Theory and Methodology

A lemons market? An incentive scheme to induce truth-telling in third party logistics providers

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Abstract

In this paper, we develop a game-theoretic model that studies the contract design problem of a third party logistics buyer when he is faced with a third party logistics provider and the quality of service and the cost of providing the service are private information to the latter. We apply the Revelation Principle to our analysis and characterise the optimal contract. We show that the contract offered to the service provider with low capability does not include any penalty for failure to comply to preset standards; neither does it include a gain-sharing scheme – the remuneration consists of an initial fixed payment which is independent of the level of performance. However, the contract offered to the service provider with high capability includes either a penalty scheme or a gain-sharing scheme. Furthermore, the more attractive the gain-sharing scheme (or alternatively, the more severe the penalty), the less the initial remuneration and vice versa. Finally, we prove that the proposed optimal contract is independent of the ex-ante beliefs which the service buyer has on the capability and the cost of the service provider. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

Third party logistics, contract logistics, integrated logistics, outsourced logistics – by any other name, third party logistics will continue to sweep through businesses, as it has done in recent years as the last competitive bastion of the 1990s. In essence, third party logistics refers to multiple logistics services provided by a single vendor on a contractual basis (Bradley, 1994). It incorporates services such as inventory management, warehousing, procurement, transportation, systems administration, information systems, materials sub-assembly, contract manufacturing, kitting and import and export assistance. With reference to the military origin of the term “logistics”, third party logistics is all about getting the right products to the right place at the right time, and at the right cost, all with the help of an outsider.

The important role of logistics in modern business is well known. The irony is: Why would
anyone who regards logistics as a source of competitive advantage want to turn the activity over to someone else outside the organization? Essentially, companies that “do it all” are beginning to realize that engaging a third party logistics provider to take charge of the company’s overall supply chain presents a more effective and efficient way of running the logistics of the business. At the most fundamental, businesses outsource their logistics operations to avoid extensive capital expenditures (such as head count or fixed costs) while improving flexibility through reduced inventory, increased productivity, improved customer satisfaction and services and decreased transportation costs.

2. Literature review

A 1996 study (Gooley, 1996) showed that senior corporate executives and logistics executives alike, agreed that high levels of logistics service have a significant impact on customer satisfaction – and on sales; that without first-class logistics performance, it is doubtful that a company will see substantial improvements in sales and profits. Also, after years of focusing on reduction in production and operating costs, companies are turning to transportation and distribution as a last frontier of sorts for having a major effect on the bottomline as these constitute a large extent total business costs. Other than considerations from the tactical aspects, companies also turn to third party logistics owing its strategic role. According to Chuck Troyer, a partner in the New York office of the consulting firm CSC, logistics ranks just below business strategy as a key growth area for consulting practices these days (Cooke, 1995). The emergence of current business philosophy that enjoins corporations to concentrate on their core competence and to bring in experts in areas that are considered peripheral is another driving force behind the rapid growth in third party logistics. Companies today invest their capital where they can get the best returns. Furthermore, logistical support has proved especially crucial in international business. With lower trade barriers, easier movement across national borders and expanded efficiency of transportation services, raw materials are sourced from all over the world, and finished goods are assembled, distributed and shipped to foreign markets all over. All these compounded the demands placed on distribution systems. And outsourcing is generally thought to be able to reduce the risk and uncertainty generally associated with international business. In addition, given the intense level of competition within product and even brand markets, service is what differentiates one supplier from another. “If you can get it there faster, in the right condition, and in compliance with your customers’ specific requirements – but your competitor cannot, then you are likely to see increased sales at that competitor’s expense” (Gooley, 1996). All these point to the need for delivery systems to be more flexible and nimble. As a consequence, corporate boardrooms are starting to realize the importance of supply chain management in maximizing profits in a competitive market. The whole issue of supply chain means that distribution systems are getting too complex and expensive and the traditional approach can no longer satisfy the constantly changing demands of the markets. One principal example is the cost of buying and maintaining the requisite information technology. “It’s one of the biggest cost factors in the business. If you come to us, we can put you on EDI tomorrow”, said Dave Chastain, vice president of operations for the industrial sector for Exel Logistics (Bradley, 1994). This forces companies to re-examine their use of third party logistics. As more and more companies adopt complex supply chain management strategies and begin using logistics expertise to achieve a competitive advantage and to achieve this very quickly, it makes sense for the companies to have a partner who already has the systems and experienced management to help. Finally, there is a benchmarking motivation too – third party logistics providers see a variety of customers across many industries and companies hope that they can bring new insights into how well current company practices are doing. To summarize, increasingly demanding customers, rapidly changing technology, intense competition as well as the emergence of global business opportunities have created a niche for third party logistics providers. And the role of third party logistics providers that started mainly...
because companies are cost motivated, has elevated from a tactical one to a strategic one in recent years.

Amid being touted for some time as the wave of the future, the third party logistics industry has been more foam than force. Although corporate executives would normally agree that third party logistics providers can contribute significantly to their businesses, more are skeptical about the quality of service, especially so, with a plethora of stories of outsourcing failures (Cooke, 1994a,b). Contracting third party logistics is normally a large, multi-year arrangement (on the average, 1–3 years) and switching providers can be very costly. As a result, it is extremely important for a company to know exactly (as far as possible) what it is getting into. Just as one would expect, a failed outsourcing project has detrimental effects on the business that may take years to rectify, if it is at all possible. Hence, accurate information regarding the level of logistics services provided will determine if the relationship can develop into a long-term, co-operative partnership or otherwise. From the point of view of a potential client, how can a company be sure that it is aligning itself with someone who has the proper resources as claimed and that the performance of the service provider will measure up to predetermined standards? To ascertain the true calibre of service providers is no easy task in the absence of adequate information and in the profusion of false claims and phoney advertising (Sayre, 1995; Daugherty et al., 1996). Credibility is a major issue facing the industry. According to Dave Dubose, senior consultant with CSC consulting in Cleveland (Cooke, 1996), “The reality is that a lot of contracts aren’t structured that way. But you’ll get the results that you design the incentives for.” The question which we wish to address in this paper is: What kind of scheme works best to induce truth-telling in third party logistics providers, penalty (for performance lower than the predetermined level) or profit sharing incentives (for better than expected performance), or a combination of both?

In this paper, we consider a simple market structure with one service buyer and a third party logistics provider whose quality of service (i.e., the capability) and the cost of providing such service are private information to the latter. We suggest a remuneration scheme for the third party logistics provider, which has the property that the service provider has no incentive to overstate (or indeed, understate) its capability or cost. The contribution of our modelling framework is based on the following aspects. Firstly, our model is the first piece of work which uses a game-theoretic framework to study the issue of third party logistics. Although game-theoretic modelling has been applied in other logistics-related areas (Cohen and Whang, 1997; Li, 1992; Kalai et al., 1992), our paper has an extra dimension in that it recognizes the informational asymmetry that is more often than not, present in any partnership. Secondly, we incorporate two structures into our scheme, namely penalty and gain-sharing incentive. We aim to find the optimal contract, which will be accepted by the service provider and at the same time will induce the service provider to truthfully reveal his capability. That is, the contract is designed such that there is no incentive for the service provider to overstate (nor underestimate) its capability and there is no potential for any opportunistic behavior by the service provider. To the best of the author’s knowledge, this is the first piece of work that develops a mathematical framework to address the issue of credibility from a contractual viewpoint. Our model yields the following insights on the optimal contract:

1. The net expected payment to the service provider is the same, regardless of his capability and cost.
2. The expected payoff of the service provider with high cost is equals to his reservation utility, which is strictly less than the expected payoff of the service provider with low cost.
3. The contract offered to the service provider with low capability does not include any penalty for failure to comply with preset standards; neither does it include a gain-sharing scheme. The remuneration consists of an initial fixed payment, which is independent of the level of performance.
4. The contract offered to the service provider with high capability includes at least a penalty scheme or a gain-sharing scheme. Furthermore, the more attractive the gain-sharing scheme (or
alternatively, the more severe the penalty), the less the initial remuneration and vice versa.

5. Under the proposed contract, the service provider with high capability is indifferent between stating his capability as ‘high’ and stating his capability as ‘low’. However, the service provider with low capability is strictly better off by revealing his true capability as low, i.e., the service provider with low capability has nothing to gain by pretending to be of high capability.

6. The proposed optimal contract is independent of the ex-ante beliefs, which the service buyer has on the possible capability and cost of the service provider.

This paper is organized as follows. In Section 3, we consider a market structure with a client and a third party logistics provider, assuming that if the client were to purchase a service, he has to purchase it from this provider. Here, we use the term capability to refer to the performance characteristics of the third party logistics provider. We assume that a provider with higher capability provides a more reliable service, which in turn implies that the probability of failure (i.e., performance level is lower than the predetermined standard) is lower. We present the optimal contract when there is complete information, i.e., the characteristics of the service provider is common knowledge to both the service provider as well as the client. In Section 4, we analyse the scenario where the capability of the service provider and the cost of providing such services are private information, known only to the service provider and the client has ex-ante beliefs about these private information. We proved the main results in this section. Finally, in Section 5, we conclude and suggest directions for future research.

3. The model

Consider a market with a client and a third party logistics provider. The service provider can be one of four types, where the type \( (i,j) \) \( (i,j \in 1,2) \) of the service provider is an indicator of a fixed capability and a fixed cost for providing the service, all of which are private information of the service provider. The client has an ex-ante belief that the service provider is of type \( (i,j) \) with probability \( \theta_{ij}, \sum_{i=1}^{2} \sum_{j=1}^{2} \theta_{ij} = 1 \). With each type of service provider, we associate the parameters \( z_i \) and \( c_i \). \( z_i \) denotes the probability of failure of the service and \( c_i \) the cost borne by the service provider. By ‘failure of the service’, we mean that the performance of the logistics services provided is not able to match the standard that has been agreed upon beforehand, i.e., \( z_i \) is a measure of the quality of service. Without loss of generality, we assume that \( z_1 < z_2 \) and \( c_1 < c_2 \). In our context, Type \( (1,1) \) has the highest capability and is most reliable in its services with the lowest cost while Type \( (2,2) \) provides the least reliable service at the maximum cost. In our model, we shall assume that the cost of providing service is independent of the reliability of the service provider. This assumption is justifiable. For instance, a logistics provider with sound infrastructure is capable of providing a more reliable service than one with a weak infrastructure at the same cost. We focus on both penalty and profit sharing as incentive schemes, which can be embedded in the design of contracts. If a third party logistics provider announces himself as type \( (i,j) \), he is offered the contract specified by \( (\pi_{ij}, s_{ij}, p_{ij}) \) where \( \pi_{ij} \) is the initial payment received for providing the logistics services, \( s_{ij} \) the extra incentive given when the level of services is at least that stipulated in the contract (for example, the cycle time meets the target set out in the contract), and \( p_{ij} \) the penalty that the service provider is liable when the level of service is lower than that previously agreed. For simplicity, we assume that \( s_{ij} \) and \( p_{ij} \) are independent of the magnitude of deviation in performance.

Our analysis makes use of the Revelation Principle (Fudenberg and Tirole, 1990, Section 7.2). For the benefit of those readers who are not familiar with it, we provide a brief description here. The Revelation Principle is a simple but fundamental result established in game theory. Essentially, it shows that, to obtain the highest expected payoff, the client can restrict his attention to direct mechanisms, which are mechanisms where the agents (in this case, the service providers) are asked to announce their types (the announced type may or may not be their true type). In addition, at the optimum solution (i.e., one that
maximizes the client’s expected payoff), the agents truthfully reveal their types and accept the respective contracts offered. In other words, this principle says that there is an optimal contract for the client whereby the service provider will reveal his true capability and cost. This result has been enunciated by many researchers (Gibbard, 1973; Green and Laffont, 1977; Myerson, 1979; Dasgupta et al., 1979). Applying this principle here allows us to focus our search for the optimal contract to one which has the truth-telling property. We proceed with the formal description of our model below.

The expected payoff for a service provider of type \((i,j)\) who announces his type as \(i',j'\) (\(i'(j')\) may be equal to \(i(j)\)) is

\[
U_{ij}^{i'j'}((\pi_{11}, s_{11}, p_{11}), \ldots, (\pi_{22}, s_{22}, p_{22})) = \pi_{i'j'} - c_j + (1 - \alpha_i)s_{i'j'} - \alpha_jp_{ij'}.
\]

By the Revelation Principle, we know that there will be truth-telling at the optimal solution, where the client’s expected payoff is maximized. Hence, we can write the expected payoff of the client as

\[
V((\pi_{11}, s_{11}, p_{11}), \ldots, (\pi_{22}, s_{22}, p_{22})) = \sum_{i=1}^{2} \sum_{j=1}^{2} \theta_{ij}(-\pi_{ij} - (1 - \alpha_i)s_{ij} + \alpha_jp_{ij})
\]

\[
= -\sum_{i=1}^{2} \sum_{j=1}^{2} \theta_{ij}(U_{ij}^{ij} + c_j).
\]

Note that neither the loss incurred nor the gain enjoyed by the client when the level of performance deviates from the expectation is indicated in the equation above. The reason being that these amounts are assumed to be independent of the scale of deviation and thus taken to be constants (this is in line with our earlier assumptions on \(s_{ij}\)’s and \(p_{ij}\)’s). In order that the service provider of type \((i,j)\) has no incentive to pretend to be of type \((i',j')\), we require that any contract \((\pi_{ij}, s_{ij}, p_{ij})\) satisfies the incentive compatibility constraints,

\[
U_{ij}^{i'j'} \geq U_{ij}^{ij} \quad \forall i' \neq i, j' \neq j,
\]

where equality holds in the above inequality when the service provider is indifferent between telling the truth and misreporting. In our entire analysis, we try as far as possible to achieve strict inequality in the incentive compatibility constraints given in (IC). However, we shall see that in some cases this is not possible, which means that a certain type is indifferent between truth-telling and mimicking other types. In addition, to ensure that the service provider of type \((i,j)(i,j \in \{1,2\})\) will accept the contract \((\pi_{ij}, s_{ij}, p_{ij})\), the contract parameters have to satisfy the individual rationality constraint

\[
U_{ij}^{ij} \geq u_0 \quad \forall i,j \in \{1,2\},
\]

where \(u_0\) is the reservation utility of the service provider. The client’s optimization problem is to choose \(\pi_{ij}, s_{ij}, p_{ij}, i,j \in \{1,2\}\) to maximize (1) subject to the incentive compatibility constraints (IC), the individual rationality constraints (IR) and the constraints \(\pi_{ij}, s_{ij}, p_{ij} \geq 0\). As the reader would have noticed, this problem is similar to the optimization problem where the objective function in (1) is replaced by (1’) while all other constraints remain.

\[
V((\pi_{11}, s_{11}, p_{11}), \ldots, (\pi_{22}, s_{22}, p_{22})) = -\sum_{i=1}^{2} \sum_{j=1}^{2} \theta_{ij}U_{ij}.
\]

To provide a benchmark, we shall state the solution to the client’s optimization problem when there is complete information, i.e., the client knows with certainty, the values of the parameters. We omit the proof, which is straightforward.

**Proposition 1.** Suppose the probability of failure \(\alpha\) and the cost of providing service \(c\) are common knowledge, the client offers the contract \((\pi, s, p)\), where \(\pi + (1-\alpha)s - \alpha p = u_0 + c\), and this contract is accepted by the service provider.

The implications of the above result are: (1) the payoff to the service provider is zero, with the client extracting the entire trade surplus; (2) the remuneration for providing the service \(\pi\) is increasing in \(p\) (the penalty) but decreasing in \(s\) (the incentive). In other words, the more attractive the incentive for performing, the lower the initial purchasing price of the service. Conversely,
the more attractive the initial remuneration, the harsher the penalty for under-performance.

4. Equilibrium with incomplete information

The main objective in this section is to establish the optimal contract parameters when there is incomplete information regarding the type of the service provider. The following lemma examines the expected payment made to service providers of various types.

Lemma 2. The optimal contract parameters must satisfy

\[ \pi_{ij} + (1 - \alpha_i)s_{ij} - \alpha_ip_i = u_0 + c_2 \quad \forall i, j \in \{1, 2\}. \]

Proof. For a fixed \(i, i \in \{1, 2\}\), the incentive compatibility constraints to ensure that type \((i, 1)\) does not imitate type \((i, 2)\) and vice versa, are given by

\[ \pi_{i1} - c_1 + (1 - \alpha_i)s_{i1} - \alpha_ip_{i1} \geq \pi_{i2} - c_1 + (1 - \alpha_i)s_{i2} - \alpha_ip_{i2}, \tag{2} \]

\[ \pi_{i2} - c_2 + (1 - \alpha_i)s_{i2} - \alpha_ip_{i2} \geq \pi_{i1} - c_2 + (1 - \alpha_i)s_{i1} - \alpha_ip_{i1}. \tag{3} \]

Combining these two inequalities, we derive

\[ \pi_{i1} + (1 - \alpha_i)s_{i1} - \alpha_ip_{i1} = \pi_{i2} - c_2 + (1 - \alpha_i)s_{i2} - \alpha_ip_{i2}. \tag{4} \]

To show that the term on each side of the equality is equal to \(u_0 + c_2\), we need only to show that the individual rationality constraint is binding for type \((i, 2)\), \(i \in \{1, 2\}\). Suppose on the contrary that it is not. Then the contract cannot be optimal since the client could reduce \(\pi_{i1}\) and \(\pi_{i2}\) (or \(s_{i1}\) and \(s_{i2}\)) by the same amount, thereby keeping (IR), (2)–(4) satisfied while increasing the objective function (1).

Lemma 2 implies that the service provider receives the same expected payment regardless of types. As a result, the service provider with high cost has expected payoff of (his reservation utility) \(u_0\), while the expected profit for the service provider with low cost is given by \(u_0 + c_2 - c_1\), which is strictly greater than his reservation utility \(u_0\). The next lemma reports our findings on the contracts for the service providers with different capabilities.

Lemma 3. If \(\{\pi_{ij}, s_{ij}, p_i\}_{i, j \in \{1, 2\}}\) is an optimal contract, \(s_{ij} + p_i > 0\) and \(s_{2j} = p_{2j} = 0\) for \(j \in \{1, 2\}\).

Proof. The proof is straightforward. For a fixed \(j \in \{1, 2\}\), Type \((1, j)\) has no incentive to imitate Type \((2, j)\), i.e.,

\[ \pi_{1j} - c_j + (1 - \alpha_1)s_{1j} - \alpha_1p_{1j} \geq \pi_{2j} - c_j + (1 - \alpha_1)s_{2j} - \alpha_1p_{2j}. \]

Using the result from Lemma 2, the above inequality simplifies to \(0 \geq (s_{2j} - \alpha_1)(s_{1j} + p_{1j})\). Clearly, a high quality service provider has no incentive to mimic a low quality service provider although it is more likely to be in the interest of the latter to misrepresent his capabilities. Since \(s_{2j} - \alpha_1 > 0\) and \(s_{1j}, p_{1j} \geq 0\), equality must hold with \(s_{2j} = p_{2j} = 0\). Similarly, Type \((2, j)\) has no incentive to mimic Type \((1, j)\) implies that \(0 \geq (\alpha_1 - \alpha_2)(s_{1j} + p_{1j})\). Thus, strict inequality holds when \(s_{1j} + p_{1j} > 0\).

From Lemmas 2 and 3, we derive the following theorem, which describes the parameters for the optimal contract.

Theorem 4. An optimal contract \(\{\pi_{ij}, s_{ij}, p_i\}_{i, j \in \{1, 2\}}\) is such that \(\pi_{ij} + (1 - \alpha_i)s_{ij} - \alpha_ip_i = \pi_{2j} = u_0 + c_2\) and \(s_{ij} + p_{ij} > 0\), for \(j \in \{1, 2\}\).

The above theorem suggests that a contract which intends to achieve truth-telling in the service providers has to have the following characteristics: anyone with an announcement of low capability is awarded a contract with a one-off fixed payment of \(u_0 + c_2\), independent of the outcome of the service; a service provider who announces high capability will have a contract with an initial fixed payment of \(\pi\), followed by a subsequent payment of \(s\), if the predetermined standard is attained, or a penalty of \(p\), otherwise. Furthermore, these parameters have to satisfy the equations
\[ \pi + (1 - \alpha_1) s - \alpha_1 p = u_0 + c_2 \text{ and } s + p > 0. \]

One example is the extreme scenario where there is neither initial remuneration nor penalty \((\pi = p = 0)\) while the gain-sharing incentive \(s\) is very high \((s = (1 - \alpha_1)^{-1}(u_0 + c_2))\). That is, there is a payment of \((1 - \alpha_1)^{-1}(u_0 + c_2)\) if and only if the service provided is at least that stipulated at the onset. In addition, these parameters are independent of the ex-ante beliefs \(\theta_{ij}\) which the client has on the type of the service provider. This observation has a significant implication that the contract is optimal under all such circumstances and that the client need not be too concerned about his beliefs (or probability distribution) on the types of the service provider. It is also clear from Theorem 4 that the contract offered to the high-capability service provider has the following property: the more attractive the gain-sharing scheme \(s\) (or alternatively, the more severe the penalty \(p\)), the less the initial remuneration \(\pi\) and vice versa. This is summarised in Corollary 5.

**Corollary 5.** \(\pi_{ij}\) is increasing in \(p_{ij}\) but decreasing in \(s_{ij}, j \in \{1, 2\} \).

5. Conclusion and further research

This paper develops a game-theoretic model to study how a contract may be established in order that service providers are encouraged to reveal their true capabilities, as a result. A search on existing literature reveals that encouraging truth-telling is a pre-eminent issue in the industry of third party logistics. Although simple, the model enriches the existing research in Operations Management by generating several insights into issues that were normally addressed from the perspective of a single decision maker.

One area where the present paper can be enhanced is to include more measures of capabilities. Here, we use the word ‘capability’ as an umbrella term to include all aspects of a logistics service. Future extensions can consider a weighted sum of several areas of capabilities, including inventory policy, warehouse management, Just-In-Time capabilities, to name a few.

**References**


