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ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 12 (22): 6553-6556, 2013
ISSN 1812-5638 / DOI: 10.3923/itj.2013.6553.6556

Game Research on Enterprise Reverse Logistics under the Complete Information

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Abstract: The construction of reverse logistics system involves the participation of enterprises, government and consumers, among which there exist the relationships of resistance and cooperation. As a result, there exists game. This article focuses on the roles of enterprises, government and consumers while reverse logistics is in progress, establishing the models in the complete information state between enterprises, between government and enterprises, between consumers and enterprises. Finally, specific measures are suggested on the basis of the game analysis that government, enterprises and consumers should take in the promotion of reverse logistics process.

Key words: Reverse logistics, game, complete information state

INTRODUCTION

The process of the implementation of reverse logistics involving three main bodies: Government, enterprises and consumers. Government is the integration of different social powers, whose function is to maintain social stability and improve people's quality of life. Enterprises participation in reverse logistics activities aim at enhancing the corporate image, gaining the trusts and supports of consumers, improving the overall force, promoting the sustainable development of enterprises, as well as achieving long-term profit maximization. Consumers participation in the reverse logistics activities aim at getting the satisfied products and services, improving their quality of the living environment and embodying their higher ecological environment awareness and social responsibility sense.

The different roles, functions and objectives decide their different ways of behaviors, but restraining and interdependent. In the game about interests of the three parties, enterprises, consumers and government are not alone. Only mutual cooperation and mutual supervision can achieve environmental protection and ecological balance, realize the rapid sustainable development of enterprises and raise consumer satisfaction.

GAME ANALYSIS PROCESS ON ENTERPRISE REVERSE LOGISTICS UNDER THE COMPLETE INFORMATION

Game analysis process on the reverse logistics is divided into game analysis between enterprises and enterprises, the government and enterprises, enterprises and consumers.

Game analysis between enterprises and enterprises: Here, enterprises can be upstream and downstream enterprises on the supply chain, also they can be the different enterprises in the same industry.

Model assumptions:

- Two players in the game-enterprises 1 and 2, both of them are rational and pursue the revenue maximization
- Two kinds of actions that enterprises can choose-implement or not implement reverse logistics
- Players have "common knowledge" to each other's strategies and revenue functions and one does not know the other's actions before one makes decisions

Model introduction: As rational economic men, the two companies want maximized profits at the lowest costs. The parameters are as follows:

P = Profit that enterprises do not implement the Reverse Logistics
N = Added costs that enterprises implement reverse logistics, including construction costs of logistics system, recyclable items for disposal and so on
V = Extra profits that enterprises implement reverse logistics, including raw materials savings and government subsidies and so on
H = Social and ecological returns that reverse logistics generate
B = Adverse effects on the environment without reverse logistics, $B<0$

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Table 1: Game matrix between two enterprises

		Enterprise 2	
Enterprise 1		Implemented	Not implemented
	Implemented	P+V-N,P+V-N	P+V-N,P
	Favorable environment	2H	H+B
	Not implemented	P,P+V-N	P,P
	Favorable environment	H+B	2B

From a long-term interests, the extent of the damage to the environment without reverse logistics is larger than that the reverse logistics impacts on the environment, so can be assumed |H| <|B|. Although the implementation of reverse logistics activities can bring social and ecological benefits, in short term, the implementation of reverse logistics enterprises activities will cause a lot of recovery costs, however, a lot of treatment costs can not necessarily bring economic benefits, or even cause a lot of losses, so it is generally considered V<N. The favorable environment is whether implementation of reverse logistics has overall impacts on the environment that is, with the B and H, the result can be the game matrix of two enterprises, as is shown in Table 1 which is a "Prisoner's Dilemma" type of game problems (Li, 2006).

Game solution: Because V<N, V-P+N<P, then the only Nash equilibrium (not implemented, not implemented) can be resulted by the crossed method (Li, 2004) which enables us to better understand the current circumstances that is, most enterprises have a weak awareness of environmental and social and do not actively implement reverse logistics. The game also indicates the contradictions of individual and collective ration, or part group ration and social community ration. If we can benefit from the adoption of environment to evaluate, when choosing (not implemented, not implemented), the environment favorable of the Nash equilibrium is the 2B which is the largest environmental broken ring; but when choosing (implemented, implemented), the environment favorable of the Nash equilibrium is 2H which is the most powerful protection strategy portfolio on the environment and it achieves Pareto optimal. However, the Pareto improvement cannot be achieved in the absence of government supervision and management, so it requires the government to play the role.

Game analysis between enterprises and government: In the reality of the interaction of the government and enterprises, there is a sequence of actions that is, the government first takes regulatory actions, enterprises then decide whether to implement the reverse logistics and therefore the process between enterprises and government is a dynamic game process.

Model assumptions:

- Only two players in the game-the government and enterprises, the government will be recorded as 1, enterprises recorded as 2
- Two kinds of actions government can choose-controlling or not controlling, two kinds of actions that enterprises can choose-implemented or not implemented
- Environmental improvement and cost input are the major concerns of the government. When the government does not control, causing the social harms, the remedial costs are ultimately borne by the government; in the state of government controlling, enterprises that don't implement reverse logistics activities must be subjected to environmental protection tax

Model introductions: Game between government and enterprises is the two phases observed dynamic game. The parameters are as follows:

C = Government controlling costs
S = Environmental remedial costs that the government is not under the control
Z = Environmental tax that enterprises are subjected to when they do not implement reverse logistics under government control

The meanings of model parameters V, N, H are the same as that of the foregoing game analysis and Z>N, N>V. But here H is also said as the social and ecological returns when the government control in a timely manner. In real life, the government's controlling costs below the government's environmental remedial costs that is, C<S.

The game tree between government and enterprises is showed as Fig. 1 (Guerin, 2007) and here uses reverse inductive method to solve its refining Nash Equilibrium of the game.

I is short for one of enterprise's actions-Implementation; NI is short for Not implementation.

Game solution: Based on the above descriptions reverse inductive method is used to solve the Nash equilibrium of sub-game. There exist two sub-tree game trees, showed as in Fig. 2a and 3b.

From the above assumptions, we can know Z>N, N>V, so P+V-N>P-Z, P+V-N<P and get the two sub-game Nash equilibrium game are X_2 (H-C, P+V-N) and X_2' (-S, P), then make these two sub-game initial nodes as the end

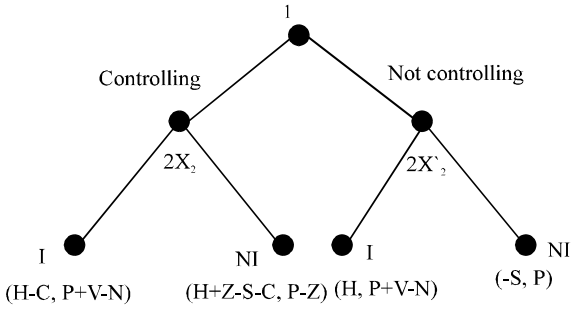

Fig. 1: Game trees of government and enterprises

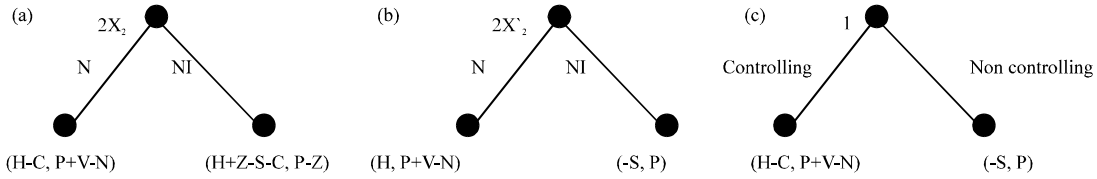

Fig. 2(a-c): ??????

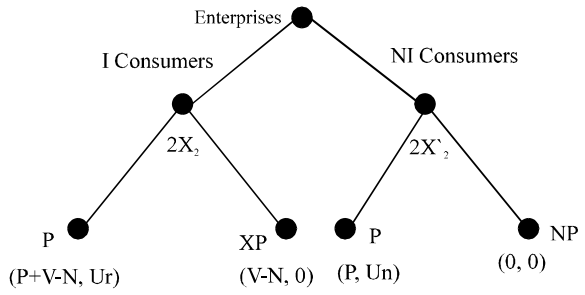

Fig. 3: Game trees of enterprises and consumers

nodes of the original game as Fig. 2c shown. Because C<S and H-C>-S, the Nash equilibrium can be got as (H-C, V-P+N), then the game process is over. We can see that the refining of Nash equilibrium is (controlling (implemented, not implemented)), namely, (implemented, not implemented) is a strategic business combination. Under the government controlling state, enterprises will implement reverse logistics. Reverse inductive solution into the game is (controlling, implemented).

Game analysis between enterprises and consumers: In real interaction of enterprises and consumers have the sequence of actions which means that enterprises act first, consumers after corporate actions decide whether to buy products or services after the implementation of the reverse logistics production, so the process is a dynamic process, where we use complete information and perfect dynamic game to analyze the model.

Model assumptions:

- Only two players in the game-enterprise and consumer, both of whom are rational economic men and pursue the profit maximization
- Two kinds of actions that enterprise can choose-implemented or not implemented and two kinds of actions consumers can choose--purchasing or not purchasing
- The model of complete and perfect information is used to analyze the game

Model introductions: The game is the same dynamic game for the two phases, the first phase is that enterprises act; the second phase is that consumers act under the first phase of the operation of enterprises. The parameters are as follows:

Ur = Revenue of consumer buying products and service when enterprise implements reverse logistics

Un = Revenue of consumer buying products and service when enterprise do not implement reverse logistics

The remaining parameters meanings are the same as these of the previous parameters, such as P, N and V. Because when consumers support enterprises reverse logistics, the purchase of products after reverse logistics activities production can reflect their higher awareness of the ecological environment and social responsibility and

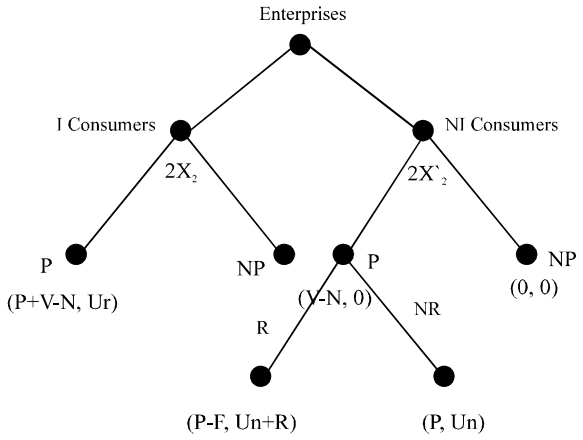

Fig. 4: Game trees of enterprises and consumers. R: Short for one of consumers' actions-Reporting; NR: Short for Not reporting

consumers will have higher satisfaction, the general view is Ur>Un. The game tree of enterprises and consumers is shown as Fig. 3.

I is short for one of enterprises' actions-Implementation; NI is short for Not implementation. P is short for one of consumers' actions -purchasing; NP is short for Not purchasing.

Game process: In the first phase, enterprises choose "implemented" or "not implemented", then the game reaches the second phase, consumers choose "purchasing" or "not purchasing" and thus the game is over. We can know from the assumption Ur>Un, Ur>0 and Un>0. From Fig. 3 end node value in brackets, whether enterprises "implement" or "not implement" reverse logistics, consumers will choose "purchasing", then we can see the V-P+N<P, obviously enterprises will choose "not implement" reverse logistics, then the Nash equilibrium is (not implementation, purchasing). From the rational view of the community as a whole it doesn't meet Pareto optimal. But if a Pareto improvement, consumers can take legal means to protect themselves' interests to raise profit and enhance social benefits which is conducive to sustainable development.

If consumers take legal means to protect their interests, they must succeed, because it will reduce consumers' profits and make environment polluted when enterprises do not implement reverse logistics. Assuming that consumers can be certainly compensated for the R(R>0) while enterprises will be penalized and forced to implement reverse logistics, assuming the amount of punitive is F (F>N). But if the consumer does not report, the profits of consumers and enterprises will not change. This game will enter the third phase, as shown in Fig. 4 game tree.

After game tree improvement, consumers' profit can be increased, then they will choose "reporting" and regardless of enterprises to implement or not to implement reverse logistics, consumers choose "purchasing". Because F>N, P+V-N>P-F, then enterprises will be rational to implement reverse logistics under the high pressure, as a result, the interests of consumers are safeguarded, environment are protected and social benefits are enhanced.

CONCLUSION

Through the above game analysis, we can see the implementation of Reverse Logistics is the game results of the government, enterprises and consumers. Although enterprises are the ultimate enforcers of the implementation of reverse logistics, the government and consumers also play very important roles.

For government, he can use legal, economic and technologic means to improve the implementation of reverse logistics, for example, bounding enterprises to implement reverse logistics by formulating relevant laws, charging the Environmental Protection tax, introducing advanced technology and so on.

For enterprises, they can construct Reverse Logistics System within the supply chain and a third party can be used to assist in the management of reverse logistics for SMEs that don't have enough financial and technical capacity to implement the reverse logistics and so on.

For consumers, they should actively study to improve their awareness of the ecological environment and social responsibility; actively cooperate with enterprises recycling waste products and take initiative to place products under the waste recovery Office, so to create a good living environment.

ACKNOWLEDGMENTS

This study is a fund project of Humanities and social science research base for institutions of higher learning in Heilongjiang province (Petroleum institute of oil economics and management): The ecological construction and evaluation of Petrochemical industrial park (JD20110206).

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