmentally sound principles, to reduce the harmful effect of operations on the natural environment. In November 2022, the PM2.5 concentration in Shenzhen was 18.5µg/m³, 3.7 times above the WHO annual air quality guideline value (IQAir, 2022).

The entire data collection spanned 12 weeks. Trained field assistants were employed to assist in the data collection. The study adopted a structured questionnaire, and each manufacturing firm was assigned one questionnaire. There were 500 questionnaires printed and distributed to the manufacturing firms within the city. A cover letter indicating the purpose of the study, the name of the principal investigator and the contact details, and the category of employees who qualified to respond to the questionnaire. The field assistants were also master's degree students and were therefore expected to show their student ID cards, as proof that the study was purely an academic exercise.

The respondents to the study were management members from various organizational units including operations, distribution, marketing and sales, procurement, and accounts. The firms were given 2 weeks to complete the questionnaire and either emailing (by scanning) or picked up in person by the field assistants. Contact details (phone and email) of the firms were also taken, and reminders were sent to unresponsive firms, during weeks 4 and 8. After week 12, the entire data collection process was brought to a close. At the end of the process, 234 questionnaires were realized as appropriately filled and fit for the data analysis. Firms came from technology and non-technology sectors.

In assessing the non-response bias, Armstrong and Overton's (1977) approach was adopted, where early responses were compared to late responses. A *t*-test was conducted to assess if there existed any significant difference in the mean scores of both the early (first 2 weeks of data collection) and late (last 2 weeks of data collection) responses. The results pointed out no significant difference in the scores of early ($n = 97$) and late ($n = 41$) responses, and as such, it was concluded that there existed no non-response bias.

3.2. Measures

A structured questionnaire was adopted for this study, with measurement items being adapted from past studies. The questionnaire was pilot-tested using 20 Executive MBA students, who were mostly in managerial positions at their various places of work. Their input helped in finetuning the statements for the development of the final questionnaire. The questionnaire was first developed in English and then translated to Chinese for the data collection since most of the respondents were handicapped in the English language. A parallel translation proposed by Malhotra and Birks (2007) was adopted. Three university professors in the area of management studies, who had some academic education from the USA and England were contacted to assist with the translation. These professors were proficient in both Chinese and English languages. Two of the professors were requested to independently translate the questionnaire from English to Chinese. The translated versions were given to the second professor for synchronization.

The questionnaire had seven sections. Section A had the name of the company, respondent's position, nature of the firm (technology and non-technology), number of employees, and age of the firm. The size of the firm (measured using the number of employees), industry (nature of firm), and age were used as control variables in this study, in congruence with studies such as Xie et al. (2022). Section B had measurement items of green value co-creation, Section C presented items under green technology development capability, Section D represented green operations capability, Section E presented green transaction capability, Section F had organizational resilience, and the last Section presented the measurement items under Socially Desirable Responding (SDR). Measurement items under green value co-creation were adapted from Chang (2019). Measurement items under green technology development, green operations, and green transaction capabilities were developed from the works of Zawislak et al. (2012), Wang et al. (2021), and Fuerst and Shimizu (2016). The measurement items under organizational resilience were adapted from Rai et al. (2021), and that of SDR was adapted from Strahan and Gerbasi (1972) and Borah et al. (2021).

There were 5 measurement items under green value co-creation, 4 under green technology development capability, 3 under green operations capability, 5 under green transaction capability, 6 under organizational resilience, and 7 under SDR. The variables studied were all first order, and measured reflectively. Measurement items under Sections B to F were responded to on a Likert scale of 1 (strongly disagree) to 7 (strongly agree). Measurement items under SDR were responded to on a Likert scale of 1 (strongly disagree) to 5 (strongly agree)(Appendix 1**)**.

3.3. Confirmatory Factor Analysis and Reliability Analysis

A covariance-based approach to structural equation modelling (SEM) was adopted by this study, using AMOS (v.23) software. Constructs were reflectively measured, and the results of the confirmatory factor analysis (CFA) were presented in Table 1 and Figure 2. The least expected standardized factor loading was 0.5 (Dogbe et al., 2020), which was achieved, as GTDC4 had the least score of 0.674. The maximum likelihood approach was adopted in the model estimation.

For the model-fit indices, CMIN/DF is expected to be ≤ 3, GFI ≥ 0.8, PClose > 0.5, TLI and CFI ≥ 0.9, and RMSEA and SRMR are also expected to be ≤ 0.08 (Hair et al., 2010; Brown, 2014). Results in Table 1 demonstrate that all these thresholds were met, and as such, it was concluded that the dataset appropriately fit the structural model.

The average variance extracted (AVE) and composite reliability (CR) was calculated using the CFA factor loadings. To achieve uni-dimensionality (convergent validity), AVE was expected to be > 0.5, and CR ≥ 0.7 (Fornell and Larcker, 1981). Results indicated these were achieved for all the constructs in the study (Table 1).

Cronbach's alpha (CA) analysis was run in SPSS (v.23) to assess the reliability of the measurement items. In tandem with studies such as Dogbe et al. (2020), the minimum expected value of 0.7 was achieved for all the measurement items in the model (Table 1). Green technology development capability had the least alpha score of 0.829, and therefore, internal consistencies were achieved under each construct.

Table 1. Confirmatory Factor Analysis (CFA)

Figure 2. Confirmatory Factor Analysis

3.4. Common Method Bias (CMB) and Socially Desirable Responding (SDR)

Podsakoff et al. (2012) recommended some procedural and statistical methods for mitigating common method bias (CMB). As procedural measures, this study pilot-tested the questionnaire, to ensure all ambiguous statements were refined before the main data collection began. Also, the respondents were provided with the actual labels of the various points on the 7-point Likert scale and not just the endpoints.

Correlation-based marker variable approach was adopted as the statistical measure of CMB. Podsakoff et al. (2012) recommended that a marker variable is supposed to be theoretically unrelated to the constructs in the model. The study used the SDR scale, as it met this condition. The study controlled for SDR by running a partial correlation using SPSS (v.23). CMB is said to be present when the partial correlation scores are significantly different from the zero-order correlation scores. Results presented in Table 2 suggest there was no CMB, as the partial correlations (above the diagonal) were not significantly different from the zero-order correlation scores (below the diagonal). The significant levels and direction of relationships were the same in both the controlled and zero-order correlations. Also, Harman's one-factor test was conducted, and the results demonstrate that the first extracted component had a variable of 42.223%, lower than

50%. No single factor, therefore, explained the majority of the variance in the model and was thus concluded that there was no CMB (Podsakoff and Organ, 1986).

Furthermore, in this dispensation of green consciousness, there was a high tendency for respondents to respond favourably to the green dimensions, contrary to what their firms do. This phenomenon is referred to as a Socially Desirable Responding. SDR is said to be present when there exists a high correlation between the SDR scale and the constructs in the model (Strahan and Gerbasi, 1972). From Table 2, it could be realized that the highest correlation was between SDR and green transactional capability – TRANS ($r = 0.094$), which was low.

3.5 Descriptive Statistics, Normality and Discriminant Validity

The five main variables of the study were measured on a 7-point Likert scale, while SDR was measured on a 5-point Likert scale. Under the main constructs, organizational resilience (RES) had the highest mean score of 5.891. To check for normality in the distribution, skewness and kurtosis tests were conducted. For a distribution to be considered normal, the value of skewness is expected to be ±2 and kurtosis of ±7 (Bryne, 2010; Hair et al., 2010). Results presented in Table 2 indicated a normal distribution for all the variables, as the scores fell within the acceptable range.

To achieve discriminant validity, the squared root of the AVEs (√AVEs) must be larger than the corresponding correlation coefficients (Borah et al., 2021). From Table 2, the highest correlation among the main variables was 0.522 (between green transaction capability – TRANS and green value co-creation – COCR), and the least √AVE was 0.754. This suggests that discriminant validity was achieved by this study. Since the entire correlation coefficient in the entire model was 0.522 (< 0.7), it implies there was no multicollinearity which could cause a confounding effect in the model estimation (Tabachnick and Fidell, 2007).

Table 2. Normality, Discriminant Validity, and Common Method Bias Tests

4. Findings

The path analysis was run using a covariance-based Structural Equation Modelling (SEM) in Amos (v.23) software. The Bias-Corrected (BC) percentile method of bootstrapping was adopted, with 5000 bootstrap samples, and a 95% confidence level. Since there were multiple mediators, Sobel's test was conducted to ascertain the statistical significance of each of the indirect effects. The results of the estimation were presented in Table 3 and Figure 3. Results indicated that both the sizes of the firms and the industry had negative and statistically insignificant effects on organizational resilience (p-values > 0.05). The age of the firm also had a positive but statistically insignificant effect on organizational resilience among Chinese manufacturing firms (p-values > 0.05).

For the hypothesized paths, it was identified that green value co-creation had a positive but statistically insignificant effect on organizational resilience among Chinese manufacturing firms ($\beta = 0.125; p > 0.05$). Hypothesis H1: Green value co-creation has a direct positive effect on organizational resilience among Chinese manufacturing firms, which was thus rejected by the study.

From the results presented, green value co-creation had a significant positive effect on green technology development capability ($\beta = 0.425; p < 0.01$). Green technology development capability had a significant positive effect on organizational resilience ($\beta = 0.281; p < 0.01$). The coefficient of the indirect effect of green technology development capability was 0.119, and Sobel's test indicates this was statistically significant. Hypothesis H2: Green technology development capability mediates the relationship between green value co-creation and organizational resilience among Chinese manufacturing firms, which was thus supported by this study.

Results showed that green value co-creation had a significant positive effect on green operation capability ($\beta = 0.301; p < 0.01$). Green operation capability had a significant positive effect on organizational resilience ($\beta = 0.189; p < 0.01$). The coefficient of the indirect effect of green operation capability was 0.057, and Sobel's test indicates this was statistically significant. Hypothesis H3: Green operations capability mediates the relationship between green value co-creation and organizational resilience among Chinese manufacturing firms, which was thus supported by this study.

It was further identified that green value co-creation had a significant positive effect on green transaction capability ($\beta = 0.576; p < 0.01$). Green transaction capability had a significant positive effect on organizational resilience ($\beta = 0.228; p < 0.01$). The coefficient of the indirect effect of green transaction capability was 0.131, and Sobel's test indicates this was statistically significant. Hypothesis H4: Green transaction capability mediates the relationship between green value co-creation and organizational resilience among Chinese manufacturing firms, which was thus supported by this study.

Table 3. Path Coefficients

Figure 3. Structural Equation Model

5. Discussions and Contributions

The first contribution of this study was premised on the findings that green value co-creation had no direct effect on organizational resilience among Chinese manufacturing firms. Firms engage in green value co-creation by sharing or exchanging green knowledge with consumers (Chang, 2019). This does not directly contribute to organizational resilience in periods of business turbulence. Rather, green value co-creation helps firms to build their green capabilities (technology, operation, and transaction), which positions firms to withstand turbulence, thereby becoming resilient.

Green technologies are essential in this era of green consumerism, where consumers are willing to pay more for green products. The study by Krass et al. (2013) found that consumers were willing to pay more for hybrid-electric cars. Manufacturing firms could only know about the preferences of their consumers when consumer value is co-created together with the consumers. Green value co-creation will help firms to identify specific green needs which could maximize consumer value, and through which firms could make specific investments in green technologies. Ramdhani et al. (2017) identified four dimensions of technology, which were technoware (physical facility and production equipment), humanware (human ability), infoware (information device and blueprint) and orgaware (organizational framework). Green technologically competent firms will not just make investments in technologies, but will consider the environmental impacts in buying the technoware, hiring technicians, developing a technology blueprint, and development of the organizational framework. Firms with green technology capability can remain relevant during business turbulence, thereby becoming more resilient. They tend to enjoy more consumer support during challenging times. Green technologies also significantly reduce the cost of mitigating CO2 emissions (Du and Li, 2019), thereby enhancing their cost-saving abilities in turbulent times.

Green operations encompass the integration of environmentally sound principles into a firm's operations management, including product development, product lifecycle management, manufacturing, and supply chain management (Moosa and He, 2022). Liu et al. (2017) identified green design (eco-design), green purchasing (green procurement), and green manufacturing, as the components of green operation. Green operation is founded on product stewardship, where the focus is not just on pollution prevention, but rather on the entire value chain or life cycle of the product systems (Hart, 1995). Through stakeholder engagements, the "voice of the environment" can be effectively integrated into the product design and development process (Maio, 2003). Green value co-creation, therefore, provides the platform by which firms discuss the environmental needs of consumers (as a stakeholder), and inculcate their concerns into the design and development of products. Green operation capability has been found to grant firms a market advantage (Zhu et al., 2012). Das (2022) also identified that green operations enhanced the competitive advantage of firms. Green operation capability grants firms an advantage, as it enables them to provide differentiated products, charge a premium price, enhance their green image, generate customer loyalty, save costs through lower waste management fees, fewer risks of accidents and liabilities, and lower fines from environmental regulators (Liu et al., 2017; Emmett and Sood, 2010; Marchi et al., 2013). These advantages make manufacturing firms more resilient during turbulent business seasons.

Another key contribution of this study was the introduction of green transaction capability into the model. Much attention in the literature has focused largely on transaction costs, with very little attention on green transactions. Green transaction capability encompasses a firm's ability to reduce transaction costs associated with outsourcing, marketing, bargaining, delivery and logistics, without compromising environmental protection (Fuerst and Shimizu, 2016; Zawislak et al., 2012). Transaction cost economics focused on the alternative means of organizing transactions which leads to the minimization of transaction costs (Williamson, 1979). The transaction cost theory suggests that the ideal governance structure grants economic efficiency to the firm, by minimizing the costs of exchange (Williamson 1979, 1986). Each transaction leads to costs associated with monitoring, controlling, and managing the transaction, and the focus is to minimize these costs by going in for the governance structure which meets this objective (Young, 2013). The focus here is on cost minimization, without recourse to the effect of transactions on the natural environment. This present study introduced green dimensions into transactions, by not just focusing on cost minimization, but transaction cost minimization without hurting the natural environment. Findings from this study indicate that green value co-creation pushes firms to build their green transaction capability, which ultimately enhanced their resilience during turbulent business periods. Green transaction capability helps firms to minimize cost, and are therefore able to remain efficient and effective during turbulent times.

The study further contributes to the Stakeholder Theory. This theory is a capitalist view that focuses on the interconnected relationships a firm has with its stakeholders (including, customers, suppliers, employees, managers, investors, communities, government, creditors, shareholders, etc.

(Freeman, 1999). The theory posits that businesses are expected to create value for all stakeholders, and not just the owners or shareholders (Steurer, 2006; Marcon et al., 2023). It focuses on business and management ethics that addresses morals and values in managing an organization (Hörisch et al., 2020). The present study looked at green value co-creation, where firms engage customers in co-creating green consumer value. Giving due regard to the interests of customers, therefore, positions this study to fit into the stakeholder theory.

6. Conclusion and Managerial Implications

The study assessed the mediating role of green organizational capabilities (green technology development, green operations, and green transactions), in the relationship between green value co-creation and organizational resilience among Chinese manufacturing firms. It was concluded that green value co-creation had no direct effect on organizational resilience, rather, its effect was realized indirectly through green organizational capabilities. That is, green technology development capability, mediated the relationship between green value co-creation and organizational resilience. Also, green operation capability mediated the relationship between green value co-creation and organizational resilience. Finally, green transaction capability mediated the relationship between green value co-creation and organizational resilience. The following managerial implications were provided.

The advent of COVID-19 has had a great toll on business operations across the globe. Businesses were displaced, as consumption patterns got altered. Building organizational resilience is thus essential for the survival of businesses in a turbulent business environment. It is recommended to the management of manufacturing firms invest in green competencies. Green competencies enable firms to significantly reduce the cost of mitigating CO2 emissions, provide differentiated products, charge a premium price, enhance their green image, generate customer loyalty, save costs through lower waste management fees, fewer risk of accidents and liabilities, and lower fines from environmental regulators. Firms could therefore operate efficiently and effectively even in turbulent times, thereby enhancing their resilience.

Green value co-creation augments green organisational capabilities. Knowledge gained by employees from value co-creation activities serves as a viable knowledge platform for competitive advantage. It is therefore recommended that manufacturing firms enhance their sharing and exchange of green knowledge with their consumers, to enable firms to co-create green values for consumers whilst enhancing their competitiveness and sustainability even in the face of uncertainties such as pandemics.

7. Limitations and Future Research Suggestions

The present study assessed the mediating effects of the individual dimensions under green organizational capability. In as much as the study provided some interesting findings, future studies are encouraged to consider the higher-order variable (green organizational capability). This may offer some more interesting results on the relationship between green value co-creation and organizational resilience.

Secondly, the data for the study was gathered from Shenzhen, a coastal city located within the Guangdong province in south-eastern China. The city has its characteristics, which may potentially influence the outcome of the study. For example, the city is known to be dominated by technology firms, which is reflected in the sample used in this study. Although the path analysis pointed out that the nature of industry had no significant effect on organizational resilience, a generalisation of the findings of this study should be made, bearing in mind the characteristics of the firms in Shenzhen.

Finally, the study used a questionnaire, which was a perceptual measure of the variables. The necessary preliminary analyses (reliability and validity checks) were conducted before the path estimation. This notwithstanding, future studies are encouraged to use secondary data and run some analyses such as structural break and regression discontinuity. This could offer some more interesting findings.

Data Availability

Data is published and publicly accessible.

Funding

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Conflict of Interest

No conflict of interest.

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Table 1. Confirmatory Factor Analysis (CFA)

Model-Fit Summary CMIN=295.789; DF=166; CMIN/DF=1.782; GFI=.898; PClose=.111; TLI=.958; CFI=.967; RMSEA=.058; RMR=.065	**Factor Loading**
Green Value Co-Creation (COCR): CA=.943; CR=.944; AVE=.770	
GVC1	.883
GVC2	.912
GVC3	.864
GVC4	.833
GVC5	.893
Green Technology Development Capability (TECH): CA=.829; CR=.839; AVE=.569	
GTDC1	.854
GTDC2	.774
GTDC3	.701
GTDC4	.674
Green Operations Capability (OPERA): CA=.910; CR=.916; AVE=.785	
GOC1	.940
GOC2	.949
GOC3	.756
Green Transaction Capability (TRANS): CA=.900; CR=.907; AVE=.662	
GTC1	.741
GTC2	.802
GTC3	.884
GTC4	.798
GTC5	.837
Organizational Resilience (RES): CA=.919; CR=.923; AVE=.750	
OR1	.876
OR2	.849
OR3	.842
OR4	.896

Notes: *CFI = Comparative fit index; CMIN/DF = Chi-square/degree of freedom; RMR = Root mean square residual; RMSEA = Root mean square error of approximation; TLI = Tukey-Lewis index*

Table 2. Normality, Discriminant Validity, and Common Method Bias Tests

Variables	Mean	SD	Skewness	Kurtosis	1	2	3	4	5	6	7	8
Size (1)	-	-	1.339	-.047	-	.088	.052	.031	-.011	.018	-.045	-.076
Industry (2)	-	-	.817	-1.344	.088	-	.032	-.021	-.061	.006	-.121	-.096
Age (3)	-	-	.794	-.057	.053	.032	-	.022	.041	-.030	.041	.108
COCR (4)	5.888	.884	-.757	.36	.029	-.023	.020	***.877***	.399**	.388**	.518**	.478**
TECH (5)	5.765	.838	-.774	1.123	-.012	-.062	.041	.400**	***.754***	.239**	.307**	.449**
OPERA (6)	5.669	1.013	-.885	1.365	.019	.007	-.030	.384**	.239**	***.886***	.321**	.403**
TRANS (7)	5.486	1.003	-.783	.837	-.046	-.122	.039	.522**	.307**	.317**	***.814***	.481**
RES (8)	5.891	.901	-1.286	2.83	-.077	-.096	.107	.480**	.450**	.402**	.483**	***866***
SDR	2.430	.580	.597	.954	-.015	-.016	-.017	.085	.024	-.023	.094	.045

*** ~ Correlation is significant at the 0.01 level (2-tailed); √AVE ~ Bold and Italics; Partial correlation scores are above the diagonal.*

Table 3. Path Coefficients

Paths	**Unstd. Estimates**	**S. E.**	**C. R.**
Size → RES	-.081	.053	-1.513
Industry → RES	-.089	.091	-.984
Age → RES	.067	.039	1.699
COCR → RES	.125	.068	1.853
TECH → RES	.281	.072	3.910**
OPERA → RES	.189	.059	3.196**
TRANS → RES	.228	.059	3.852**
COCR → TECH	.425	.067	6.302**
COCR → OPERA	.301	.058	5.165**
COCR → TRANS	.576	.069	8.346**
Indirect Effect			***Sobel's Test***
COCR → TECH → RES	.119		3.322**
COCR → OPERA → RES	.057		2.718**
COCR → TRANS → RES	.131		3.497**
Model-Fit Summary			
CMIN=372.993; DF=232; CMIN/DF=1.608; GFI=.890; PClose=.417; TLI=.957; CFI=.964; RMSEA=.051; RMR=.070			

Bootstrap Bias-Corrected Confidence Interval at 95%; **~Sig. at 1%

Notes: *CFI = Comparative fit index; CMIN/DF = Chi-square/degree of freedom; RMR = Root mean square residual; RMSEA = Root mean square error of approximation; TLI = Tukey-Lewis index*

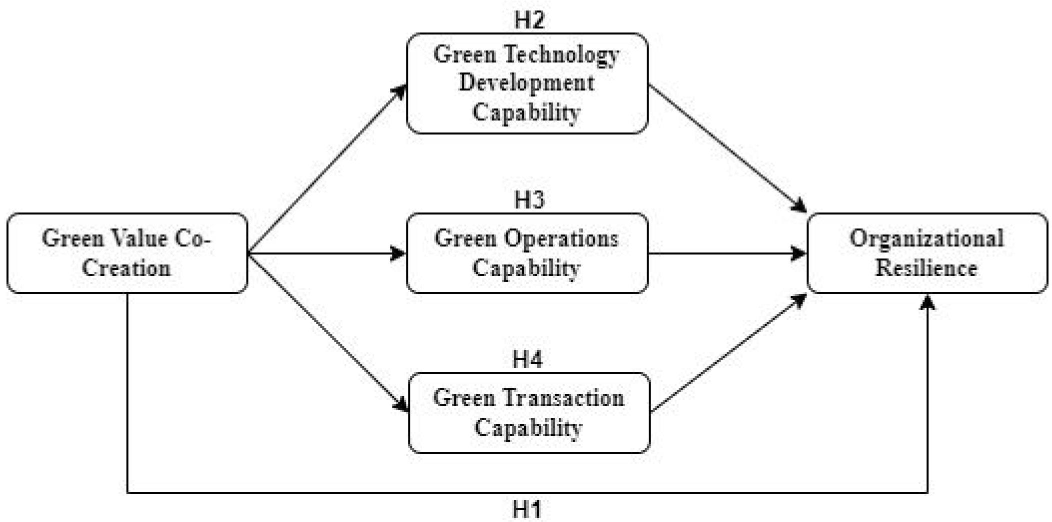

Figure 1. Conceptual Framework

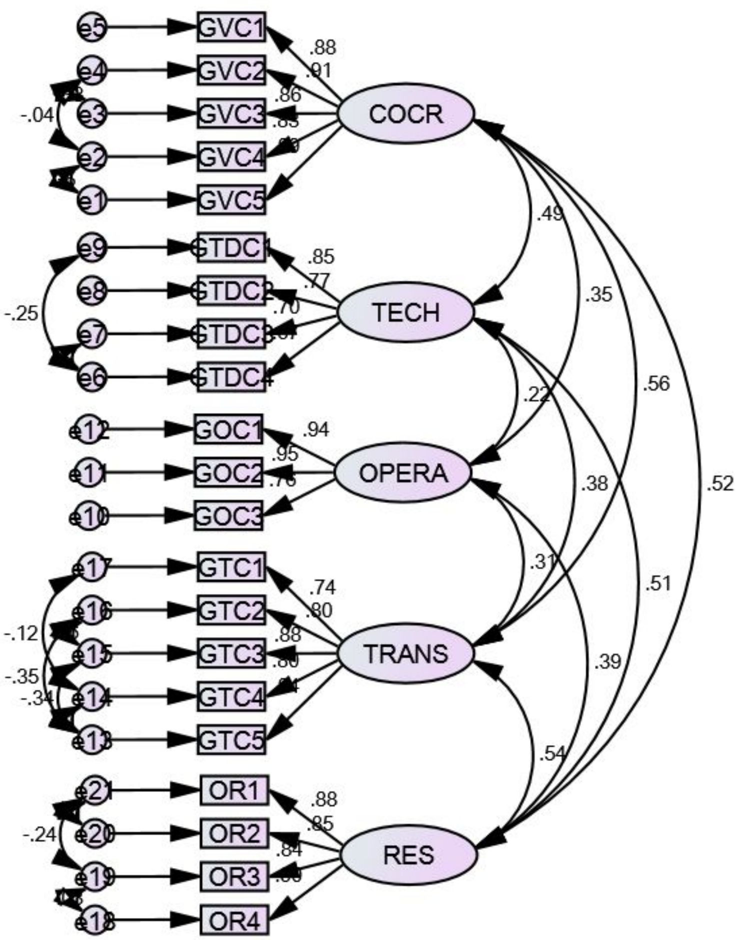

Figure 2. Confirmatory Factor Analysis

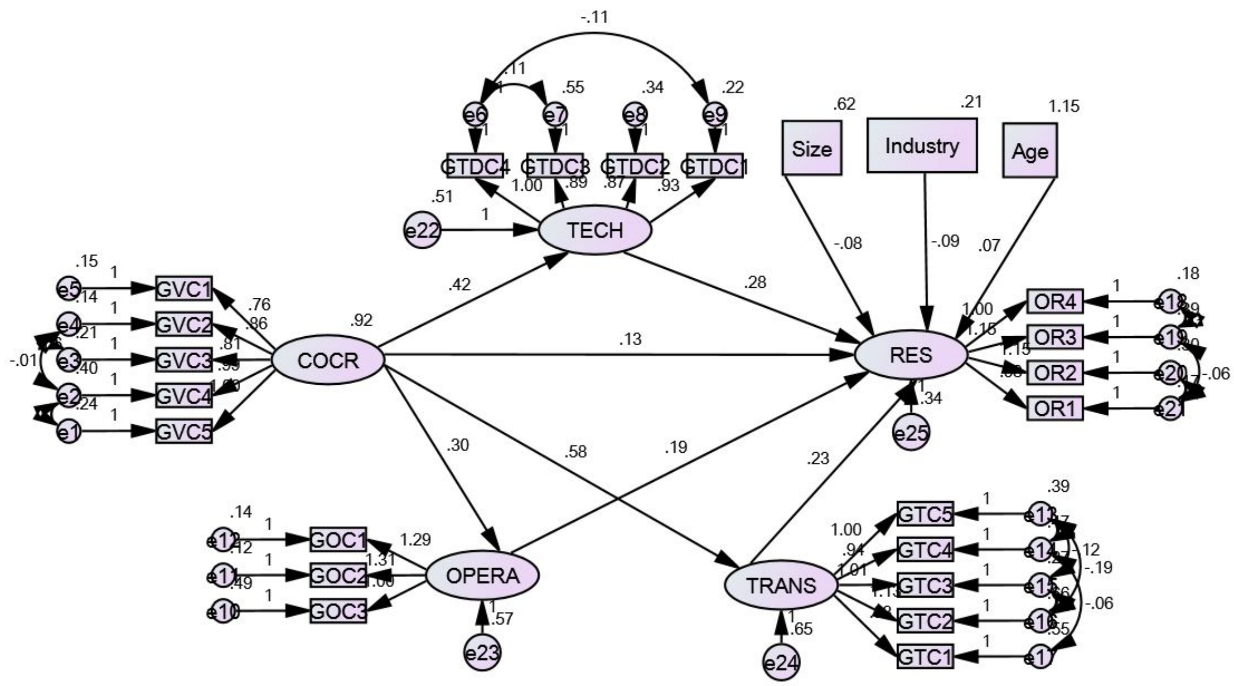

Figure 3. Structural Equation Model

Appendix 1: Questionnaire

Green Value Co-Creation

Our firm shares ideas with its customers about its green products during the development process
Our firm is willing to spare time and effort to share its suggestions with its customers to improve its green products or processes further
Our firm has easy access to information about customers' environmental preferences
Our firm is aligned with customers' environmental requirements
Our firm considered its role to be as crucial as its customers in the green product development process

Green Technology Development Capability

Our firm has the ability to understand the operations of novel state-of-the-art technologies being used in our industry, which have minimal destruction on the natural environment
Our firm has the ability to acquire novel state-of-the-art technologies being used in our industry, which have minimal destruction on the natural environment
Our firm has the ability to transform novel state-of-the-art technologies being used in our industry, which have minimal destruction on the natural environment
Our firm has the ability to exploit novel state-of-the-art technologies being used in our industry, which have minimal destruction on the natural environment

Green Operations Capability

Our firm has the ability to inculcate eco-design into its core business activities

Our firm has the ability to inculcate cleaner production into its core business activities
Our firm has the ability to recycle or reuse materials in its core business activities

Green Transaction Capability
Our firm has the ability to reduce transaction costs associated with outsourcing, without compromising environmental protection
Our firm has the ability to reduce transaction costs associated with marketing, without compromising environmental protection
Our firm has the ability to reduce transaction costs associated with bargaining, without compromising environmental protection
Our firm has the ability to reduce transaction costs associated with delivery, without compromising environmental protection
Our firm has the ability to reduce transaction costs associated with logistics, without compromising environmental protection

Organizational Resilience
We are prepared enough to manage the predictable challenges
We have the preparedness to overcome the unknown challenges
We prepared ourselves when news of the pandemic came out
The current has not affected our operations very much
We have maintained a supply network during the crisis
We can fulfil our customers' requirements without disruption

Socially Desirable Responding
You like to gossip at times
There have been occasions when you took advantage of someone
You are always willing to admit it when you make a mistake
You sometimes try to get even rather than forgive and forget
At times you have really insisted on having things your own way
You have never been annoyed when people expressed ideas very different "from your own"
You have never deliberately said something that hurt someone's feelings

Profile
Size of the firm/number of employees:
Industry (nature of firm):
Age of firm: