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Outsourcing to suppliers with unknown capabilities

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ABSTRACT

We investigate the make-buy decision of a manufacturer who does not know its potential suppliers' capabilities. In order to mitigate the consequences of this limited knowledge, the manufacturer can either perform in-house or audit suppliers. An audit reveals the audited supplier's capability such that the manufacturer can base the make-buy decision on the audit outcome; the manufacturer might also learn from the audit and update its beliefs about the capabilities of the unaudited suppliers. Interestingly, using a very general model we find that the manufacturer's decision can be independent of both the number of available suppliers and of the mechanism it uses to update its beliefs after an audit. We illustrate our general model by considering a possible application, where a manufacturer is making the outsource-audit decisions when the suppliers are more cost effective. However, when outsourcing to supplier, the manufacturer would face the uncertainty of whether or not the delivered task can integrate well with the other parts of the project.

1. Introduction

Consider a manufacturer that needs to complete a task and must decide whether or not it should outsource the task. Outsourcing allows the manufacturer to benefit from a supplier's expertise or cost advantage. However, the consequences of contracting with an incompetent supplier can be substantial. To reduce the production cost of the Dreamliner, Boeing outsourced 70% of the manufacturing of the plane. The development of the rear fuselage was outsourced to Dallas-based Vought Aircraft Industries, who turned out to be incapable of performing the assigned project, resulting in production delays and multi-million dollar losses. In order to regain control over its supply chain, Boeing ultimately purchased Vought's North Charleston plant (Lunsford, 2007; Sanders, 2009). Currently, Airbus is in the process of developing the A350, a plane that is designed to compete with the Dreamliner. Similar to Boeing, it "expects to outsource production of substantial chunks of the A350 to places as far-flung as China and Russia", so Airbus also faces the challenge of finding suppliers that "have the technical know-how and manufacturing capacity to deliver what Airbus needs" (Matlack, 2008).

Other manufacturers face similar problems with their suppliers. Faulty speed sensors by airplane supplier Thales contributed to the crashing of an Airbus in June 2009, illustrating the importance of ensuring the quality of each outsourced part. Sprint was disappointed that its supplier IBM "failed to live up to expectation" (Jones, 2009), and it later rehired its former workers to perform the task in-house (Hepher, 2009); Toyota also found out that the suppliers that produce the most critical parts were not as reliable as it had originally thought (Nikoofal & Gumus, 2013). The Sprint and Toyota examples demonstrate that even outsourcing to presumably competent suppliers does not eliminate these risks, and manufacturers rather perform in-house than contract with incompetent suppliers. It is often difficult to assess a supplier's capability, and recent work by Hasija, Pinker, and Shumsky (2008) suggests that future research should "examine the impact of information asymmetry in the reliability of the vendor".

In this paper, we consider a scenario where a manufacturer needs to complete a task, and it must decide whether to perform the task in-house, or to outsource its completion to a supplier. In preparation of performing a task, firms often need to make substantial investments in capacity and employee training. If the associated costs are non-recoverable, switching suppliers might be prohibitively expensive. In addition, at times outsourcing requires the sharing of highly sensitive information. Finally, bringing back production in-house might be difficult once a firm has decided to outsource that task and has lost its in-house capabilities. In this paper, we assume that, once taken, a manufacturer will not reconsider the decision to outsource. The potential suppliers can either be of high type or of low type, where contracting with a high-type supplier is more profitable than contracting with a low-type supplier. Each supplier has private information about its type, and the manufacturer has *a priori* beliefs that any given supplier is of

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high type. There are two main problems when the manufacturer does not know what type of supplier it is facing. First, the manufacturer may only benefit from outsourcing if contracting with a high-type supplier, so the manufacturer cannot make the most profitable make-buy decision without knowing the suppliers' type. Second, the supplier could leverage its private information to obtain higher profits, at the expense of the manufacturer. In order to mitigate these problems, the manufacturer could audit the supplier. An audit reveals the type of the audited supplier, providing the manufacturer a better basis for its make-buy decision. The manufacturer might also infer some information about the composition of the pool of unaudited suppliers. We consider a generalized updating technique where an audit of a low-type supplier reduces the manufacturer's beliefs regarding the proportion of high-type suppliers in the remaining supply pool. Our research questions can be stated as follows:

(1) When a manufacturer does not know the capabilities of its potential suppliers, should it perform the task in-house, outsource the task without knowing the suppliers' capabilities, or audit any of the suppliers?
(2) How is the manufacturer's decision affected by how it updates its beliefs after an audit?

We develop a game theoretical model to solve the research questions.[2] We have three primary findings. First, one might expect that, if the manufacturer does not update its beliefs, the manufacturer's decision should not be affected by the number of suppliers in the pool. We find that this intuition may not be true. In particular, we find that the manufacturer can follow the same strategy (auditing) for all but the last supplier. However, after auditing all but the last supplier, the manufacturer may find it optimal to outsource without auditing this supplier. Second, when the manufacturer updates its beliefs after an audit, we anticipate two opposing drivers that affect when the manufacturer performs in-house without auditing any supplier. On one hand, one might expect that performing in-house should become less attractive as the number of available suppliers increases as the manufacturer might find it more likely that one of the suppliers is of high-type. On the other hand, the more pessimistic the manufacturer becomes after negative audit outcomes, the less profitable the audit strategy is going to appear, increasing how often the manufacturer finds it optimal to perform in-house. Interestingly, we find that the probability with which the manufacturer finds it optimal to perform in-house is affected neither by the number of available suppliers, nor by how the manufacturer updates its beliefs. Lastly, when the manufacturer becomes more pessimistic about the proportion of high-type suppliers in the remaining supply pool, it may find outsourcing without knowing the suppliers' capability more attractive.

This paper is structured as follows. We review the related literature in the next section. Section 3 describes the mathematical model. Section 4 presents the results for the general model for the case where the manufacturer does not update its beliefs regarding the composition of the supplier pool. In Section 5 we analyze the case where the manufacturer updates its beliefs after each audit. We suggest an application of the general model and thereby illustrate our results in Section 6. We conclude in Section 7 with a discussion of our findings and of potential areas for future research. Details of the game sequence of the application discussed in Section 6 and the derivation of the equilibrium solutions are given in Appendix A. Appendix B provides the proofs for all results given in the text.

[2] We refer the reader to Fudenberg and Tirole (1991) for a detailed introduction to the concepts and terms of game theory.

2. Literature review

There is a stream of research that investigates a manufacturer's use of inspections to reveal the contribution of a supplier in a moral hazard environment (e.g., Baiman, Fischer, & Rajan, 2000; Balachandran & Radhakrishnan, 2005; Hwang, Radhakrishnan, & Su, 2006). In our paper the suppliers' capability are private information (adverse selection), and the manufacturer can audit the supplier to reveal its type. There is also research that studies the value of information when the supplier's capability is not known, where the capability can involve inventory holding cost (e.g., Corbett, 2001), capacity cost (e.g., Cachon & Zhang, 2006) or the supplier's reliability (e.g., Yang, Aydın, Babich, & Beil, 2009). The problems studied in this literature are similar to our problem, where the manufacturer decides between outsourcing without knowing the supplier's type and basing the outsourcing decision on the audit outcome. However, this stream of research does not examine the make-buy decision.

There are several studies that investigate the make-buy decision under information asymmetry, examining a similar tradeoff as that studied in our paper between performing in-house and outsourcing without knowing the supplier's type. Richmond and Seidmann Andrew (1992) consider the case where an internal staff (user group) knows the value of effort, but not its cost; an external firm (external development group), on the other hand, knows the cost of effort but not its value. Assuming that the internal staff is paid a fixed salary while the external firm is paid according to the outcome, they show that the internal staff is not as motivated to exert effort as the external firm. When performing in-house, we assume that the upper management knows the capability of its employees and can properly motivate them to exert the desired effort. Hence, for equal capabilities, the firm is better off performing in-house. Sridhar and Balachandran (1997) consider the case in which the internal and external agents are equally cost effective and uncertainties originate from the task environment, about which the internal employee has more information than the external employee. In a software development setting, Wang, Barron, and Seidmann (1997) investigate a firm's outsourcing strategy in the presence of information asymmetry regarding user valuation and developer costs. They find that the manufacturer should outsource only if the external developer has a significant cost advantage. In our paper, the concept of capability can entail various dimensions, such as cost and how well the individual component can integrate with the product. The manufacturer then may outsource even if its suppliers are less cost effective.

Nikoofal and Gumus (2013) compare the effectiveness of the incentive- and audit-based approaches under information asymmetry. Auditing allows the manufacturer to control the supplier's effort and to provide more information about the supplier's type. They find that auditing is optimal when the supply chain partners' incentives for improving the system's reliability are not aligned, or when the degree of information asymmetry is high. Wan and Beil (2009) study the audit decision under the availability of an outside option, e.g., performing in-house. They examine *how much* the manufacturer should audit the supplier, assuming that all suppliers are identical ex ante, and the manufacturer and the suppliers are equally unsure about the probability that any given supplier is qualified. In our paper, we examine *whether or not* the manufacturer should audit, and the suppliers are privileged with additional information about their own types.

There is also research that studies the operational implications of learning about suppliers' capabilities. Valluri and Croson (2005) consider the supplier selection problem when the manufacturer does not know the capabilities of its available suppliers, and how to motivate the capable suppliers. They use reinforcement-based models, assuming that the suppliers do not know which action to