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Governance Mechanisms for Green Supply Chain Partnership

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Abstract: The literature has recognized the value of green supply chain management in achieving the goals of environmental management. Yet developing and fostering sustainability partnerships among supply chain organizations remains challenging. Bounded rationality and opportunistic behaviors are likely to hinder joint sustainability collaboration and performance. The literature has called for a better understanding of the governance of green supply chain collaboration. This study applies transactional cost economics as a conceptual framework to investigate the relationships among transaction features, governance mechanisms, and environmental performance. Using the data collected from 969 plants in 17 countries, the statistical analysis compares and validates the effectiveness of three alternative governance mechanisms: contractual governance, problem-solving cooperation governance, and information-sharing governance. The statistical results reveal significant performance differences in how firms apply alternative governance mechanisms to mitigate opportunism, manage adaptation problems, and improve green supply chain collaboration and performance. Overall, this study makes research contributions by confirming the mediation effects of governance mechanisms on green supply chain practices. For green supply chains to be a viable practice, firms should apply governance mechanisms in proper alignment with the nature of the collaborative and environmental conditions.

Keywords: green supply chains; transaction cost economics; supply chain governance; environmental management; supplier management

1. Introduction

Over the last two decades, more companies began to realize that most environmental management initiatives could not be implemented without partnering with their trade partners. Leading manufacturers (e.g., HP and Ford) began to integrate their sustainability program with their supply chain management [1,2]. Managers understand that manufacturing sustainability requires close collaboration among supply chain members. This perspective promotes the concept of green supply chain management (GSCM) as a necessary strategy to implement sustainability or corporate responsibility.

Green supply chain management can be defined as management of the supply-chain (product design, raw material procurement, manufacturing processes, delivery of the final product, product lifecycle management) in an environmentally conscious way. GSCM helps companies reach their sustainability goals, as well as strengthen their social endeavors, further increasing the value and need of GSCM [3–6]. GSCM requires cooperation among supply chain parties in various areas, such as green purchasing [7], process improvement and product design [8], green innovations [8–10], and reverse logistics [11]. For instance, General Motors outsourced its painting process for cost and waste reductions. Manufacturing firms began to outsource their environmental programs (e.g.,

chemical waste) to third-party firms with specialties [10]. Similarly, firms chose to subcontract their logistics operations to third-party logistics to reduce their carbon footprint [12–14]. GSCM is now regarded as an effective means of achieving environmental management.

Nonetheless, while the GSCM initiatives have tremendous potential for improving environmental management performance, they do not always succeed as intended [5,7]. Without proper collaboration arrangements and necessary coordination, green collaborative initiatives often fail due to lack of trust or opportunistic behavior [3,5]. A recent MIT survey suggests that many firms still do not have a coherent sustainability approach/strategy for working with their supply chain partners [15]. Firms struggle with structuring and governing joint sustainability arrangements (classical contract or joint venture) or managing the associated exchange contingencies. In many cases, opportunistic behavior, caused by various unexpected situations, hinders the implementation of mutually agreed upon green collaborations [16,17]. With no effective governance mechanisms, managers are discouraged from engaging in more extensive and effective green collaboration [10,18,19]. The literature has recognized the need for governing sustainability collaboration, and offered suggestions of some contractual mechanisms (e.g., cost/revenue sharing plan). However, the extant research has remained mostly conceptual and more work is necessary [5,10].

In response to this research and managerial gap, this study applies transaction cost economics (TCE) to investigate how manufacturing firms can engage in green collaboration with their suppliers. Specifically, this study investigates the effectiveness of applying various governance mechanisms: contractual governance, problem-solving cooperation governance, and information-sharing governance. Contractual governance is the formal mechanism to monitor supplier performance and to control opportunism through legal stipulations, formal rules, terms and procedures, and penalties for noncompliance [18]. Problem-solving cooperation refers to the establishment of problem-solving procedures and reliance on 'implicit agreements' for dealing with contingencies not covered by formal contractual clauses. That way, neither party could exploit the other party's vulnerabilities in the exchange relationship [19,20]. Information sharing refers to sharing of important information—such as forecasts, production plans, and schedules—and would facilitate a high level of inter-firm problem-solving cooperation. Overall, this study intends to extend the discussion of transaction cost economics to investigating the contingent applications and effectiveness of contracts and two relational mechanisms on environmental performance. Specifically, this study would address two specific research questions:

(1) How well do the three governance mechanisms (contract, problem-solving cooperation, and information-sharing) reduce the opportunistic behavior and adaptation problems?
(2) How well do the three governance mechanisms enhance the performance of environmental management?

For the remainder of this paper, Section 2 of this article provides a literature review in relation to contractual and relational governance. A research model and several research hypotheses are developed. The research methodology, data collection, and measurements are discussed in Section 3. Section 4 presents statistical results and discussion, followed by the conclusions in Section 5.

2. Literature Review

The TCE theory originally focused on two basic governance methods: market and formal contract [21–23]. The market method is the reliance on the supplier's competitive market for obtaining the best value for the buyer. While the formal contract method is the extensive contract to seek legal damages for contract clause non-fulfillment, it did not emphasize many unforeseen factors such as technology, behavioral, and market vicissitudes. Managers in both buying and supplying organizations have incomplete knowledge about all of the conditions under which the contract will be executed. This incomplete knowledge, or bounded rationality, would later entail additional adaptation, as the contract would have to be modified after signing.

Williamson [24,25] extended the discussion of relational governance by proposing that adaptation minimizes supplier and buyer opportunities to use the incomplete conditions to their own advantage. For instance, one party could take financial advantage of the contract's uncertain conditions caused by both buyer's and supplier's bounded rationality [25]. Contract governance has two basic elements, the formal contract and relational governance. When these two methods are both used, it is collectively known as hybrid governance. Managers should be able to employ hybrid governance to effectively manage opportunism and adaptation problems, arising from two primary transaction attributes: supplier asset specificity and environmental uncertainty [23,26,27]. Supplier specificity refers to the investment made in a particular transaction that would have less value to other transactions. Asset specificity could potentially cause opportunism, as both supplier and buyer could engage in 'hold up' behavior if a supplier made a specialized investment. On the other hand, environmental uncertainty refers to the level of market/demand and technology uncertainties. Environmental uncertainty tends to affect various company operations, increasing information asymmetry, encouraging opportunism, and forcing firms to adapt to completely unexpected changes.

The literature has confirmed the effectiveness of contractual governance and relational governance mechanisms in curtailing opportunistic behaviors and managing adaptation problems [2,23,28]. Nonetheless, the alignment of transaction attributes and governance mechanisms, the relative effectiveness of the contractual governance, and different social control mechanisms have not been fully examined [29,30].

The remainder of this section describes and hypothesizes the theoretical relationships among environmental uncertainty, asset specificity, contractual governance, problem-solving cooperation governance, information-sharing governance, and environmental performance.

2.1. Effects of Supplier Asset Specificity

Supplier asset specificity refers to the extent to which particular suppliers invest to meet buyer's specific needs [26]. Such investments have a higher value to that particular transaction and buyer than they would have if they were redeployed for any other purpose. For instance, in the case of repairing returned products, third-party service providers sometimes have to build specific repair lines and reporting systems for important manufacturers, due to concerns of unique product design and confidentiality. The literature indicates such supplier investments would improve the performance of the area buyers intend to focus on [26,29]. Accordingly, the following hypotheses are developed.

Hypothesis 1a. *Supplier asset specificity improves environmental performance.*

Nonetheless, transaction-specific investments could cause safeguarding problems, and governance mechanisms are necessary to lessen the risk of opportunistic exploitation (Williamson 1985). Specifically, asset specificity could potentially cause opportunism, as both supplier and buyer could engage in hold-up behavior [5,19,31]. On the one hand, buyers may leverage the supplier's dedicated assets to lower prices. Yet again, the supplier might "ask the buyer to pay more or risk having to find a new supplier willing to invest" ([32], p. 89). From the aspect of governance mechanism, asset specificity triggers the development of more detailed and specific contractual clauses, due to both buyer and supplier being forced to protect against opportunistic behavior [14,33]. Therefore, the following hypothesis is proposed.

Hypothesis 1b. *Supplier asset specificity increases the use of contractual governance.*

Asset specificity also encourages the adoption of another form of relational governance, including inter-firm cooperation and information-sharing [26,30]. The presence of specialized investments makes the continuity of existing transaction exchanges vital. In addition to neoclassical contracts, firms may also apply informal cooperation to foster longevity of the supplier–buyer relationship in order to resolve unforeseen disputes. Informal problem-solving cooperation would enhance the commitment

to taking joint action in solving unexpected problem. We propose that firms would use inter-firm cooperation as a mechanism to ensure appropriate returns from these specialized investments.

Similar to problem-solving cooperation governance, the level of information interactions engaged in by buyers and suppliers is likely to increase with dedicated investments from the supplier [18,26,28,29]. In particular, with specific investments, both parties would like to communicate to ensure the function of the dedicated assets and safeguard such specialized investments from costly termination. Moreover, when supplier asset specificity increases, both parties become vulnerable to holdup risk and would increase their commitment to the relationship and the level of information interactions [1,30]. Accordingly, the following hypotheses are developed.

Hypothesis 1c. *Supplier asset specificity increases the use of Problem-solving cooperation governance.*

Hypothesis 1d. *Supplier asset specificity increases the use of information-sharing governance.*

2.2. Effects of Environmental Uncertainty

Environmental uncertainty refers to a state of flux and unpredictability that exists in a firm's external environment. Most of the TCE literature stresses the impact of two types of uncertainty: technology uncertainty and market uncertainty. Technology uncertainty may be caused by failure of the green purchase to meet the requirements of the buyer's system or failure to meet the ultimate customer's requirements. Market uncertainty is the failure of the purchased item to satisfy customer needs. Environmental uncertainty is pervasive in all supply chain activities and has important effects on supplier governance and buyer performance [23]. These uncertainties induce challenges to manufacturing operations and increase supplier performance ambiguity and exchange hazards, which, in turn, reduces plant efficiency and environmental performance [18].

Hypothesis 2a. *Environmental uncertainty decreases environmental performance.*

Environmental uncertainty creates adaptation and information-processing problems, which would encourage the use of control mechanisms—such as contractual governance, problem-solving cooperation, and information sharing—to cope with external uncertainties [29,34]. Specifically, firms perceive environmental uncertainties as dangerous threats with significant ambiguity, and would desire to adopt formal contractual governance. Specifically, formal documents function not only as a protection against opportunism, but also to help delineate courses of action to resolve unexpected problems. Crafting complex contracts is commonly believed to be an effective response to hazardous exchange settings to measure purchasing performance [10,35]. Precise contract language, with 'contingency' clauses, must be used to prepare joint sustainability agreements to address unforeseen situations. Therefore, managers are likely to rely on formal contractual clauses to mitigate the negative effects of environmental uncertainty [23].

Hypothesis 2b. *Environmental uncertainty increases the use of contractual governance.*

Nonetheless, contracts have limitations. Firms cannot possibly predict and contractually resolve every future contingency. Facing environmental uncertainty, firms are forced to continually renegotiate and modify contracts. It becomes difficult to create complete contracts outlining all potential contingencies. Relational governance can be applied to better manage environmental disturbances. The literature suggests that cooperation in problem solving, in response to supply chain disruptions, is effective relational governance [20,29]. Inter-organizational cooperation of problem solving provides necessary flexibility and adaptability to cope with unforeseen uncertainties that arise in supply chain transactions. Both manufacturers and suppliers would recognize such a need and cooperate more closely to achieve the flexibility and adaptability necessary to circumvent exchange hazards and strengthen bilateral commitment.

Hypothesis 2c. *Environmental uncertainty increases the use of problem-solving cooperation governance.*

The literature confirms the value of information sharing on mitigating market demand and supply uncertainties [30]. When facing demand and technology uncertainties, information sharing could effectively reduce information asymmetries and motivate both parties to plan together. For instance, firms share point-of-sales and forecasting information to minimize the bullwhip effect, reduce inventory, and improve customer service. Lin and Chen [36] found that OEMs, understanding the unpredictability of service parts demand, are motivated to share new product production and shipment information with third-party logistics to provide better after-sales service. Firms hope to share important information with business partners in order to respond to environmental changes more quickly and effectively. Therefore,

Hypothesis 2d. *Environmental uncertainty increases the use of information-sharing governance.*

2.3. Effects of Contractual Governance

Contractual governance is the primary mechanism to facilitate and monitor the success of supply chain collaboration [23,28]. Its governance purpose is to control buyer–supplier opportunism through legal stipulations, formal rules, terms and procedures, and penalties for noncompliance [23]. TCE suggests that a detailed contract can minimize any uncertainty associated with business transactions [24]. A higher degree of contract specificity could impose stronger control on business relationships and, thus, discourages opportunistic behavior or abuse [8,33]. Many studies suggested incorporating incentives into the contract (e.g., revenue sharing) to facilitate the implementation of joint sustainability initiatives [12,37]. It is common industry practice that comprehensive contractual clauses cover the concerns about financial repayment, poor technical performance, exclusivity, and late delivery [23]. These clauses can effectively reduce levels of risk, cultivate buyer–supplier cooperation, suppress opportunistic behavior, and assure the successful implementation of joint sustainability efforts. Ultimately, detailed and complex contracts can more effectively respond to hazardous exchange settings, and monitor agreed upon collaboration, thereby enhancing environmental performance [28]. Therefore, we hypothesize that contractual governance is expected to increase environmental performance.

Hypothesis 3. *Contractual governance improves environmental performance.*

2.4. Effects of Relational Governance

Relational governance consists of multiple components [27,28,38] such as solidarity, flexibility, and information exchange. Both flexibility and solidarity facilitate adaptation to unexpected events through a bilateral approach and cooperation in problem solving. On the other hand, information sharing facilitates adaptation through the sharing of private information with one another. These social processes seem to engage in different types of activities to facilitate relational adaptation: cooperation in problem-solving and information sharing.

Extending from the view of the multi-dimensionality of relational governance, this study proposes there are two different types of relational governance, cooperation of problem solving and information sharing that may display different effects on curtailing opportunism, providing adaptability, and improving environmental performance. These two governance mechanisms highlight the engagement of two informal supply chain activities during the implementation and fulfillment of a formal sustainability agreement. After the contract is signed, buyers and suppliers interact and cooperate with each other, with the intent of satisfying contract specifications and cooperating with unexpected contingencies, and such cooperation is referred to as problem-solving cooperation [6,19,28]. In general, problem-solving cooperation includes various activities, such as developing a standard approach to problem solving, establishing implicit agreements, and making a

commitment to not alter facts to a party's advantage [28]. The literature has confirmed the benefits of those cooperative activities in fostering flexibility in buyer–supplier relationships and creating informal support to strengthen cooperation in problem-solving which, in turn, improves environmental performance [37,39]. Therefore, we propose that cooperation fosters continuance and bilateralism, which, in turn, enhance environmental performance.

Hypothesis 4a. *Problem-solving cooperation governance improves environmental performance.*

Another type of relational governance, information sharing governance, stresses the communication and transfer of information between supplier and buyer to process the transaction [40,41]. Many studies have empirically verified the benefits of supply chain information sharing, including shortening lead time, improving forecasting, mitigating the bullwhip effect, and reducing inventory [8,30]. In the case of sustainability collaboration, Lin and Chen [39] found that sharing production plan and shipment information with their 3PL providers would significantly improve after-sale service. Specifically, sharing necessary information among ODMs, OEMs, and 3PLs helps in the prediction of product failure rate and preparation of service parts. Sharing of eco-innovation ideas and practices can also lead to achievement of sustainability improvement. We propose that information sharing mitigates the exchange hazards associated with specific investments and uncertainties that, in turn, enhance environmental performance.

Hypothesis 4b. *Information-sharing governance improves environmental performance.*

Figure 1 displays the hypothesized relationships among environmental uncertainty, asset specificity, contractual governance, problem-solving cooperation governance, information-sharing governance, and environmental performance.

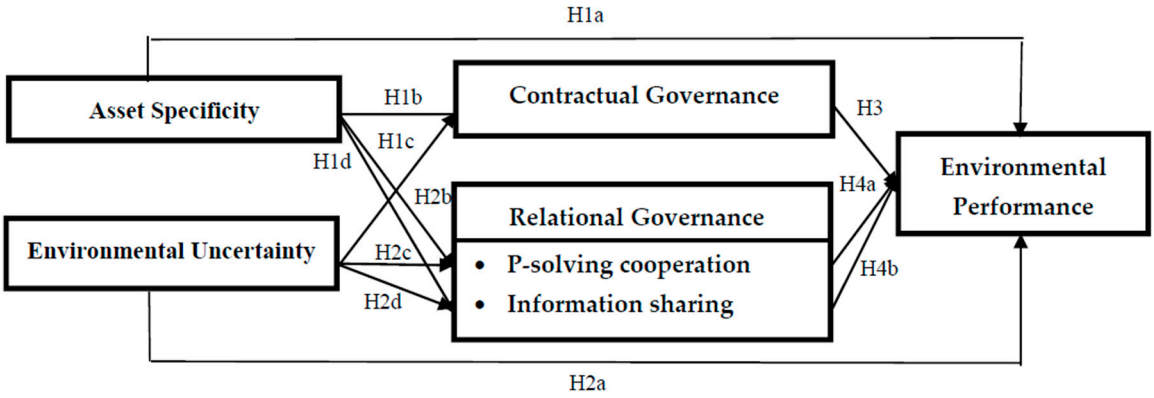

Figure 1. Research model.

3. Research Methodology

Several research methods have been applied to investigate the research issues on green supply chain management, including case studies, statistical analysis, and heuristic optimization. Table 1 provides an overview of popular research methods used in relation to applications of green supply chain governance mechanisms. Due to the complexity of the issue (the number of latent and measurable variables, the number of possible hybrid governance mechanisms, the nature of research questions), this study selects structural equation modeling (SEM) to test the research hypotheses and the theoretical model. SEM is chosen for its capability to impute relationships between latent variables from observable variables, whereas other multivariate techniques mostly rely on observed measurements [33]. Moreover, most other multivariate techniques are descriptive by nature, and it is more difficult to perform hypothesis testing in this study.

Table 1. Summary of green supply chain governance research methods.

Case Studies	Statistical Methods	Heuristic Optimization
• Relational governance (information sharing, cooperation): [9,18,42,43]	• Contractual governance: [40] • Relational governance (information sharing, cooperation): [4,5,7,8,10,16,41,44,45]	• Contractual governance: [12,37,38,46–48] • Relational governance (information sharing, cooperation): [12,13,36,39]

3.1. Data and SEM Analysis

Structural equation modeling (SEM) is used to test the theoretical model and examine how and why various exogenous factors directly and indirectly affect environmental management performance outcomes. We used the traditional varimax with Kaiser normalization of principal component analyses. The empirical analysis gives both the direct and indirect effects of specific causal variables on performance variables. SEM is able to simultaneously estimate multiple dependence relationships, while also incorporating multiple measures for each construct. Each of the path coefficients is estimated, using the maximum likelihood method, while the model's overall goodness of fit is evaluated using the following six indicators: chi-square statistic/degree of freedom, goodness-of-fit index (GFI), normed fit index (NFI), comparative fit index (CFI), root mean square residual (RMR), and root mean square error of approximation (RMSEA).

This study uses data collected by the Global Manufacturing Research Group (GMRG) (www.gmrg.org) from the Round 4.0 Survey, with 969 samples from 17 countries [49,50]. Appendix A provides more details on the samples. The unit of analysis was the relationship between a plant and its most important supplier, and plant managers were key informants. The data collectors were instructed to assess non-response bias by comparing early and late respondents (responses received after a reminder mailing) regarding the variable means. No systemic differences between early and late respondents were detected. More than 50% of the samples were collected from manufacturers of electronic and electrical equipment (US SIC 36), fabricated metal products (US SIC 34), commercial machinery, as well as computer equipment (US SIC 35), and food and kindred products (US SIC 20). We do not find significant differences in environmental uncertainty, asset specificity, or governance between industry types. Schoenherr [51] and Wiengarten et al. [35] have made similar observations regarding the effects of industry type and firm size using a similar dataset. Normality of the data distribution is supported by the generalized multi-variate central limit theorem (CLT). For multicollinearity, the VIFs were statistically insignificant using SPSS.

3.2. Psychometric Properties

This study used confirmatory factor analysis (CFA) to test the reliability and validity of the measurement model. With the exception of asset specificity, this study uses multiple item variables to present the latent constructs using a structured questionnaire. The scales of five latent variables are adopted from previous studies: environmental uncertainty [52], environmental performance [3], contractual governance [28], relational governance—problem-solving cooperation [21], and relational governance—information sharing [32]. Face validity is ensured since the multi-attributed variables are defined based on the literature. Additionally, all multiple-item variables achieved internal consistency and reliability, with Cronbach's alpha coefficients greater than the threshold 0.7 [53] (see Table 2).

Table 2. Reliability and convergent validity analyses (n = 969).

Dimensions	Item	Factor Loading	Cronbach α	Construct Reliability
Supplier asset specificity	Transaction-specific investment from the supplier	—	—	—
Environmental uncertainty	Technology uncertainty	0.77	0.814	0.785
	Market/demand uncertainty	0.80		
Problem-solving cooperation governance	Commitment to resolving unexpected problems	0.72	0.737	0.764
	Commitment to maintaining mutual-respect relationship	0.68		
	Reliance on implicit agreements for solving problems	0.69		
Information sharing governance	Information sharing on demand and production	0.70	0.773	0.731
	Information sharing on quality	0.72		
	Stabilization of production schedules	0.74		
	Avoidance of unnecessary schedule changes	0.69		
Contractual governance	Financial repayment for pre-terminated contract	0.66	0.766	0.785
	Exclusivity clause	0.70		
	Penalties for poor performance	0.80		
	Cost sharing	0.85		
Environmental performance	Reduction of waste	0.79	0.847	0.792
	Reduction of water use	0.82		
	Reduction of energy use	0.78		
	Reduction of emission	0.81		

The CFA results reveal that χ^2/df = 4.83, GFI = 0.94, AGFI = 0.91, NFI = 0.91, CFI = 0.93, RMSEA = 0.063, and RMR = 0.049, suggesting good model fit [47]. Furthermore, Table 2 shows all factor loadings are greater than 0.50. Accordingly, the construct validity and convergent validity are validated [53]. Finally, Table 3 reveals that the average variance extracted (AVE) is larger than the squared correlations between variables. Therefore, discriminant validity is also confirmed.

Table 3. Discriminant validity analysis.

Dimensions	1	2	3	4	5	6
1. Asset specificity	(1)					
2. Uncertainty	0.035	(0.46)				
3. Relational governance—problem-solving cooperation	0.108	0.022	(0.42)			
4. Relational governance—information sharing	0.068	0.031	0.021	(0.49)		
5. Contractual governance	0.042	0.047	0.015	0.152	(0.55)	
6. Environmental performance	0.068	0.011	0.039	0.036	0.028	(0.51)

The numbers in the lower triangular matrix are the squared correlations; the numbers in parentheses are AVE.

Fit indices for the multi-factor model are better than those for the single-factor model (CFI = 0.93 vs. 0.64, GFI = 0.94 vs. 0.57, NFI = 0.91 vs. 0.61). Additionally, we used Harman's one-factor test to examine the concern of common method bias [47]. All items are included in exploratory factory analysis, through principal components without rotation. The first factor explains 17.28% of the total

variance, and no single factor accounts for the majority of the covariance. Accordingly, there are no major concerns about CMV or common method bias [54]. The model is a good fit to the data, since the overall fit indices of the model are all within the acceptable scope: RMSEA = 0.057; RMR = 0.050; CFI = 0.91; NFI = 0.93; GFI = 0.95; AGFI = 0.92.

4. Statistical Results and Discussion

4.1. SEM Findings

The statistical results are presented in Figure 2 and the results of hypotheses tests are summarized in Table 4.

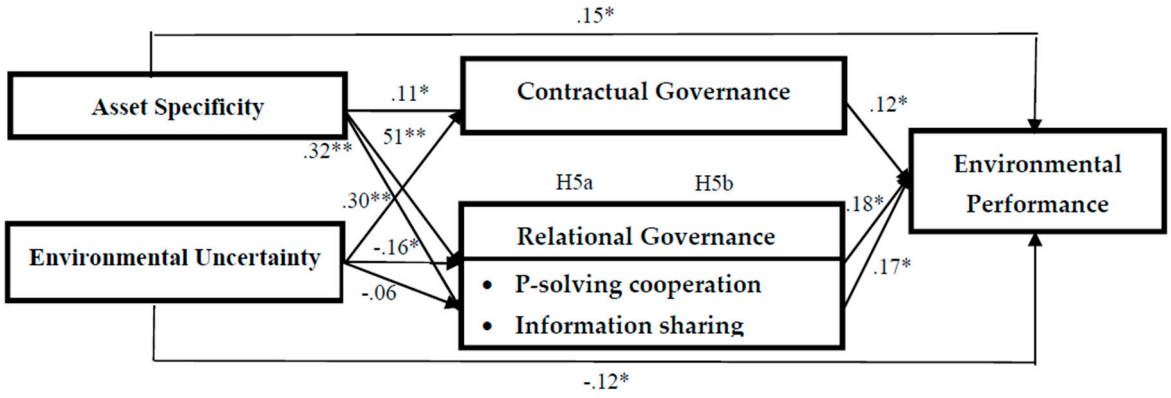

Figure 2. SEM results.

Table 4. SEM results.

Path (Hypothesis)	Std. Parameter Estimate (*t*-Value)	Result
H1a: Asset specificity → Environmental performance	0.15 (2.58) *	Supported
H1b: Asset specificity → Contractual governance	0.11 (1.96) *	Supported
H1c: Asset specificity → Inter-firm cooperation	0.51 (14.42) **	Supported
H1d: Asset specificity → Information sharing	0.30 (8.59) **	Supported
H2a: Env. uncertainty → Environmental performance	−0.12 (−1.99) *	Supported
H2b: Env. uncertainty → Contractual governance	0.30 (3.46) *	Supported
H2c: Env. uncertainty → Inter-firm cooperation	−0.16 (−3.95) *	Unsupported
H2d: Env. uncertainty → Information sharing	−0.06 (−0.47)	Unsupported
H3: Contractual governance → Environmental performance	0.12 (2.36) *	Supported
H4a: P-solving cooperation → Environmental performance	0.18 (2.61) *	Supported
H4b: Information sharing → Environmental performance	0.17 (3.08) *	Supported

Note: ** $p < 0.01$, * $p < 0.05$.

First, asset specificity has a positive influence on environmental performance (standardized path coefficient = 0.15), while environmental uncertainty reduces environmental performance (−0.12), supporting H1a and H2a, respectively. Asset specificity is significantly associated with the use of contractual governance (0.11), relational governance—problem-solving cooperation (0.51), and relational governance—information sharing (0.32), thus supporting H1b, H1c, and H1d. Meanwhile, EU significantly increases the use of contractual governance (0.30), supporting H2b, but not so with problem-solving cooperation (−0.16) or information sharing (−0.06). H2c and H2d are not supported. Finally, regarding the effectiveness of governance mechanisms, paths contractual governance → environmental performance (0.12), problem-solving cooperation → environmental performance (0.18),

and information sharing → environmental performance (0.17) are significant, supporting H3, H4a, and H4b.

Moreover, the total effects of asset specificity and environmental uncertainty are examined to better understand the mediating effects of governance mechanisms. Specifically, through the governance mechanisms (problem-solving cooperation, information sharing, and contractual governance), asset specificity significantly improves environmental performance, and the negative impact of environmental uncertainty on environmental performance is reduced. The total effect of asset specificity is 0.251 (direct = 0.15, indirect = 0.101) and the total effect of environmental uncertainty is −0.04 (direct = −0.12, indirect = 0.008). Contractual governance, problem-solving cooperation, and information sharing are partial mediators for asset specificity—environmental performance and environmental uncertainty—environmental performance. In other words, three governance mechanisms, Contractual governance, problem-solving cooperation, and information sharing, together, effectively mediate asset specificity and environmental uncertainty and significantly enhance environmental performance.

4.2. Discussion

The literature has confirmed the value of sustainability initiatives through the structure of green supply chain collaboration. Nonetheless, bounded rationality and opportunistic behaviors have often hindered the effectiveness of well-intentioned green collaboration [16]. Very little guidance is provided on how supply chain members could collaborate on joint sustainability initiatives, and green supply chain collaboration has remained challenging. With no proper governance mechanisms, organizations involved in joint sustainability initiatives are exposed to opportunism, which discourages firms from making meaningful and intensive joint efforts [16,17,53]. The literature has called for developing effective governance mechanisms for supporting the implementation of green supply chain collaboration [16,17,50]. The following is a summary of research and managerial implications.

(1) Crafting complex contractual clauses is insufficient to address all uncertainties, and relational adaptation is necessary. While this finding supports previous studies [23,40], the usage of different control mechanisms varies by the source of opportunism and adaptation problems (asset specificity and environmental uncertainty), which was never addressed in the past. For instance, the firms reduce the use of both relational mechanisms when facing environmental uncertainty. Apparently, our samples chose to increase the use of contractual governance, but reduce the level of problem-solving cooperation (Figure 2, H2c) and information-sharing (H2d), to safeguard against environmental uncertainties.

(2) Enhancing the use of relational governance is critical to environmental management performance. Note the execution of both relational governances requires a high level of trust [28,38]. Without trust, there can be no engagement in inter-firm information-sharing and joint collaboration. Some researchers [6,20,31,45,48] found that, when facing stressful and uncertain situations, the managers might develop distrust and fear toward their supply chain partners. If so, it is very possible that manufacturers, in the case of environmental uncertainty, are discouraged to rely on informal social ties to protect their interests. This could explain the unexpected results in H2c and H2d. In any case, considering the positive, partial, mediating effect of information-sharing and problem-solving cooperation, our samples might have missed the opportunity to enhance their environmental performance when choosing not to adopt relational governance.

(3) Contractual governance can reduce the risk and opportunisms. The statistical results clearly suggest that contractual clauses are critical in mediating the negative effects of asset specificity and environmental uncertainty. Despite the increasing discussion of buyer–supplier relationships in the literature, the contract remains a necessary instrument to govern supplier performance. Moreover, problem-solving cooperation governance and information-sharing governance seem to be conceptually and pragmatically different from each other.

(4) The multi-dimensionality of relational governance should be recognized. These two relational mechanisms were previously labeled as social or informal mechanisms by the literature [27,38].

Both social mechanisms are based on trust and are always treated as one single construct, even though they represent different concepts. Combining them as a composite construct is misleading and may contribute to the inconsistent findings regarding the effect of social/relational governance in previous studies [30]. Future research on supplier governance should recognize relational governance as a multi-dimensional construct.

5. Conclusions

This study proposes a structural equation model, under the framework of transaction economics theory, that hypothesizes a set of 'green transaction attributes—governance mechanism—environmental performance' relationships, with three governance mechanisms (contract, problem-solving cooperation, and information-sharing) being the partial mediators. Using the data collected from 969 plants in 17 countries, we validate the proposed model and confirm that three control mechanisms (contract, problem-solving cooperation, and information sharing) are simultaneously adopted to mediate the effects of asset specificity and environmental uncertainty. The results also reveal significant differences in the efficacy of alternative governance mechanisms in mitigating opportunism and managing adaptation problems to improve environmental performance. Overall, this study makes research contributions by confirming the mediation effects of various governance mechanisms, a very important aspect of sustainability collaboration that has not been properly examined. Apparently, the indirect effects of contractual governance and relational adaptation can make green supply chain collaboration more effective. For green supply chains to be a viable strategy, firms should apply multiple governance mechanisms properly, in alignment with the nature of the sustainability transaction and environmental conditions. The important managerial and research implication is that it is insufficient to merely discuss the relationships among the green initiatives and governance structure along the market-hierarchy continuum. Managers should also recognize how various forms of hybrid governance mechanisms enhance the performance of environmental management.

Our results also offer valuable suggestions as to green supply chain collaboration practices. Managers should recognize the relative efficacy and contingency of the three forms of governance, contractual clauses, inter-firm cooperation governance, and information-sharing governance. Contractual governance was found to be very effective in mitigating the risk from market, technology, and special investment. A contract is a critical juncture for determining the success of a commercial relationship. In light of the growth of global sourcing, green partnership involves multiple jurisdictions with an inconsistent legal framework. Companies must carefully study the content and role of contracts in enhancing green supply chain performance. However, the managers should be aware of the limitations of using a legal contract as a single governance mechanism. Namely, contractual clauses would not be able to address all performance measurement difficulties resulting from the use of new technology. Firms should engage in relational adaptation to become flexible when facing performance ambiguity. This finding responds to and validates the call from the literature for more studies on the issue of trust and social norms in TCE and inter-organizational transaction research. The development of informal buyer–supplier collaboration is especially critical for manufacturers from the western world to engage in green supply chain collaboration in Asian countries [30].

Finally, we would review a few research limitations and propose plausible resolutions. First, the cross-sectional nature of this research allows us to analyze the proposed theoretical relationships at only one specific point in time, not over a period of time. Thus, further longitudinal evaluation may be needed. For instance, it would be interesting to monitor how the buyer–supplier relationships' time dimension affects choices among governance mechanisms. The collection of same data in the next GMRG survey would be very helpful in addressing this issue. Next, asset specificity is measured as a single item. Although it is possible to add more questions to the survey (e.g., how much does this supplier invest in physical equipment, labor resources, manufacturing process changes, etc.), the question utilized covers the formal definition's conceptual domain and avoids unnecessary vagueness. Overall, we believe the measurement of supplier asset specificity is not a major issue.

Even with those limitations, there is strong evidence regarding the contingent nature of the usage and effectiveness of governance mechanisms. We believe the discussion of supplier governance is incomplete without including those contingency factors. In any case, the TCE governance model presented in this study provides a guideline for a more incisive analysis of how firms govern suppliers to control opportunism in environmental management.

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Appendix A. Samples

Table A1. Country distribution.

Country	Frequency	Country	Frequency
(1) Albania	15	(11) South Korea	115
(2) Australia	30	(12) Macedonia	39
(3) Austria	17	(13) Mexico	105
(4) China	57	(14) Poland	57
(5) Croatia	82	(15) Sweden	32
(6) Fiji	110	(16) Switzerland	31
(7) Germany	60	(17) Taiwan	50
(8) Ghana	63	**Total**	**969**
(9) Hungary	53		
(10) Italy	54		

Table A2. Industry distribution.

Industry	Freq.	Percent	Industry	Freq.	Percent
Electronic and other equipment	124	12.8%	Motor vehicles, trailers, and semi-trailers	18	1.9%
Industrial machines and computer equipment	116	12.0%	Other manufactured transport equipment	16	1.6%
Fabricated metal	115	11.9%	Apparel and other finished products	13	1.3%
Food products GMP	60	6.3%	Lumber and wood products	12	1.2%
Textile mill products	37	3.8%	Leather and other products	8	0.8%
Stone, clay, glass, and concrete products	33	3.3%	Primary metal industries	8	0.8%
Furniture and fixtures	30	3.1%	Petroleum refining and related products	5	0.5%
Rubber and plastic products	30	3.1%	Recycling	2	0.2%
Chemical and allied products	25	2.6%	Miscellaneous manufacturing	258	26.7%
Measuring, analyzing and control photographic, medical equipment	23	2.3%	**Total**	**969**	**100.0%**
Paper and allied products	18	1.9%			
Printing and Publishing and Allied Industries	18	1.9%			

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