



High-value transportation disruption risk management: Shipment insurance with declared value



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ABSTRACT

Shipment insurance has been widely used in express logistics and airline transportation. If a customer purchases a shipment insurance service and a disruption occurs, he could be compensated based on the declared value. This paper studies two contracts and investigates how shipment insurance premium affects the ex ante declared value and the ex post compensation. The customer purchases shipment insurance only when the cargo value is relatively high and his declared value does not exceed the actual cargo value. The optimal insurance premiums for both contracts and contract preference are obtained. Finally, we investigate the impact of effort towards transport process improvement.

1. Introduction

With the rising economy of e-commerce and online shopping in recent years, express shipping services (e.g., FedEx, DHL and UPS) are becoming increasingly important in people's daily lives (Tan et al., 2014). For instance, China's express delivery business volume totaled 20.67 billion piece in 2015, increased by 48% from the past year and with a compound annual growth rate (CAGR) of 54.6% over the past five years; express delivery revenue surged to 276.96 billion CNY, with a 35.4% annual growth and a CAGR of 37.0% over the past five years (China Express Delivery Industry Report, 2016). Last year, Tmall's "Double 11" sales (Nov. 11, also called Singles' Day, is China's largest online shopping festival) has reached 123 billion CNY, creating 0.68 billion packages. Such rapid volume growth has made the execution of logistics-related operations extremely difficult because any disruption such as unpredictable events, bad weather, staff absence, moral hazard or mechanical failure could cause delays and even significant losses.¹ Sinclair et al. (2014) offered a detailed discussion on different causes of disruption. Unfortunately, however, it is now almost impossible to predict all disruptions that may interrupt service continuity (Chan et al., 2015).

Shipping disruption arriving in the large volume shipments is an important challenge faced by express logistics providers (ELPs) and customers. In March 2015, the Chinese State Postal Bureau surveyed two major domestic express companies, STO and QF, both of which blamed their poor express logistics service offerings on the high disruption frequencies. With the increased customer concerns of cargo safety, ELPs are motivated to offer shipment insurance service to better enhance customer experiences. The disruption problem is not alone in express logistic industry. For example, airline transportation also faces great disruption risks due to its

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¹ For example, in July 2016, a staff member of ZTO Express, one of the largest express shipping service companies in China, opened a cargo box without customer's permission and lost a limited edition doll inside. < <http://tech.btime.com/internet/20160720/n313139.shtml> > .

complex aviation environment and the variety of passenger baggage, which can cause inconvenience or even misery to passengers (Chung et al., 2015). More importantly, airline transportation often faces significant financial loss after disruption as it is generally charged with high-value cargoes such as artwork, jewellery, film images, precious metals, or other collectibles. To minimize the negative impact of disruption, it is important to solve the compensation problem for high-value transportation.

Shipment insurance is a form of risk management that can be used to hedge the risk of contingent, uncertain losses due to disruptions (Choi et al., 2016). As limited liability covers up to a certain dollar amount per pound of freight, shipment insurance is a good way to protect customers from lost or damaged freight that has a higher value than what is covered by liability. Unlike limited liability coverage, shipment insurance charges additional fees and offers full compensation of customer declared value if the freight is lost or damaged in transit by carrier. To keep customers from declaring a higher value, some ELPs such as SF Express in China have ruled that customer declared value should not exceed the actual cargo value. Some other countries also have prescribed laws that if the insurer proves the actual cargo value to be less than the declared value, he may only compensate on the actual cargo value. However, the problem still remains as sometimes ELPs cannot evaluate the actual cargo value because of information asymmetry. In addition, the information acquisition for evaluation itself may also incur additional cost by ELPs.

To answer to the above research inquiry, our study aims to explore the conditions under which a customer would voluntarily declare the cargo value without exceeding its actual value. Specifically, we consider a risk-neutral ELP that offers shipment insurance to a risk-averse customer. Two commonly used contract formats are discussed here: (1) “multiplicative contract” (for example, FedEx collects a surcharge of 0.5% based on the declared value, while the rates of DHL are 1% for international shipments and 0.5% for domestic shipments); and (2) “additive contract” (UPS charges \$2.30 per additional \$150.00 or a fraction thereof is charged for shipments with a declared value of more than \$150.00).

Customer’s decision to whether purchase shipment insurance and the actual cargo value are private information possessed by the customer, and a customer may declare cargo value greater than, equal to or less than the actual value. We further assume that a customer does not have prior knowledge other than an estimation of the disruption probability because disruption information can be considered as business secrets and carefully protected by the ELP. We first derive the optimal declared value for the customer (i.e., the follower). Our results also show that contract format has significant effect on the customer’s declared value. Then, we focus on the pricing decisions and selection problem of these two shipment insurance contracts faced by the ELP. Furthermore, if the customer chooses to purchase shipment insurance service, the ELP might exert efforts (e.g., improvement of packaging or/and vehicle) to reduce disruption probability. We do not consider other potential efforts and first only focus on the ex post compensation problem. The possible variations of both the transport cost and disruption probability are finally considered in the end of our paper. To be specific, we try to shed light on the following questions:

Research Question 1: When would a customer purchase a shipment insurance? And what is his optimal declared value?

Research Question 2: What are ELP’s optimal pricing decisions? How does an ELP choose between the two shipment insurance contracts?

Research Question 3: Does the ELP always benefit from customer’s estimated disruption probability under both two shipment insurance contracts?

The main results of our study show that a customer purchases a shipment insurance only if the cargo value is relatively high. When the customer accepts shipment insurance service, he voluntarily declares his value that doesn’t exceed the actual cargo value, under the condition that the premium rate is not less than his estimated disruption probability. A high risk-averse customer prefers to purchase the multiplicative contract while the opposite is true for the additive contract, which finding is counterintuitive. The expected profit of the ELP is an increasing function of the customer’s degree of risk aversion. Moreover, the ELP’s expected profit is a decreasing function of disruption probability under the multiplicative contract, but a U-shaped quasi-convex under the additive contract. Specifically, the ELP’s expected profit first decreases and then increases under the additive contract, which is somewhat interesting and counterintuitive. Concerning the contract format, the ELP should offer the multiplicative contract when the customer’s estimated disruption probability is strictly less than the actual disruption probability. If the customer’s estimated value is more than or equal to the disruption probability, then knowing the actual cargo value ex ante would become critical for the ELP’s profit maximization when choosing between the two contracts. Under this circumstance, the ELP prefers the multiplicative contract when the cargo value is high while the additive contract dominates the multiplicative contract if the cargo value is low. Finally, it is better off for the ELP to reduce ex-ante investment when the customer expresses low willingness to purchase shipment insurance service.

The academic insurance literature has extensively studied major issues in the insurance industry, including (but not limited to) risk assessment, insurance purchase and claim decisions and the design of an optimal insurance policy (von Lanzanauer and Wright, 1991). Dong and Tomlin (2012) published the first paper on the relationship between business interruption (BI) insurance and operational measures. Based on their study, Zhen et al. (2016) assumed that transportation recovery is an endogenous factor and developed a model to characterize the relationship between transportation recovery and BI insurance in the presence of uncertain transportation costs. Lin et al. (2010) proposed an insurance contract under which the supplier shares the risk of overstock and understock with the retailer, improving the efficiency of the supply chain with a newsvendor-type product. Verter and Erkut (1997) incorporated the cost of liability insurance in a hazardous material vehicle routing optimization problem. Watt and Vázquez (2017) considered optimal insurance in the standard newsboy problem, with a weakly risk-averse newsboy. The fundamental role of insurance is to provide financial protection by offering a method of transferring the risk to another party for a premium (David, 2015). As viewed in other papers (e.g., Lodree and Taskin, 2008; Lin et al., 2010; Sorg et al., 2002; Watt and Vázquez, 2017), we consider shipment insurance as an operational measure for managing disruptions or a contractual arrangement under which one supply chain

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