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Information acquisition and transparency in a supply chain with asymmetric production cost information

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ABSTRACT

This paper studies a retailer outsourcing the production to a supplier who can improve the quality of the production cost information by exerting costly forecasting effort. The outcome of the supplier's information acquisition may turn out to be either successful, with the supplier becoming informed, or unsuccessful, with the supplier remaining uninformed. Once the outcome of the forecasting is resolved, the supplier knows the information status (informed or uninformed) and content (high type or low type). We consider two-layer information asymmetry and analyze three different scenarios: no forecasting, forecasting with transparent information acquisition (disclosing information status) and forecasting with nontransparent information acquisition (hiding information status). We study both the retailer's contract design and the supplier's information disclosure decision. We obtain some interesting observations. First, the retailer's incentive for the supplier's forecasting is a threshold policy: If the forecasting cost is low, then the retailer will prefer the supplier to forecast, otherwise, the retailer will prefer the supplier not to forecast. Second, when the forecasting cost is high and the production cost variance is small, under transparent information acquisition, the high cost supplier's production quantity may be either upward or downward distorted; while under nontransparent information acquisition, the uninformed supplier's production quantity is either upward or downward distorted, and the high cost supplier's production quantity is always downward distorted. At last, the supplier can benefit from transparency only under some specific conditions, and when the production cost variance is extremely large, nontransparent information acquisition is always the supplier's first choice.

1. Introduction

Global outsourcing has been increasingly popular in the past a few decades with the development of economic globalization. Many giant brand retailers, such as Apple, Huawei, and Nike, are outsourcing the production of their products to contract suppliers. For example, the production of iPhone cellphone of Apple is conducted in China factories owned by the Taiwan-based company known as Foxconn Technology Group (Zhang, 2012). This outsourcing strategy makes the retailer concentrate more efficiently on the core businesses, such as designing, development and marketing, and enhances the retailer's competence in the market. Meanwhile, the supplier can efficiently focus on improving the production process control. Fierce competition among the retailer, especially in the industries of electronics and apparels, has made the production cost control extremely important for the success of pricing and marketing decisions, which will eventually impact the retailer's competitiveness. Usually, the production cost is affected by many factors, such as the prices of raw materials, the complexity of production process, wages of skilled workers, and sometimes even the oil price, which has been experiencing continuous price fluctuations. For example, rare earth elements, which are widely used in fluorescent lamp, LED device, mobile phone, and some other semi-conductor industries, have experienced dramatic price fluctuations since 2011. It is reported that the prices of rare earth elements increased 10 times in 2011, leading to a price increase of 37% for the energy saving lamp industry (Bradsher, 2011).

Before a production process is initiated, the real production cost is usually unknown to both parties. The supplier, who is more familiar with the production environment, is in the ideal position to invest resources to acquire fresh production cost information. For example, the supplier can devote recourses to analyze the price trends of the critical materials, hire more talented experts to manage the production processes, and use more advanced software to help control the cost, to acquire accurate production cost information. The retailer is also willing to know the accurate production cost information, because accurate production cost information can benefit the ordering deci-

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sions. Since information acquisition is usually not free, whether the supplier will find it attractive to exert such costly forecasting effort depends critically on the contractual terms offered by the retailer. In addition, even if the supplier decides to conduct information acquisition activities, the outcome of which is usually unobserved by the retailer, which means that the supplier's production cost information is only privately known (Çakanyıldırım et al., 2012; Lei et al., 2015). Thus, the retailer is facing an adverse selection problem but with a major modification. The retailer now should provide contracts that are effective both to encourage the supplier to forecast and to elicit the supplier's private production cost information. This problem is called the endogenous adverse selection problem. Are the traditional contracts with asymmetric information still valid in the endogenous adverse selection problem? If not, what are the optimal contracts? How does the forecasting cost impact the optimal contracts?

In addition, the extant literature on information acquisition mainly assumes that information can always be acquired after forecasting. However, the supplier may obtain nothing useful after exerting costly forecasting effort. The outcome of the forecasting may turn out to be either successful or unsuccessful. Following Li et al. (2014), we define the supplier's information status as being informed or uninformed, depending on whether or not the supplier succeeds in getting useful information after forecasting. The term information status is different from the term information content. The former refers to whether the supplier gets useful information, while the latter refers to what the supplier really gets. Since both the information status and the information content are the supplier's private knowledge, the supplier can decide whether or not to disclose the information status (not the information content) to the retailer. If the supplier voluntarily discloses the information status to the retailer, we refer to this kind of information acquisition as the transparent information acquisition. Otherwise, we refer to it as the nontransparent information acquisition. Under transparent or nontransparent information acquisition, how should the retailer design the contracts? Is transparent information acquisition always beneficial to the supplier? If not, under what conditions?

To answer these questions, we consider a supply chain composed of a giant retailer and a supplier. The retailer can choose to induce the supplier to forecast or not to forecast. We consider both the retailer's forecasting decision and the supplier's information status disclosure decision. The retailer should determine under what conditions to forecast, and what is the impact of the retailer's forecasting cost on the optimal contracts. The supplier should determine whether to disclose the information status to the retailer after forecasting. The extant literature usually consider these two problems separately, however, since the information acquisition decision and the information status disclosure decision are conducted individually by the retailer and the supplier, it is necessary to address these two problems in a unified framework.

We have obtained some interesting observations. First, the retailer's incentive for the supplier's forecasting is a threshold policy, no matter whether the supplier chooses to share the information status or not. If the forecasting cost is low, then the retailer will prefer the supplier to forecast, otherwise, the retailer will prefer the supplier not to forecast. Second, when the forecasting cost is high and the production cost variance is small, under transparent information acquisition, the high cost supplier's production quantity may be either upward or downward distorted, but the low cost supplier's and the uninformed supplier's production quantities are not distorted. While under nontransparent information acquisition, the low cost supplier's production quantity remains unchanged, the uninformed supplier's production is either upward or downward distorted, and the high cost supplier's production quantity is always downward distorted. At last, the supplier can benefit from transparency only under specific conditions, but when the production cost variance is extremely large, nontransparency is always the supplier's first choice.

The rest of the paper is organized as follows. Section 2 reviews the relevant literature. In Section 3, we present the model setup and analyze the optimal decisions in an integrated supply chain. Section 4 derives the retailer's optimal contract when the retailer does not induce the supplier to forecast. Section 5 analyzes the scenario of transparent information acquisition, and Section 6 analyzes the scenario of nontransparent information acquisition. Section 7 concludes. All proofs are relegated to the Appendix A.

2. Literature review

This paper falls into the screening models in supply chain contracting literature (Chen, 2003; Cachon and Lariviere, 2001; Ha, 2001; Özer and Wei, 2006; Ha and Tong, 2008; Ha et al., 2011; Zhang et al., 2010; Lei et al., 2012; Çakanyıldırım et al., 2012; Dai and Chao, 2016). Chen (2003) provides an excellent review of the literature. Cachon and Lariviere (2001) consider the capacity reservation contract with asymmetric demand information. Özer and Wei (2006) study both the capacity reservation contract the advance purchase contract with asymmetric forecasting information to ensure credible demand information sharing. Ha and Tong (2008) and Ha et al. (2011) study the issue of contracting and information sharing with competing supply chains. Zhang et al. (2010) investigate the contracting under asymmetric inventory information. In a paper also studying the contracting under asymmetric cost information, Çakanyıldırım et al. (2012) assume nonzero reservation profits for the manufacturer. They find that in equilibrium, the optimal production may be overproduction, efficient production or underproduction, depending on the level of reservation profit. These papers consider the supply chain contracting under various asymmetric information scenarios and assume that the agent is freely endowed with the private information. Our work differs the above literature in that we incorporates both the supplier's information acquisition decision and information status disclosure decision into the framework of supply chain contracting with asymmetric production cost information.

Our work is also related to the literature on contracting to induce the downstream firm to forecast by exerting forecast effort (Taylor and Xiao, 2009; Fu and Zhu, 2010; Shin and Tunca, 2010; Chen et al., 2016). Taylor and Xiao (2009) investigate the contracting in a newsvendor model when the retailer can improve the quality of the demand information by exerting costly forecasting effort. They study two kinds of contracts, rebates and returns, and find that returns are superior to rebates. Fu and Zhu (2010) investigate contracting to induce the downstream retailer to exert costly forecasting effort and examine the performance of several commonly used contracts. Shin and Tunca (2010) study the effect of downstream competition on incentive for demand forecast investments in supply chains. Chen et al. (2016) study the contracting to induce the retailer to improve demand forecast and sales effort simultaneously by exerting costly information acquisition effort. All these papers assume that once the agent forecasts, the agent can obtain useful information and the principal knows the agent's information status. In other words, information acquisition is always successful and the retailer's information status is transparent to the manufacturer. Sometimes, the agent may be reluctant to share the information status with the principal especially when the principal also cooperates with other competing agents, because disclosing such information to the principal will make the agent lose competitive advantage. Therefore, we consider the situation of nontransparent information acquisition in this paper, that is, the principal does not know the agent's information status after forecasting.

In a paper closely related to our work, to the best of our knowledge, Li et al. (2014) first consider the impact of information transparency on the optimal contacts under demand asymmetry. They find that under some specific conditions, sharing the information status with the manufacturer is superior to holding back the information. In other words, there are benefits that are foregone by following strict con-