

Manufacturing Supply Chain Governance under the Objective of Enterprise Ecological Innovation: Contract or Relationship?

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Abstract—Enterprise eco-innovation has become the key to achieving "green manufacturing". However, the potential opportunistic behavior among manufacturing supply chain enterprises hinders the practice of eco-innovation. The key to promote eco-innovation is the effective implementation of manufacturing supply chain governance. This study deeply analyzes the core logic of supply chain governance and ecological innovation, innovatively establishing the supply chain governance mechanism based on contract and relationship governance, and making theoretical assumptions on the impact of ecological innovation mechanism based on management, technology and product dimension, for empirical research on traditional manufacturing industry in Guangxi Province of China. The results show that contract governance had a significant positive impact on the eco-product innovation; relationship governance had a positive and significant impact on ecological product, management and technology innovation; Regulation pressure had a negative effect on the relationship between relationship governance and eco-product innovation; And imitation pressure has negative regulation and positive regulation on contract governance, relationship governance and eco-product innovation respectively. Therefore, from the perspective of supply chain governance, this study puts forward feasible countermeasures to effectively promote the ecological innovation in manufacturing supply chain enterprises in Guangxi Province of China.

Keywords—*Manufacturing supply chain; enterprise ecological innovation; supply chain governance; contract governance; relationship governance*

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I. INTRODUCTION

"Green Manufacturing" is becoming the main trend of China's manufacturing industry. In the "Thirteenth Five-Year" Plan and "Made in China 2025", China's government has promoted "green manufacturing" to the national strategic level. In this context, implementing ecological innovation is an important engine for manufacturing enterprises to achieve "green manufacturing".

The eco-innovation of manufacturing enterprises relies on eco-technology, eco-product and eco-management innovation[1]. In other words, eco-innovation needs to be implemented through the research and development or use of eco-friendly products that meet the ecological requirements and the management of eco-targets. The implementation of ecological innovation in enterprises involves many aspects of procurement and production, which are closely linked with other node enterprises in the supply chain where they are located. R&D of ecological innovation requires the participation and cooperation of upstream and downstream enterprises in the industry[2]. Compared with other environmental measures, ecological innovation has a higher risk, requiring more financial commitment and longer payback period[3]. So the supply chain companies out of their own interests, with the use of asymmetric information between enterprises and other factors, the implementation of ecological innovation is likely to exist opportunistic behavior, which is not conducive to ecological innovation practice in the supply chain enterprises.

Based on this, the implementation of supply chain governance is particularly important for the practice of ecological innovation in manufacturing supply chain enterprises. For the performance of supply chain governance, mainly through the governance mechanism[4]. Contract governance and relationship governance is the two main governance mechanisms[5]. Scholars have conducted a large number of studies, emphasizing the two governance effects.

However, no scholars have explored the impact of supply chain governance on the practice of eco-innovation. In view of this, in view of the ecological innovation behavior of manufacturing supply chain enterprises, to explore different governance mechanisms to reduce the effect of opportunistic behavior among enterprises and to make up for the existing research deficiencies meanwhile, the study provides a theoretical reference for clarifying the relationship between supply chain governance and ecological innovation. At the same time, the research results also help the manufacturing supply chain through the implementation of supply chain governance to ensure the realization of ecological innovation in the manufacturing supply chain enterprise.

II. THEORETICAL ANALYSIS AND RESEARCH ASSUMPTIONS

A. Contract Governance and Ecological Innovation

Through formal and legally-effective contracts, contract governance mainly regulates and restricts the cooperation behavior of supply chain nodes and strictly supervises the process and results of cooperation and the responsibilities and obligations of both parties to prevent or reduce the occurrence of opportunistic behavior[6]. As far as the governance performance of contract governance is concerned, the contract governance mechanism significantly inhibits the speculation of channel partners[7]. Contract control has a positive impact on the performance of cooperation during the exploration phase of the manufacturer's relationship with its partner[8]. In view of the ecological innovation behavior of manufacturing supply chain enterprises, its substance runs through the whole life cycle of products. The cooperation agreement signed between upstream and downstream enterprises for ecological innovation clearly stipulates the rights and obligations that enterprises should fulfill, and the breach of contract. To some extent, this can affect opportunistic motives of supply chain enterprises and give up their opportunistic behavior[9]. It should be pointed out that the actual role of contract governance in supply chain governance remains controversial. In other words, contract governance may not be able to effectively promote supply chain manufacturing enterprises to achieve ecological innovation[10]. Therefore, for the purpose of further clarifying the role of contract governance in ecological innovation, we propose the hypothesis 1:

Hypothesis 1: Contract governance positively affects the enterprise's ecological innovation behavior.

B. Relationship Governance and Ecological Innovation

Relationship governance is a mechanism to govern opportunistic behavior among supply chain enterprises by virtue of trust, commitment and joint actions among supply chain enterprises. It has played a positive role in cooperating with companies under supply chain environment with uncertainty and complexity. Especially in the social environment where China pays attention to "relationship", relationship governance in coordinating the relationship among supply chain enterprises and reducing opportunistic behavior is extremely significant[11]. Relationship governance can effectively increase the quantity and credibility of knowledge transfer among enterprises, especially trust[3]. Existing research also shows that the level of

governance between the manufacturing enterprises in the supply chain and the upstream manufacturing enterprises is the higher, they will help them to improve the ability to prevent pollution better[12]. In the practice of ecological innovation, manufacturing supply chain enterprises rely on mutual trust, mutual interaction and information sharing to enhance their expectation of cooperation. It also regulates the cooperative behavior of joint enterprises and restrains the occurrence of opportunistic behavior, and further enhances the willingness and enthusiasm of enterprises in the supply chain to adopt ecological innovation behavior. Accordingly, we propose hypothesis 2:

Hypothesis 2: Relationship Governance Positively Affects Enterprise's Ecological Innovation Behavior.

C. The interaction of contract governance and relationship governance on the eco-innovation of enterprises

Compared to an interactive governance mechanism, the utility of the interaction between the enterprises is mainly reflected on eco-innovation in the following: in the environment of volatility, relationship governance is more effective. And under the ambiguous environment, contract governance has more advantages[13]. The utility of governance for the eco-innovation is mainly manifested in the process of ecological innovation, relying on the long-term cooperation between enterprises formed by the relationship between the implementation of governance. At the same time, in the process of actual cooperation with each other, relying on the complementary relationship between formal governance and relationship governance, the combination of the two can more effectively prevent opportunistic risks and bring about better performance.[14]. In the supply chain network, the trust, social norms and shared values between buyers and sellers can interact with unobtrusive monitoring activities and formal contracts that adapt with each other to improve cooperative performance[15]. So we propose the hypothesis 3:

Hypothesis 3: The joint implementation of contract governance and relationship governance positively affects the enterprise's ecological innovation behavior.

D. The regulatory role of institutional pressure

The main theoretical basis of the hypothesis of the influence of selection system pressure on enterprise ecological innovation is institutional theory. Specific to the manufacturing enterprise's ecological innovation behavior, the institutional pressure that urges enterprise to pursue eco-innovation goals lies in the regulation pressures brought about by the environmental protection policies or environmental regulations of the government and regulatory agencies, the imitation pressure from competition enterprise to gain competitive advantage by ecological innovation behavior, consumer demand, encouraging the growth of the industry standard specification[16]. Specific to the impact of the role, the existing research also shows that institutional pressure for the implementation of enterprise ecological innovation has an important role[17]. Some studies have found that on the one hand, the degree of contract execution under contract governance varies greatly in the supply chain[18], depending on the efficiency and cost of third-party interventions, which depend largely on the institutional framework[19]. That the

impact of contract governance depends on the institutional environment. On the other hand, because supply chain relationships are embedded in a macro-social environment[20]. Successful supply chain governance often depends on supportive institutional frameworks, including legal systems and government. Therefore, the supply chain contract governance, the implementation of relationship governance must be subject to institutional pressure. Considering that consumers have been regarded as members of the supply chain, so the study chose environmental pressure from the government and competitors as the main institutional pressure. Based on this, the research hypothesis 4-7:

Hypothesis 4: Regulation pressure strengthens the positive impact of contract governance on firms' eco-innovation behavior;

Hypothesis 5: Regulation pressure strengthens the positive impact of relationship governance on corporate eco-innovation behavior;

Hypothesis 6: Imitation pressure strengthens the positive impact of contract governance on firms' eco-innovation behavior;

Hypothesis 7: Imitation pressure strengthens the positive impact of relationship governance on corporate eco-innovation behavior.

III. STUDY DESIGN AND MODEL OPERATION

The research chooses manufacturing enterprises in Guangxi Province of China as an empirical research object. The main reason is that the manufacturing system in Guangxi Province is relatively complete. The supply chain of manufacturing companies is relatively complex, and it is easy

to generate potential opportunistic risks in the field of ecological innovation. At the same time, according to the requirements of environmental protection in the autonomous region, the ecological innovation in Guangxi's Province manufacturing industry is also facing greater institutional pressure. Data collection is mainly conducted through field surveys to directly issue questionnaires to minimize invalid questionnaires. A total of 153 valid questionnaires were obtained. In order to increase the reliability of the questionnaire and the representation of the data, referring to the practice of Qinghua Zhu[23] (2009), field survey companies involved state-owned enterprises, private enterprises, and foreign-funded joint ventures. Specific information as shown in the appendix.

A. Reliability and validity

The Cronbach's coefficients for all variables ranged from 0.854 to 0.923, all of which were greater than 0.7. The reliability of combination factors (CR) of all the potential constructs were all larger than 0.7, indicating that the latent constructs measured by the item had high internal consistency and construal confidence.

The scales used in this study are based on the relevant scales used by domestic and foreign scholars and developed in conjunction with the knowledge of supply chain governance and corporate ecological innovation. Therefore, it has good content validity. Second, through the confirmatory factor analysis, the results obtained are shown in Table I: the factor loading values of all the measured variables are greater than 0.7, and the mean variance of all potential constructs (AVE) are greater than 0.5, indicating that aggregation validity is good.

TABLE I. RELIABILITY ANALYSIS AND VALIDITY ANALYSIS

Potential constructs	Item	Factor load value	Average variance extraction	Combination reliability	Cronbach's a
Contract Governance	CG1	0.938	0.764	0.928	0.922
	CG2	0.959			
	CG3	0.824			
	CG4	0.759			
Relationship Management	RG1	0.836	0.694	0.900	0.892
	RG2	0.884			
	RG3	0.882			
	RG4	0.720			
Ecological Management Innovation	EMI1	0.751	0.593	0.853	0.854
	EMI2	0.781			
	EMI3	0.817			
	EMI4	0.729			
Ecological Technology Innovation	ETI1	0.932	0.789	0.918	0.907
	ETI2	0.924			
	ETI3	0.803			
Ecological Product Innovation	EPI1	0.866	0.752	0.924	0.923
	EPI2	0.879			
	EPI3	0.892			
	EPI4	0.831			
Regulation Pressure	RP1	0.808	0.706	0.878	0.879
	RP2	0.838			
	RP3	0.874			
Imitation Pressure	IP1	0.875	0.676	0.862	0.861
	IP2	0.796			
	IP3	0.792			

B. Descriptive statistics and correlation analysis.

Table II shows the mean, standard deviation and Pearson correlation coefficient of all potential constructs in this study.

C. Multiple linear regression analysis

In order to further verify the hypothesis proposed, multiple hierarchical regression analysis was performed. By computing

VIF, there is no collinearity between the potential constructs. Multiple regression results are shown in table III, table IV, table V.

1) According to the above regression results, it can be concluded that contract governance has a significant and positive impact on eco-product innovation. Relationship governance has a positive and significant impact on eco-management innovation, eco-technology innovation and eco-product innovation. Considering the existence of an inverted U-shaped relationship among contract governance, relationship governance, eco-management innovation, eco-technology innovation and eco-product innovation, the quadratic power of contract governance and the quadratic relationship governance of regression are analyzed. The results show that: The quadratic term of contract governance has a significant and negative impact on eco-management innovation and eco-technology innovation, indicating that there is an inverted U-shaped relationship between contract governance and eco-management innovation and eco-technology innovation. Hypothesis 1 is partially supported and Hypothesis 2 is fully supported.

2) The regression results show that the interaction between contract governance and relationship governance shows a negative and significant relationship between eco-management innovation and eco-technological innovation, which is contrary to the conclusion of Hypothesis 3.

3) Further, the regulatory effects of regulation pressure and imitation pressure on the relationship between contract governance and relationship governance and the eco-management innovation, eco-technology innovation and eco-product innovation are examined. From the above regression results, it can be seen that regulation pressure has a negative regulating effect on the relationship between relationship governance and eco-product innovation. Hypothesis 4 is not supported, and Hypothesis 5 is the opposite. However, the imitation pressure has a negative regulation between contract governance and eco-product innovation, and positively regulates the relationship between relationship governance and eco-product innovation. Therefore, Hypothesis 7 is partially supported.

4) To further examine the regulatory effect of regulation pressure and imitation pressure on the relationship between contract governance and relationship governance, and eco-management innovation, eco-technology innovation, and eco-product innovation, we further conduct regression analysis on this point, which shows that regulation pressure and imitation pressure has no significant effect on the square of contract governance and innovation of eco-management, nor does the regulation of eco-technology innovation. Regulation pressure has a positive regulating effect on the square of contract governance and eco-technology innovation.

IV. CONCLUSION AND INSPIRATION

A. Conclusion

1) There is a significant positive correlation between contract governance and eco-product innovation, and an inverted U-shaped relationship between contract governance and eco-management innovation, eco-technology innovation.

The cooperation between manufacturing supply chain companies is often based on the flow of raw materials, semi-finished products and finished products. The ecological innovation practice under contract governance is the most direct product. The cooperation between upstream companies and their downstream enterprises is to satisfy the downstream companies' products that meet the requirements of ecological innovation. The possible existence of an inverted U-shaped relationship between contract governance and eco-management innovation and eco-technology innovation may lie in the fact that excessive adoption of formal control may not prevent opportunistic behavior but may lead to a lack of autonomy and trust among partners[14, 24], which may adversely reduce the cooperation performance. In other word, the agreement is too narrow and strict, which is not conducive to eco-management innovation and eco-technology innovation. As Porter and Van der Linde's point of view, they believe that regulations that promote eco-innovation should have the characteristics of flexibility and steady progress, so that companies can have time for eco-innovation instead of using existing EOP technologies[25].

2) Relationship governance has a significant positive correlation with ecological management innovation, ecological technology innovation and ecological product innovation. This result once again validates the affirmation of the majority of scholars on the effectiveness of relationship governance, and also meets the influence and role of "relationship" in Chinese society under the traditional concept. Relationship governance relies on the trust, commitment, and willingness to cooperate between companies in the supply chain to maintain cooperative relationships among enterprises so as to reduce the occurrence of opportunistic behavior. Relying on the relationship governance is advantageous to the enterprise to maintain cooperative relations, and it has positive significance in eco-product innovation level. To a certain extent, eco-product innovation will promote enterprises to carry out eco-technology innovation. The role of relationship governance is often reflected in the long-term cooperation between large-scale enterprises, and this type of enterprise has developed itself well, so it also has advantages in eco-management innovation and is more likely to carry out eco-management innovation.

3) The interaction between contract governance and relationship governance negatively affects eco-management innovation and eco-technology innovation. This test is contrary to the original hypothesis. Possible explanation is that with the high requirement of agreement and relationship, it is difficult for cooperative enterprises to launch high-level eco-management innovation and eco-technology innovation in a short period of time.

4) The regulation pressure from the government has negative regulating effect on the relationship between relationship governance and eco-product innovation; the imitation pressure from competitors has a negative regulating effect on contract governance and eco-product innovation, and has a positive regulating effect on the relationship between relationship governance and eco-product innovation. Regulation pressure has a positive regulating effect on the relationship between square of contract governance and

ecological process innovation. Regulation pressure or imitation pressure is too strong, which may cause supply chain cooperation companies to produce products that meet the requirements. Relative to contract governance, imitation pressure has a positive regulating role in relationship governance and eco-product innovation. This study believes that long-term cooperation between supply chain companies built on trust, commitment, and cooperation has a high degree of recognition of each other's cooperation goals. Its main competitor is often a company with strong strength and size, and the other party's competitive advantage has an inestimable impact on the company's own development. Therefore, to a certain extent, imitation pressure from competitive companies can promote the implementation of ecological product innovation by companies that rely on highly cooperative relationships.

B. Inspiration

First, through the introduction of system binding, enterprises in manufacturing supply chain nodes should sign an appropriate legal contract to clearly define the roles, rights, obligations and behaviors of all parties in implementing ecological innovation to realize supply chain governance,

reduce opportunism and promote effectively eco-innovation among members. Second, member companies in the manufacturing supply chain should establish common shared norms, so that member companies consciously reduce opportunistic behavior and promote the process of enterprise ecological innovation. Third, contract governance and relationship governance should not interact intensively with the practice of enterprise eco-innovation. Both of them should differ in the degree of cooperation among the nodes and moderately and coordinately work together in the eco-innovation practice of enterprises. Fourthly, manufacturing supply chain member companies should be aware of the impact of pressure from competitors and their own substitutability on the relationship between governance mechanisms and governance effects. As far as suppliers are concerned, the less they focus on the implementation of ecological innovation, the greater the pressure from competitors. The more they need to strengthen their ecological innovation through management, technology and products, and maintain stable and long-term cooperation with downstream manufacturing enterprises to assist in the ecological innovation practice of each node company.

TABLE II. DESCRIPTIVE STATISTICS AND CORRELATION COEFFICIENT ANALYSIS

Variable	Mean	standard deviation	1	2	3	4	5	6	7
1.CG	2.976	1.027	1						
2.RG	3.072	1.070	0.498**	1					
3.EMI	2.922	1.145	0.462**	0.707*	1				
4.ETI	3.357	1.113	0.513**	0.659*	0.838**	1			
5.EPI	2.884	1.068	0.587**	0.693*	0.578**	0.610**	1		
6.RP	3.129	1.101	0.507**	0.672*	0.726**	0.727**	0.639**	1	
7.IP	2.802	1.138	0.487**	0.605*	0.674**	0.612**	0.576**	0.727**	1

Notation: **. Indicates a significant level at 0.01.

TABLE III. MULTIPLE REGRESSION ANALYSIS RESULTS 1

Variable	EMI					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
ES(enterprise scale)	0.674***	0.393***	0.387***	0.387***	0.268***	0.252***
CG		-0.008	-0.020	-0.030	-0.065	-0.067
RG		0.474***	0.460***	0.479***	0.290***	0.276***
CG ²			-0.108 ⁺		0.249**	
RG ²			-0.011		0.199**	
CG×RG				-0.115*		
RP						0.262**
IP						0.187*
CG×RP						-0.092
CG×IP						-0.066
RG×RP						0.056
RG×IP						-0.014
R square	0.454	0.596	0.608	0.609	0.671	0.686
Adjust the R square	0.451	0.588	0.594	0.598	0.659	0.666
The maximum value of VIF	1	1.921	1.938	1.925	2.813	3.418

Notation: ***, **, *, + indicate significant levels at 0.001, 0.01, 0.05, 0.1.

TABLE IV. MULTIPLE REGRESSION ANALYSIS RESULTS 2

Variable	ETI					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
ES(enterprise scale)	0.724***	0.488***	0.480***	0.479***	0.373***	0.345***
CG		0.053	0.044	0.024	0.011	-0.020
RG		0.339***	0.326***	0.346***	0.178*	0.153*
CG ²			-0.091 ⁺			
RG ²			-0.030			
CG×RG				-0.151**		
RP					0.326***	0.313***
IP					0.052	0.078

Cont. to TABLE IV						
CG×RP						-0.060
CG×IP						-0.091
RG×RP						0.135
RG×IP						-0.181*
R square	0.524	0.604	0.613	0.626	0.662	0.698
Adjust the R square	0.521	0.596	0.600	0.616	0.651	0.679
The maximum value of VIF	1	1.921	1.938	1.925	2.813	3.481

Notation: ***, **, *, + indicate significant levels at 0.001, 0.01, 0.05, 0.1.

TABLE V. MULTIPLE REGRESSION ANALYSIS RESULTS 3

Variable	EPI					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
ES(enterprise scale)	0.616***	0.198**	0.200**	0.198**	0.134 ⁺	0.142 ⁺
CG		0.244***	0.251***	0.243**	0.218**	0.243**
RG		0.453***	0.461***	0.453***	0.362***	0.353***
CG ²			0.069			
RG ²			-0.009			
CG×RG				-0.002		
RP					0.154 ⁺	0.172 ⁺
IP					0.064	0.027
CG×RP						0.135
CG×IP						-0.140 ⁺
RG×RP						-0.225*
RG×IP						0.211*
R square	0.379	0.579	0.583	0.579	0.596	0.615
Adjust the R square	0.375	0.570	0.569	0.567	0.583	0.591
The maximum value of VIF	1	1.921	1.938	1.925	2.813	3.228

Notation: ***, **, *, + indicate significant levels at 0.001, 0.01, 0.05, 0.1.

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APPENDIX

TABLE VI. POTENTIAL CONSTRUCTS AND MEASUREMENT ITEMS

Potential constructs	Items			references
Contract Governance	CG1	My company and partner companies implement ecological innovation	Signed a dedicated contract based on the specific content of the cooperation.	Poppo and Zenger[14] (2002) Antia and Frazier[18] (2001) Luo[21] (2005)
	CG2		Signed contract is very detailed.	
	CG3		In the event of a foreseeable event, specific response measures are stipulated in the contract.	
	CG4		When a party breaches the contract, the defaulting party will be subject to severe economic penalties and legal sanctions.	
Relationship Management	RG1	My company and partner companies implement ecological innovation	Established official channels for information exchange.	Jap and Ganesan[22] (2000)
	RG2		Both sides of the overall goal are very willing to accept.	
	RG3		When problems occur, the two parties take the initiative to mobilize their resources to jointly solve.	
	RG4		Regular exchanges between the two sides.	
Ecological Management Innovation	EMI1	To achieve the goal of ecological innovation for cooperative companies, our company	Adopting new environmental management system or method.	Cheng C C and Shiu E C[1] (2012) Xuerong Peng and Jiang Wei[17] (2015)
	EMI2		Collecting and sharing the latest information on ecological innovation.	
	EMI3		Actively carry out various ecological innovation activities.	
	EMI4		Putting more money into ecological innovation.	
Ecological Technology Innovation	ETI1	In response to the goal of implementing ecological innovation in cooperative companies, our company often	Improving production processes to reduce environmental pollution.	
	ETI2		Improving production processes to comply with environmental regulations.	
	ETI3		Introducing new energy-saving technologies for manufacturing.	
Ecological Product Innovation	EPI1	The company often adopts or develops the goal of implementing ecological innovation for cooperative companies	Simplified new products for structure and packaging.	
	EPI2		New products that are easy to degrade raw materials.	
	EPI3		Low-energy new products.	
	EPI4		New products that are easy to recycle and reuse.	
Regulation Pressure	RP1	Local government of the company	Making environmental protection one of the most important tasks for the government.	Xuerong Peng and Jiang Wei [17] (2015), Qinghua Zhu and Yong Geng[23] (2009)
	RP2		Using environmental protection as an important indicator to evaluate the reputation of this company.	
	RP3		Concerned about the environmental protection of the company.	
Imitation Pressure	IP1	The main competitor of this company	The business attaches great importance to environmental protection.	
	IP2		Using environmental protection as an important indicator to evaluate the reputation of this company.	
	IP3		Concerned about the environmental protection of the company.	

Notation: The above variables are measured using the Likert five-point scale. The greater the score, the more consistent with the actual situation. The establishment of enterprise scale is mainly based on the practice of Cheng Yin and others[26] (2016). According to the number of companies, the company is divided into 50 companies, 100-500 employees, 500-1000 employees, 1000-2000 employees, and 2000 employees 1 to 5 values.