Multi-period incentive contract design in the agent emergency supplies reservation strategy with asymmetric information

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ARTICLE INFO
Keywords: Emergency supplies Agent reserve strategy Effort degree Multi-period incentive contract model

ABSTRACT
Agent reserve strategy have experienced increased popularity in recent decades. In such a reservation method, the amount of effort exerted by an enterprise has significant influence on the value and supply capacity of emergency materials. When the interests of the government and the enterprise are not aligned, combined with poor information sharing, the members of the enterprise are more likely to suffer from emotional burnout, especially when considering long-term contract periods. Thus, the enterprise usually cannot consciously act in accordance with the government’s wishes. We extend the one-period incentive contract model to multi-periods to constrain the enterprise’s behavior and stimulate it to exert more effort. We conduct a numerical experiment to illustrate the changes in the two parties’ benefits over the contract period using the MATLAB experimental platform. The results show that both parties can benefit, and the incentive power of a multi-period incentive contract is better than that of a one-period contract. Furthermore, we analyze and determine the optimal cooperation period and the optimal joint profit. The practical purpose of using a multi-period incentive contract is steady improvement in emergency supplies’ capabilities and a strengthening of the enterprise’s effort, which lead to long-term benefits for both the government and the enterprise and valuable suggestions for the government’s decision-making.

1. Introduction
The Civil Affairs Ministry submitted a proposal about building central-leveled emergency supplies repository in 1998, then the proposal put into effect in 2003. The central-leveled emergency supplies repository means a reserve strategy that the central government finance offers reserve funds, the civil affairs ministry is to deal with material procurement and management. The Civil Affairs Ministry entrusts the people’s government at the provincial level to store the emergency supplies, so far there are 19 central-leveled emergency supplies repositories in China. During the past few years, Chinese government has stored emergency supplies to accommodate the victims in emergencies through the central-level reserve strategy. However, Beyond the insufficient quantity, there are also other problems with the central reserve strategy at central level, including the small capacity of each storehouse and their scarcity and unbalanced distribution. Once emergencies actually occur, the supply of materials is often unreliable. The agent reserve strategy is a reserve strategy in which the government signs a contract with an enterprise and entrusts the enterprise with a certain amount of emergency supplies as a solution to these problems. Thus, the enterprise will act based on the contract after receiving subsidies from the government, and if the enterprise provides sufficient materials when emergencies occur, then it will obtain additional rewards, but if the materials are insufficient, then the enterprise will be punished. The agent emergency supplies reservation has become a widely publicized method that has been extensively adopted by local governments (Zhang & Chen, 2015).

The agent reserve strategy has gradually gained the characteristics of lower stocking costs, decreased funding and reduced waste. However, the enterprise’s effort has significant influence on the value of the emergency supplies during this reservation strategy (He, Jiang, Wang, & Chen, 2014). On the one hand, the enterprise owns the emergency supplies in the agent reserve strategy, and although the government has the right to use the materials, there are inevitable benefits to the relationship between the government and the enterprise. The government expects to maximize the value of the emergency supplies, and the less in subsidies that the government must pay, the better it is for the government. The enterprise seeks to maximize its economic benefits through the lowest input costs, so the enterprise as the agent often cannot earnestly perform its duties when the two parties’ interests are not aligned. On the other hand, asymmetric information is widespread in supply networks (Egri & Váncaž, 2013). In the process of
agent reserve strategy, the government and enterprises share some common information but also have their own private information. The government is at a disadvantage when faced with information acquisition because it cannot obtain complete information from the enterprise, whereas the enterprise, which has advantages in information sharing, cannot consciously handle matters in accordance with the wishes of the government, especially when it is only receiving fixed subsidies. Furthermore, the enterprise is likely to reduce its input of manpower and material resources over the long term, thereby maximizing its interests at the cost of sacrificing government benefits. Despite the large amount of fiscal funds allocated from the government, some companies do not use them for purchasing and reserving medicine, so the actual amounts are far short of government requirements (Wu, 2003).

Therefore, in the agent reserve strategy, the question of how to constrain the agent’s behavior becomes the key to ensuring the value of the emergency supplies and guaranteeing the supply of material. Corbett, Decroix, and Ha (2005) builds an optimal shared-saving contract to improve the efforts exerted by suppliers and consumers in which incentives are provided to reduce the consumption of indirect materials. Because we consider long-term cooperation here, whereby the government and the enterprise sign a multi-period contract. The practical significance of using a multi-period incentive contract is steady improvement in emergency supplies’ capabilities and a strengthening of the enterprise’s effort, which lead to long-term benefits for both the government and the enterprise and valuable suggestions for the government’s decision-making. We must also determine the optimal period in order to encourage the enterprise to exert more effort. Researching and designing a multi-period incentive contract is an effective way to solve this problem.

The paper is organized as follows. Section 2 provides a survey of the related research, and Section 3 describes our model variables and assumptions. Section 4 presents the modeling framework and builds a one-period incentive contract model for an agent reserve strategy, then extends the one-period model to multi-periods based on long-term cooperation. Section 5 analyzes the model to derive main results regarding the importance of the efforts exerted by the enterprise for both parties’ benefit. Section 6 provides a comparison between the one-period and multi-period incentive contract models. It mainly describes the tendency of the variables to change based on the contract period using the MATLAB experimental platform, then further attempts to determine the optimal cooperation period and the optimal joint profit between the government and the enterprise. Section 7 provides conclusions.

2. Literature review

The origin of research on incentive contracts is in the principal-agent theory. Basu, Lal, Srinivasan, and Staelin (1985) and Parteus and Whang (1991) were the earliest scholars who applied the principal-agent theory to supply chain enterprises when they studied the problems of sales staff salary distribution and production distribution in supply chains, respectively. Both Lal and Staelin (1986) and Lal and Srinivasan (1993) further studied the principal-agent relationship in supply chains with the addition of asymmetric information factors to the principal-agent theory. Hölmlstrom (1979) analyzed previous application research with asymmetric information and considered how to design an incentive contract to reduce the risk of moral hazard problems for the principal when the agent is engaged in a single behavior on behalf of the principal that cannot be observed. Haugen and Taylor (1987) examined the manager-investor relationship in the case of exponential utility when the manager has private information using the agent-principal relationship. Meanwhile, Fayezi, O’Loughlin, and Zutshi (2012) summarized the application fields, application purposes and application strategies of the principal-agent theory based on previous academic research and analyzed how to apply the principal-agent theory to supply chains and how to clarify the relationships and behaviors of each role in the supply chain in detail on the basis of a broad aggregation of the literature. In addition, supply chain management scholars have shown increased interest in using agency theory to comprehend how participants in SCM forge relationships with others and work together to solve problems.

In the field of agent emergency supplies reservation and academic research regarding the supply chain coordination problem derived from cooperation between the government and a supplier, most studies have analyzed the purchase pricing model of emergency supplies with complete information, such as designing emergency supplies purchasing model based on real option contracts by Tian, Ge, and Hou (2014), building emergency supplies purchasing model based on capacity option contracts by Zhang and Tian (2011), as well as extending capacity option contracts with dual purchasing sources by Tian, Zhang, and Wang (2013). Moreover, to achieve supply chain coordination, Qi, Bard, and Yu (2004) investigated a one-supplier-one-retailer supply chain that was coordinated not only through centralized procurement but also decentralized procurement under the condition of demand disruption. Meanwhile, Gastaldi, Kettikidis, and Cuccirolla (2006) reduced the risk of procurement in supply chains by building a real option contract purchase model to achieve supply chain coordination. Furthermore, Kleindorfer and Wu (2003) studied option purchasing under the condition of requirements and analyzed the costs and benefits for the government and the supplier. The authors then provided conclusions regarding option contract procurement and optimal spot market procurement. The aforementioned research has provided important references for our paper. However, few studies have considered the behavior of the agent in the context of asymmetric information, so we will begin by studying how to improve an enterprise’s effort with asymmetric information.

In general, many researches focused on how to negotiate the relationships between the two-parties in supply chain can resolve the possible benefits conflicts among them, such as Lee (2014) developed and analyzed the many-to-many supply negotiation process, explored the relationships between a demander’s bidding strategies and negotiation efficiency under different order and competitive conditions by designing the interactive and competitive bidding strategies of both-side parties. Renna (2010) also proposed negotiation policies and used multi Agent Strategy methodology in e-marketplace environment, which has brought benefits both for suppliers and customers. Some researches use incentive method to study the income distribution of the two-parties in supply chain, for example, Mohebbi and Li (2015) proposed a proper cooperation mechanism among distributed supply network members affects the success of supply networks, in their research, they developed a model by designing a criterion named Shared Capability Index to resolve the possible conflicts among network numbers. In our research, the enterprise’s effort has significant influence on the amount of emergency supplies in the agent reserve strategy, but a dearth of studies considers the speculative behavior of the agent. The incentive mechanism is an effective method to solve this problem, but the current research related to incentive contracts in supply chains mostly focuses on how to reduce manufacturers’ costs. Manufacturers’ costs caused by asymmetric information can be lowered by adopting cost-sharing contracts, which can greatly improve the quality of products in Chao, Iravani, and Savaskan (2009), Weitzman (1980) studied how to encourage suppliers to lower their total development costs by using incentive contracts and concluded that the optimal cost allocation proportion is closely related to the degree of uncertainty, the degree of risk aversion of the suppliers and their cost-control abilities. In a one-retailer-one-manufacturer supply chain, Runter (2012) designed an incentive contract whereby the retailer paid royalties and both sides shared the cost of the manufacturer’s marketing efforts. The study showed that the retailer must be responsible for at least 50% of the marketing costs to achieve supply chain coordination. Previous studies have shown the academic difficulty of using supply chain management