

Research Article**Driving Low-Carbon Supply Chain Integration in Youth Ventures: A Multiple-Case Study of Green Entrepreneurial Orientation and Human Capital**Xuanye Zhuang^{1,*}¹Macau University of Science and Technology, Taipa 999078, Macau***Correspondence:** Xuanye Zhuang, 1230015311@student.must.edu.mo

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Abstract

The paper explores how youth-managed manufacturing enterprises are engaged in the process of achieving supply chain integration through low-carbon processes under conditions of permanent uncertainty. While there is some empirical research evidence indicating the presence of relations between green entrepreneurial orientation, green human capital, and low-carbon supply chain integration effects, the literature provides almost no insight into mechanisms causing these results. Qualitative research based on multiple cases of green supply chains is used whereby six youth-managed enterprises representing three industry sub-sectors are examined by means of publicly available data and Gioia method. Thus, eighteen cases of low-carbon supply chain integration are identified and analyzed. As a result, three problems of supply chain management experienced by youth enterprises and a recursive process including three steps, namely (i) green opportunities recognition, (ii) low-cost carbon exploration, and (iii) environmental policy institutionalization, are identified. According to the results of the research, green entrepreneurial orientation and green human capital are activated sequentially rather than simultaneously, while environmental leadership acts as a catalyst shortening the duration of transition from one step to another. The presented research offers an explanation of a middle-range phenomenon contributing to the variance-based body of knowledge related to green supply chain management, while also providing the grounds for choosing those phases of low-carbon integration that appear to be the most vulnerable.

Keywords

Youth entrepreneurship, Green entrepreneurial orientation, Green human capital, Low-carbon supply chain integration, Qualitative case study

1. Introduction

1.1. Background and Problem Statement

Rapidly growing tendency among major economies to become carbon neutral has led to inclusion of supply chain emissions within the scope of international decarbonization trends, wherein manufacturing supply chains contribute a disproportionately high share of carbon footprint of industrial sector in the emerging economies. Youth-owned companies, defined here as the companies established during the last five years by entrepreneurs under thirty-five years of age, represent a rapidly developing group of organizations operating in manufacturing sector in such economies. Still, involvement of such companies into the process of supply chain integration with low-carbon approach is hampered by the lack of necessary funding, weak bargaining power vis-a-vis suppliers, poor partnership network, and lack of corporate-level environmental management experience. This combination of factors results in long-standing uncertainty regarding the carbon reduction process in relation to supply chain operations of these companies. Empirical research proves that implementation of pilot project with regard to green supply chain management practices has a positive impact on carbon performance of corporations; however, this evidence concerns mainly listed corporations (Zou et al., 2024).

Some empirical studies of the past five years provide evidence of a positive effect of green entrepreneurial orientation on the integration of supply chains with regard to environmental issues; in addition, environmental leadership emerges as a significant moderating variable in this situation (Wang, G. et al., 2023). Moreover, the same green entrepreneurial orientation may serve as a mediator of the process of turning sustainability commitment of leaders into supply chain activities (Feng, T., Li et al., 2022). In addition to these constructs, one more internal resource of supply chain greening is identified – green human capital – which implies knowledge of and skills relevant to environmental aspects and sustainability in the human resources of an organization. When viewed together as antecedent factors of green supply chain integration, these two constructs may have an impact on its efficiency in the presence of corporate environmental strategy as a mediating factor (Zhang et al., 2025). NRBV – the framework which views these resources as value and rare assets allowing sustaining competitive advantage – remains a commonly-used framework for theoretical justification (Makhoulfi et al., 2022); yet it does not account for mechanisms. Process-oriented research is currently missing in literature on green entrepreneurship – especially as cross-sectional survey studies tended to focus only on correlation relationships (Fubah & Barnard, 2026).

A similar influence takes on particular significance in cases of youth-oriented businesses. Modulating influence of firm's age on the link between environmental entrepreneurship and business performance shows that young businesses pass through all these stages in a manner that is difficult to measure via interactions in regression models (Lloria Aramburo et al., 2021). Bibliometric analysis also suggests that there have been very few case study-based studies in relation to low carbon supply chain management (Du & Zhou, 2022), and meta-analytic evidence reveals that innovations may vary significantly based on different contexts (Ilyas et al., 2024). It is reasonable to assume that innovations in youth-oriented organizations depend on their specific contexts too.

1.2. Research Questions and Paper Structure

The current research attempts to explore how youth-managed manufacturing firms in emerging economies contribute towards creating low carbon in the supply chain through uncertainty by examining the impact of green entrepreneurial orientation, green human capital, corporate environmental strategy, and environmental leadership. The two questions that form the basis for this research are; (i) How do youth-managed organizations use green entrepreneurial orientation and green human capital to create low carbon in the supply chain and (ii) In what ways can corporate environmental strategy and environmental leadership in the founder hinder or support the process above? This research question is investigated through a multiple case study of six firms across three different sub-sectors of emerging economies based on public data sources.

This paper constitutes a process approach to explaining the association between green entrepreneurial orientation and green human capital on the one hand, and low-carbon supply chain integration on the other, revealing the mid-level mechanism that describes the intermediary process through which the two sets of phenomena are related, and thus demonstrates how statistical studies have previously addressed this issue. It becomes clear from this paper that a relevant and insightful qualitative analysis can be carried out even without direct access to the primary source of data as this study demonstrates that a relevant qualitative analysis can be conducted even based on secondary publicly available data on green supply chain integration.

2. Data and Methods

2.1. Research Design

In this regard, the important research questions for this study will focus on understanding how youth-driven companies manage to employ green entrepreneurial orientation and green

human capital in adopting low-carbon strategies in the context of supply chain management and how environment strategy and environment leadership act as mediators in the phenomenon. In other words, the important research questions that are raised here are mainly process-oriented rather than variance-oriented, which implies that a suitable methodological strategy to examine a series of events in an organization is required. In this sense, a multiple case study strategy is adopted since the patterns from the analysis of multiple cases can be identified without sacrificing the uniqueness of each case, which is necessary when one is developing the mechanisms of the phenomenon under examination. More specifically, multiple case studies were selected rather than a single case study because if a mechanism is observed in a single case, no basis for analytic generalization will exist since there is no way to tell if the mechanism is only specific to that venture's unique circumstances. This methodology is consistent with the long-standing tradition in entrepreneurship research in generating theories based on multiple cases, where well-known theories have been derived by examining how start-up ventures adapt to emerging situations through the analysis of a few cases operating in partially similar but partially different environments (McDonald & Eisenhardt, 2020).

Methodology employed adheres to the Gioia model wherein there exists an organized framework that enables analysis of qualitative data for purposes of developing theories without compromising clarity within the process involved. More information about this methodology is found in Section 2.3.

2.2. Case Selection and Public Data Sources

After defining the basic framework of the study, case selection proceeded according to a sampling method that stressed more importance on the need to examine phenomena rather than their representativeness statistically. In this sense, the following three criteria had to be satisfied at the same time: (1) the age of the main founder of the company should not exceed thirty-five years at the time of establishment; (2) the company had to have been established within five years prior to obtaining empirical data; and (3) there needs to be a traceable indication of one major change that occurred in regard to the low carbon strategy of the company's supply chain management. The first two criteria are needed to ensure that the sample firms are consistent with the scope of youth entrepreneurship studies while the third criterion is necessary to provide sufficient empirical data to examine the process of integrating low carbon supply chain..

The six firms that were found to meet all three conditions were selected from three distinct manufacturing sub-sectors in developing nations: green manufacturing, clean

technologies, and sustainable consumer goods. Inclusion of diversity in terms of these sub-sectors as part of this exercise is meant to convey the understanding that every one of these manufacturing sub-sectors has its unique set of supply chain challenges; a lesson that can be better driven home in a scenario where there is repetition of such lesson in different manufacturing sub-sectors with varying costs, laws, and suppliers. The firms in question are spread in three geographical locations, with two firms each from these different locations. With respect to the selected firms, the next task was to decide on how to measure.

The restriction of the use of solely publicly available data does not stem from external factors but, per se, represents another important contribution. Previous research on qualitative green supply chain integration has been based largely on interview data, which made it inaccessible and unreproducible due to the need of founders' participation. Five kinds of publicly available sources were used for each case study. Sources from Crunchbase consisted primarily of structured data such as founding date, founder profile, funding round and personnel. Industry analysis provided by CB Insights and sometimes post-mortem analysis (if any) were used. Sources from the website and product blogs of the venture included records of what changes were introduced in the supply chain, information on partners in the supply chain and milestones related to environment certifications. Interviews provided on YouTube, podcasts and media interviews provided a first-hand experience of decision making. Major business and technology media gave third-party data and analysis at the time of event, hence complementing interview data. Triangulation of different sources mitigates the limitations of public data as interview data would explain why and how the decision was made, while product blogs and media would provide data on events around the time. Limitation to the use of publicly available data eliminates necessity of ethical approval and allows for equal access to the data for future researchers. Below is the table which includes summary of the cases, with respect to the year of founding, founder age range, sector, main problem in the supply chain and public sources used..

Table 1

Profile of the Six Youth-Led Manufacturing Ventures, Primary Supply Chain Challenges, and Public Data Sources

Case	Sector	Founded	Founder age	Primary challenge	Public data sources consulted
V1	Green manufacturing	2020	28	Supplier carbon information opacity	Crunchbase; CB Insights; company blog; <i>TechCrunch</i>
V2	Green manufacturing	2021	31	Supplier carbon information opacity	Crunchbase; founder podcast; <i>Forbes</i>

V3	Clean technology	2021	26	Green procurement cost asymmetry	Crunchbase; CB Insights; 36Kr
V4	Clean technology	2022	24	Green procurement cost asymmetry	Crunchbase; founder YouTube; TechCrunch
V5	Sustainable consumer products	2023	34	Environmental standard misalignment	Crunchbase; CB Insights; company website; Forbes
V6	Sustainable consumer products	2024	29	Environmental standard misalignment	Crunchbase; venture blog; 36Kr

Note. Founder age refers to the lead founder where multiple co-founders were involved. Secondary challenges: V1, cost asymmetry; V2, standard misalignment; V3 and V4, supplier carbon information opacity; V5, cost asymmetry; V6, supplier carbon information opacity.

As can be seen in Table 1, all six case studies are published in 2020-2024, and their founders' ages at starting these businesses are in the range of 24-34 years old. Also, the main challenges in supply chains depend on different industries, and a particular pattern exists regarding which can offer some fruitful variation possibilities for cross-case analysis. In fact, the supply chains of green manufacturers face challenges due to carbon data transparency issues with suppliers, those of clean-technology companies are affected by cost challenges because of green procurement among very specialized suppliers, and finally, those of sustainable consumer products startups have problems of alignment in environmental challenges in supply chains of their upstream/downstream supply chain stages. Each case study includes 2-5 supply chain integration events so that three can be selected for further analysis.

2.3. Coding Procedure and Analysis

The coding procedure involved three stages of work that were in line with the Gioia approach, which can be considered especially valuable for entrepreneurial research due to its transparency of interpretation when going from first order concepts via second order themes to dimensions (Magnani & Gioia, 2023). First of all, all the raw data available from all five sources was subjected to close analysis and coding into first-order concepts. One should note that during the process of creating these first-order concepts, it was critical to rely solely on the provided data of entrepreneurs' operation or journalists'/analysts' reports on it. As a result, the concepts could be formulated in an action-oriented way and represented by phrases such as “identifies a tier two supplier ready to provide emissions data,” “conducts a pilot run with recycled materials,” “founder personally negotiates green procurement conditions with three suppliers” and others. The main objective here was to capture the events rather than to build an abstract theoretical picture.

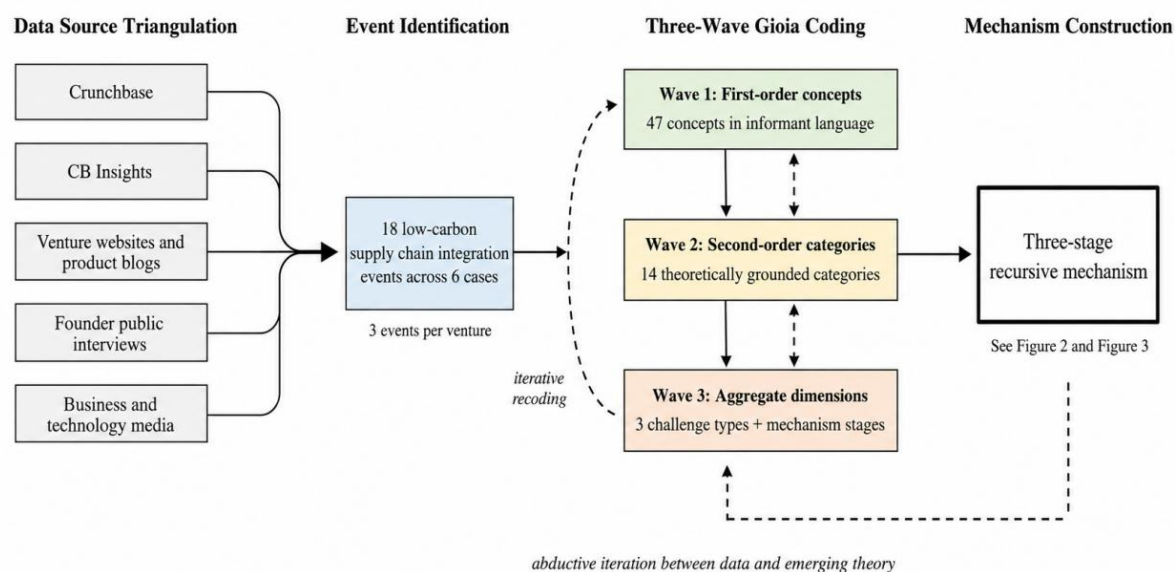
Second-order constructs arose from organizing the first-order constructs into second-order constructs through the use of constant comparison whereby constructs that share common reasoning patterns are put together irrespective of the language differences in which they are defined. Examples of these second-order constructs include "green opportunity identification," "low cost carbon exploration," "environmental strategy institutionalization" and "founder driven environmental championing." What is important to note is that second-order constructs are more abstract than first-order constructs although empirically sound and theory free. Organizing second-order constructs gave rise to theoretical mechanisms.

Following the description of the procedure of coding presented above, it is necessary to outline what was actually coded. Unit of analysis in question refers to the low-carbon supply chain integration event. Specifically, the concept implies a point in time where the company recognizes a certain problem or opportunity relating to carbon usage in its supply chain; makes an effort to address this problem or opportunity; and consequently changes its behavior. Episodes that could be defined as such were triangulated by means of comparing temporal markers obtained from different types of materials because, first of all, the story of a founder might compress a chain of events into a single episode, whereas product blog or news article would represent much more of a sequential approach to this matter. Thus, three different integration events were selected for each venture, being not concentrated in time, but rather evenly distributed during all the life cycle of the venture. Coding itself consisted in assignment of codes to randomly selected pieces of material, reconciliation of disagreements between two independent coders and coding of the remaining parts of data. Agreement between two raters was measured using Cohen's Kappa coefficient (0.81). In order to organize coding process and extract codes for the second level of category structure, NVivo 14 was used.

This entire process including triangulation of the five categories of sources of data, generation of eighteen processes of integration in six instances, coding in three rounds and development of the theoretical process is depicted in Figure 1 below. The process has been depicted using diagrams due to the non-linearity of the process where the back and forth movement from coding rounds cannot be explained through mere writing alone.

Figure 1

Analytical Workflow from Public Data Sources to the Construction of the Low-Carbon Supply Chain Integration Mechanism



Inter-rater reliability: Cohen's $\kappa = 0.81$
Software: NVivo 14

Figure 1 demonstrates how several second-order constructs needed to be re-conceptualized once they were extracted from the aggregate level dimensions due to the observed contradictions. At the same time, Figure 1 also demonstrates how some first-order constructs required re-categorization when the comparative analysis revealed certain patterns not visible at the level of a single case. This type of thinking is typical of the Gioia technique and is a form of abduction that distinguishes case study from other forms of reasoning.

3. Results

3.1. Types of Green Supply Chain Challenges Facing Youth-Led Ventures

The cross-case analysis of eighteen low carbon supply chain integration approaches undertaken for six companies reveals three major categories of problems that may be encountered by young entrepreneurs running manufacturing businesses when carrying out their efforts aimed at saving carbon. Challenges revealed by the present study cannot be assessed through the lens of the known dichotomy between internal and external opposition that underpins green supply chain management theory. Instead, one may argue that these issues are inherently relational in nature, emerging out of the relationship between organizational constraints and supply chain characteristics.

The first and foremost type of challenge faced by ventures occurred in thirteen out of eighteen instances under consideration and was related to lack of transparency about carbon impact information available from suppliers. Ventures seeking ways of measuring and minimizing environmental impact of the supply chain met difficulties because upstream suppliers (particularly small manufacturers of parts and components) lacked data regarding

carbon emission or refused to share it due to insufficient order quantities for such calculations to be meaningful. The second most common challenge was identified nine times and related specifically to green procurement cost disadvantage – in other words, when environmentally friendly components had an additional cost charged which the venture could not afford considering their small profit margins unless it passed it on to customers or reduced its potential earnings, both options being undesirable because growth strategy was currently employed by them. The third type of challenge was observed seven times and was typical for ventures operating in sustainable consumer goods industry. This challenge involved incompatibility of environmental standards applied at various levels of the supply chain because a particular EMS used by the venture was unfamiliar to their partners in the upstream or downstream positions. It should be noted that challenges mentioned above are non-exclusive because some of the considered events included several types of challenges at once.

Table 2

Coding Structure — First-Order Concepts, Second-Order Categories, and Aggregate Challenge Dimensions

First-order concepts	Second-order categories	Aggregate dimensions
"Supplier has no idea what their carbon footprint is"	Absence of supplier emission tracking	Supplier carbon information opacity
"They track costs per unit but not carbon per unit"	Mismatched measurement systems	
"Order volume too small for them to bother sharing data"	Bargaining power deficit blocking disclosure	
"Recycled-content components cost 30% more than virgin"	Price premium of certified green inputs	Green procurement cost asymmetry
"Had to choose between hitting revenue targets and sourcing green"	Growth-sustainability trade-off pressure	
"Minimum order quantity for eco-certified material exceeds our monthly need"	Scale threshold for green procurement access	
"Our ISO 14001 means nothing to tier-two suppliers"	Framework non-recognition across tiers	Environmental standard misalignment
"Upstream and downstream partners operate under different national standards"	Cross-border regulatory fragmentation	

Note. Representative examples from 47 first-order concepts and 14 second-order categories across 18 events in 6 cases. Challenge types are not mutually exclusive.

Table 2 reveals that the three challenge dimensions emerge out of 14 second-order and 47 first-order constructs; the supplier carbon information opacity construct emerges as the one contributing the highest number of first-order constructs, as expected from its significant presence in 13 of the 18 cases. The significance of the sectoral distribution is due to the fact that all three challenges occurred in all three sub-sectors; however, the significance of each type of challenge was an influencing factor for the mechanism described in the next section.

3.2. The Three-Stage Mechanism of Low-Carbon Supply Chain Integration

In any case, the examination of how entrepreneurship ventures react to those issues in 18 cases reveals that there is an identifiable three stage approach that can be considered the key finding from the empirical point of view in this research paper. These stages of green opportunity exploration, low carbon probing and institutionalization of the environmental strategy were identified in each of the six examined businesses across all three sub-industries described above, but in various ways to address the problems.

In the case of opportunity identification stage, green entrepreneurship helped identify those parts of the supply chain where the reductions in carbon footprints would be possible. To put it differently, there was no structured approach comparable to one that is used in conventional management in more developed organizations. Rather, the opportunistic method was applied in terms of the interaction between the founders and other players in the market, including suppliers and clients. Examples of opportunistic analysis include knowledge of a shift in supplier by a competing firm to a lower-emission alternative and knowledge about a new product that could be purchased competitively on some industrial podcast, among others. The crucial aspect of the stage under discussion may be seen as a transformation of knowledge into the concept of a feasible low-carbon solution.

The probing stage, distinguished by its cheapness, turned out to be the moment when green human capital got involved into action. Once having discovered a chance to change things, the firm should have estimated the feasibility, viability, and acceptability of such changes from the perspective of technical, economic, and human aspects but without spending additional venture's funds on it. Instruments that could be applied in this probing process included the following: tests of alternative inputs in small batches performed with the assistance of one cooperative supplier; negotiations on carbon emission exchange with the founder and one concrete person of interest in the network of supply chain; introduction of products manufactured under greener conditions; as well as alternatives' cost/carbon emissions analysis. In view of a particular impediment, it was necessary to apply a particular instrument. When the information on suppliers' carbon footprint was not available, it was

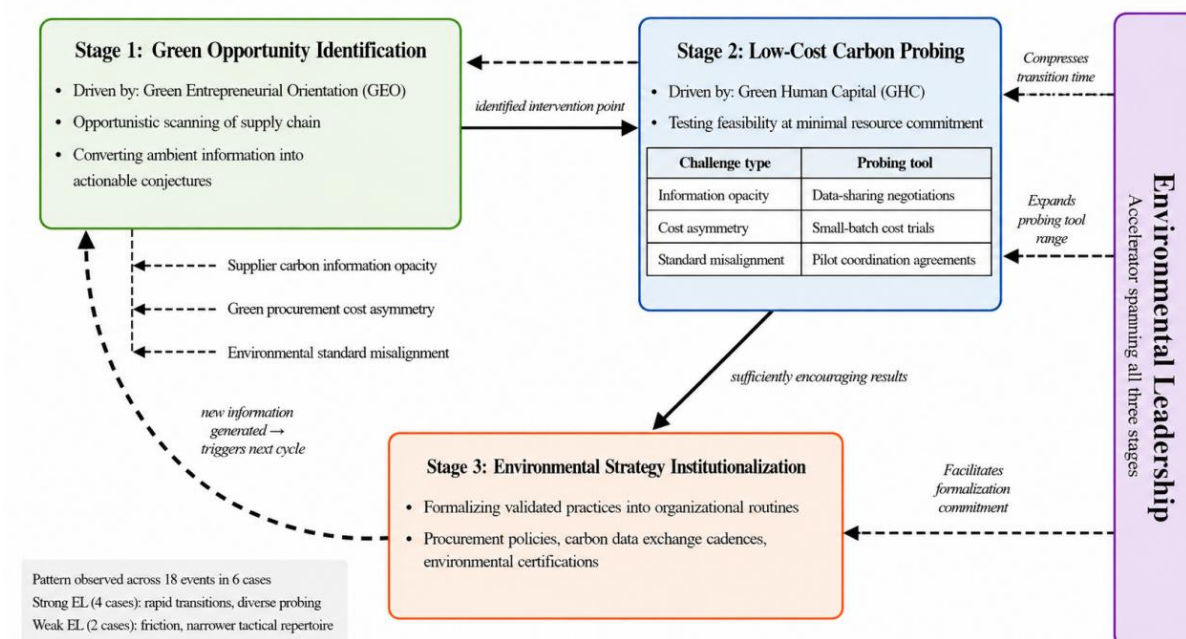
necessary to carry out negotiations with regard to sharing it. When there were asymmetric costs of green purchase alternatives, tests of alternatives in small batches had to be carried out. Finally, when there were environmental standards disalignment, negotiations with one/two partners were needed. Common features of the probing stage included its cheapness and reversibility.

Institutionalization became evident in the environmental strategy once it was recognized that the results attained by way of exploring had become good enough to institutionalize. Some of the approaches utilized for instituting the process involved introducing environmental considerations when procuring supplies, coming up with a set rhythm whereby information about carbon footprint is shared amongst suppliers, and obtaining an environmental certificate to ensure the environmental process will be permanent. In this stage, the environmental strategy becomes formalized since the supply chain management process becomes institutionalized independent of the entrepreneur's focus.

One of the distinguishing features of the mechanism is its recursive nature. The institution of any practice is sure to lead to generation of new information, hence triggering the next round of opportunity identification. For example, when an innovative firm institutionalizes its information exchange practice regarding carbon emissions by its Tier One suppliers, it discovers the information regarding emissions made by its Tier Two suppliers, hence identifying new opportunities. Hence, the integration of low carbon supply chains in youth ventures will not be a one-off exercise, but an ongoing process in which every cycle of institutionalization creates additional information available to the venture and also ensures a platform for further identification and probing. It is crucial to emphasize that this recursive nature of the mechanism is an insight that requires to be illustrated by virtue of the relationships that exist between stages three and one of the pathway and stage four of the latter respectively.

Figure 2

The Three-Stage Recursive Mechanism of Low-Carbon Supply Chain Integration in Youth-Led Ventures



This feedback process of institutionalization-identification presented in Figure 2 is recognized as the most important structural feature of the mechanism discussed above. In opposition to the mechanism, models related to the stages of the greening of supply chains involve a continuous process of integration, which begins from planning and proceeds through implementation and evaluation. Thus, one can now clearly understand why the events studied in this paper were not grouped in the initial stages of emergence of the ventures but instead dispersed at the initial development stages with later events using the previous events' data and connections.

3.3. The Enabling Role of Environmental Leadership

This three-stage process was found in all six cases, yet there were some discrepancies concerning pace and predictability. However, on analyzing these cases in combination with one another, the influence of environmental leadership played by the company founder, that is his personal involvement in environmental decisions and support of green agenda, proved to be a kind of an accelerator of the process.

Indeed, in all four cases in which environmental leadership played a crucial role, the transition from identification to probing was quick, owing to the fact that the founder did not have to persuade anybody from the team of the need to take advantage of the opportunity identified. The reason for this was that the environmental leadership of the founder reduced the transaction costs associated with probing, particularly since, as far as probing methods involving supplier negotiations were concerned, the supply chain partners would readily be willing to exchange their carbon-related data informally and participate in pilot projects only if such an offer came from a leader that had proven its environmental commitment rather than

a person with opportunistic intentions.

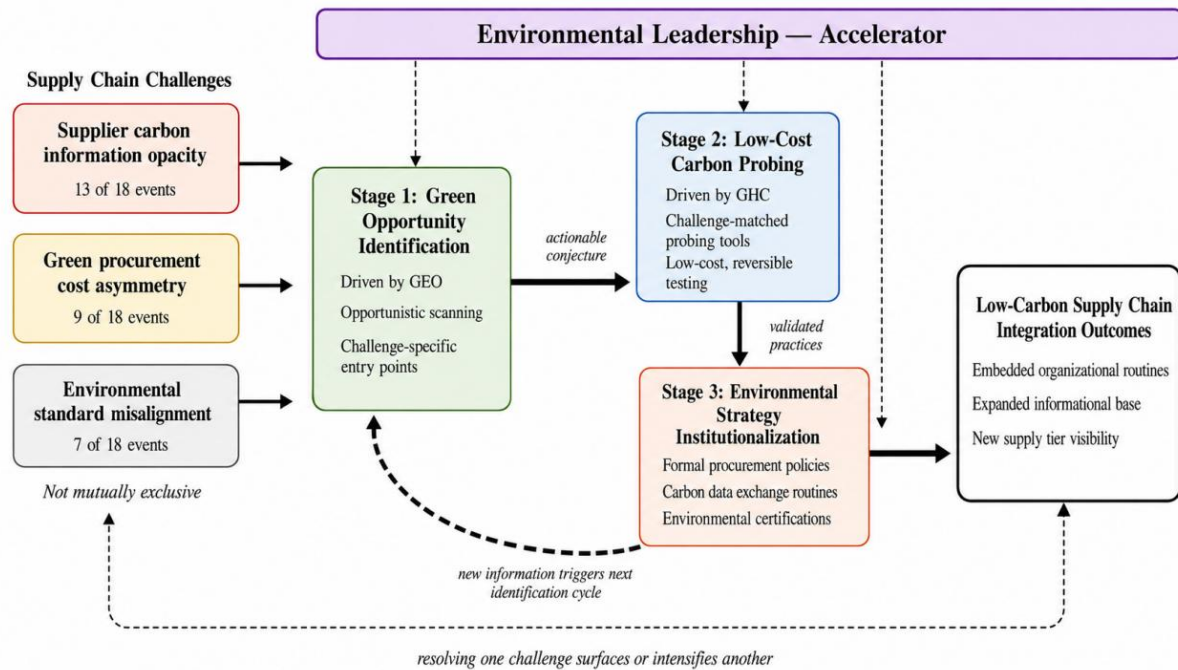
The same goes for both cases of relatively weak environmental leadership; no break down of the mechanism took place; however, there were certain elements of resistance to the process. The probes became stuck on the way because the founder shifted his attention to other problems, and the stage of institutionalization faced delays because there was insufficient motivational capacity from the entrepreneur to achieve institutionalization without his involvement. Moreover, there were limitations concerning probing procedures applied to the cases presented; more specifically, most of them involved desk research and cost analysis as opposed to more time-consuming methods like negotiations with suppliers and organization of pilot projects. It means that environmental leadership does not influence the operation of the mechanism but sets the level of its efficiency.

3.4. An Integrated Model

From the above three sub-sections, the nature of challenges that lead to the process, the three step process in recursion that operates within the process, and the founder attributes that can either expedite or delay such process have been clearly defined. The synthesis of all these elements can result to one single model which captures everything about the process of how youth firms facilitate the process of creating low carbon supply chain integration in uncertain environment. From the synthesized model, one can clearly understand how the three kinds of challenges lead the firm towards the process of identification; how green entrepreneurship orientation and green human capital influence the process of identification at stage one and stage two respectively, how environmental leadership runs through all process and finally how institutionalization of environmental strategy ensures that the learning experience continues endlessly. Figure 3 shows the synthesized model.

Figure 3

Integrated Model Linking Challenge Types, the Three-Stage Recursive Mechanism, and Environmental Leadership in Youth-Led Ventures' Low-Carbon Supply Chain Integration



Many of the linkages depicted in Figure 3 are too numerous to capture in sequence-based prose. First, it must be noted that the linkages between each challenge and identification mean that different challenges influence not only what opportunities are recognized but also what diagnostic tools are then employed. This creates a path specific for each particular challenge. Second, since the influence of environmental leadership is accelerating throughout the entire life cycle and not at a specific moment in time, the depiction of the factor must be spread over all three stages of the process in question. Third, the feedback loop created between integration results and each type of challenge denotes the existence of some cases wherein implementation of the supply chain practice in order to address one challenge ended up posing other problems. Fourth, the overall message conveyed in this model is that the low carbon supply chain integration in the youth sector cannot be viewed as a rational solution carried out through a series of rational steps.

4. Discussion

This three-phase recursive process suggested in the present study offers an explanation as to how the dynamic interconnection arises between the factors of input and the output sides of those models that have been dominant in the GSCM concept so far. The fact that the recursive process, in which every step of institutionalization results in some feedback, in the shape of the information that is used to generate new opportunities for the next step, relates directly to the latest findings concerning strategic change in the entrepreneurial business with respect to the pivot process. As Kirtley & O'Mahony (2023) say, pivot should not be viewed as a radical decision but rather as the accumulation of small decisions that retrospectively

could be viewed as pivotal. What is added by the present research is the substance of such decisions.

The result where the role of environmental leadership is an accelerator but not a trigger adds to the debate about whether environmental leadership is a prerequisite or merely an amplifier. According to quantitative research, there is a strong positive progression sequence running from environmental leadership to green intellectual capital and then to environmental performance (Xi et al., 2025); yet, its dynamic nature is still unclear. As for the findings of the current study, environmental leadership reduces the time frame in the different mechanism processes stages and at the same time raises probing among young ventures. This finding is in line with the results of earlier empirical studies confirming that the effect of environmental leadership can improve the green innovation practices by setting the common goal and hence minimizing experiment costs (Xu, B. et al., 2022). The finding where there was reluctance in probing related to institutionalization among ventures with low levels of leadership may be relevant to research dedicated to how new ventures manage to cooperate with their stakeholders when strategy changes take place (Hampel et al., 2020). Nevertheless, in this particular case, the reluctance is less intense as compared to other cases due to lower engagement with the stakeholders among young ventures.

The sequential consideration of green entrepreneurial orientation in the identification phase and green human capital in the probing phase helps gain a better understanding of the quantitative findings, considering that both concepts may be viewed as parallel yet separate predictors of performance outcomes. As for the differential division of labor, it could not be captured by any prior empirical research due to continuous scaling of survey-based measurements, which implies a treatment of the process of using the two resources as simultaneity and hence cannot account for the possibility of utilizing them at separate points in time. One more angle that has been considered in this study and was lacking in the quantitative analysis carried out previously relates to episodic use of the green entrepreneurial orientation. In contrast to prior quantitative work, where green entrepreneurial orientation is perceived as a continuous construct used for the impact on sustainable development through mediating effects of green product and process innovations (Coelho et al., 2024), this study provides a new perspective on the phenomenon in question. As far as the result concerning the influence of green human capital on outcome via probing rather than utilization of any formal environmental management system is concerned, it seems similar to findings related to the mediating effect of green human resource management on top management commitment and environmental performance in hotels (Haldorai et al., 2022).

In practice, the recursive approach implies that the investment in the process of

development of low-cost probing mechanisms may be much more valuable than a perfect initial plan of handling the environmental situation. Incubators need to develop probing procedures, using such tools as carbon measurement devices and standard protocols for data exchanges. Policymakers should consider approaches that will allow businesses to act gradually and incrementally rather than obligate them to implement everything at once. There are some points to keep in mind when considering generalizations in regard to this case study analysis. First, there might be biases associated with publicly accessible data. Second, there was only a limited sample size (six examples). Third, cross-cultural issues were not addressed.

5. Conclusion

In this study, the authors aim to investigate the process mechanisms through which youth-managed manufacturing firms integrate low carbon in their supply chain operations amid uncertainties existing in developing countries, through a qualitative multiple case study approach that examines the process of six companies operating in three categories of sub-industries. This study recognizes three categories of supply chain challenges that youth-managed companies face when trying to incorporate low carbon operations in their organizations: opaque supplier carbon information, imbalanced costs of green procurement and inconsistent environmental regulations at different tiers of the supply chain. A three-stage recursive process is revealed wherein the companies manage to address the above-mentioned issues in a way that involves identifying the green opportunities first, and then probing low-cost carbon in the supply chain, eventually leading to institutionalizing environment-related strategies, and successful completion of each stage forms the knowledge base that enables the next step.

This study finds that green entrepreneurial orientation and green human capital have two different sequential roles to play in this mechanism, the former enabling the identification stage whereas the latter enabling the probing stage. There can be no temporal specialization in the above mentioned mechanism as indicated through the existing quantitative literature on this phenomenon. Environmental leadership does not form a necessary element in the mechanism but acts as an accelerator by reducing the time taken for switching from one stage to another and by increasing tactics used during probing stage; otherwise there will be friction but no paralysis involved. An integrated theory is presented which represents a middle-range explanation of the above phenomenon by putting together all the results into one mechanism instead of relying on variance-oriented statistical models currently dominant in literature. It also leaves avenues for further longitudinal studies, cross-country studies and intervention

strategies by incubators and policy makers.

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Data availability

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The authors declare that there is no conflict of interest.

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Consent to participate

Not applicable.

Consent for publication

All authors have given their consent.

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