



Warranty and price optimization in a competitive duopoly supply chain with parallel importation



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ABSTRACT

Gray market has always been an opposing challenge for manufacturers. Parallel markets tend to purchase the manufacturer's product at a lower price and resell it in another market with a higher price. In order to ameliorate the effects of parallel importation, the offering of a warranty for authorized channels is suggested as a competitive strategy. This paper considers two markets with different levels of willingness to pay. A manufacturer is present at both of these markets and offers the same product with different prices according to each market's willingness to pay. In the market with a lower willingness to pay, the manufacturer's product is not only purchased by a group of customers, but also by the parallel importer who later attempts to sell this product in the market with a higher willingness to pay. Moreover, in the market with lower willingness to pay, the manufacturer competes with another manufacturer that offers a similar product. A model for this problem is proposed when the manufacturer offers warranty as a competitive strategy against the parallel importer at the market with higher willingness to pay. Furthermore, a numerical example and a sensitivity analysis for the model are presented. Additionally, due to the practicality of this problem, managerial insights are included at the end of this research work.

1. Introduction

When genuine branded products are sold without official authorization by third parties is known as gray market. The problem of how to confront the diversion of products in an unauthorized channel (gray market) is an important concern for manufacturers. Regularly, in the gray market the manufacturer's product is sold cheaper than the manufacturer's authorized price but higher than the original price that they paid in order to make profit and compete with the manufacturer. According to Duhan and Sheffet (1988) these price differentials are caused by differences in demand, currency exchange rate or a segmentation strategy.

Online retail sector expands due to the progress of internet technology; which in turn helps boost gray markets. Ahmadi et al. (2015) mentioned that retailers such as Amazon, eBay, Alibaba, Kmart, and Costco are among those that sell gray products. Gray markets are divided into two groups: channel flow diversion and parallel importation. Channel flow diversion is mainly due to wholesale prices or other forms of sales offered by a manufacturer. Taking the advantage of the

wholesale price the unauthorized channel purchases these products and attempts to resell them in retail in the same market or geographical zone. Although the channel flow diversion occurs often, it is also common to import products from another area or geographical zone in order to take advantage of the benefits of unofficial imports. For example, low costs of an unofficial importation and wide price discriminations across international markets result in higher profits. Parallel importations bring legitimately products. They are authorized for the original sale, and have no problem with their legality in their importation to a country. However, the parallel importations do not have the authorization of the local owner or patent holder of a copyright or trademark in order to be sold at the same market. Any company that provides products in different markets with different prices, for instance electronic devices such as cell phones, laptops, digital cameras, etc. may have to compete with parallel importers. Other than that, gray markets are also present at a variety of different markets. According to Christensen (2010) a gray market exists for dental products, such as dental implant products.

Unlike counterfeit products that are sold at black market, gray

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market products are bought directly or indirectly from the original manufacturer and these are authentic. However, companies are limited with respect to legal strategies available to eliminate these unauthorized channels. Therefore, it is critical to analyze the system with regards to the existence of parallel importations. According to [Howell et al. \(1986\)](#) manufacturers need to offer a warranty in order to preserve their competitive advantage over the gray market. It is well known that a warranty is a liability of the manufacturer for its customer in order to compensate the customer if a product fails.

In fact the warranty means protect both manufacturer and customer. With respect to customer, the warranty is an insurance that compensates to buyer in case that the product is not up to its promised quality and functional features. On the other hand, [Murthy and Djameludin \(2002\)](#) mentioned that with respect to manufacturer, the length of time and the predefined conditions save manufacturer from having to compensate to its buyer when she or he has misused or overused of the product. Moreover, warranty is viewed as a competitive strategy similar to price or quality. [Menezes and Currim \(1992\)](#) classify the failures that can occur after purchase of a product into three groups: initial, chance and wear-out failures. Initial failures occur during the break-in period at time $t = 0$. Chance failures have a constant failure rate and occur at $t > 0$. Wear-out failures happen after that product has functioned a certain length of time and these have a higher failure rate. Assuming that initial failures are immediately identified and solved, in this paper the warranty length is set based on chance failures, the second type of failures.

Even though warranty is recognized as a competitive strategy, sometimes the manufacturer chooses to set lower prices for its product. When customers have low levels of willingness to pay then manufacturer may decide not to offer the warranty. In this situation, in order to keep the price at a certain level, the warranty offered can be purchased with an additional cost. Customers may or may not select to pay for the warranty. That is why a manufacturer may offer warranty at one market and decide on not to offer it in another market.

Fundamentally, this paper aims to perform the following:

- Introducing warranty as a practical factor for diminishing the effects of gray markets.
- Modeling the problem considering competition between two manufacturers, and competition between a manufacturer and a parallel importer.
- Identifying how warranty offered affects the competition between authorized and unauthorized channels.
- Comparing current work with those that ignore the warranty as a competing factor.

Furthermore, it is our intention to suggest some insights for managers that can help them in solving similar scenarios in real life.

The rest of this paper proceeds as follows. A review of the literature is presented in [Section 2](#). Following that, the problem and its model are explained and presented in [Section 3](#). A numerical example is described in [Section 4](#). A sensitivity analysis is done in [Section 5](#). Some managerial insights are provided in [Section 6](#). Finally, the conclusion and some ideas for future research directions are given in [Section 7](#).

2. Literature review

This paper is based on and contributes to several streams of literature such as it is reviewed in this section. Pricing problems between substitutable products often has been under consideration in the literature. [Ma et al. \(2012\)](#) examined the effects of a dominant manufacturer with substitutable products on members of the whole supply chain comprised of two manufacturers, one retailer, and several final consumers. Decision variables in their model are prices for each channel member. [Zhao et al. \(2012\)](#) developed a pricing problem of substitutable products of one manufacturer and two competitive

retailers under fuzzy demands and manufacturer costs. [Xu and Zhou \(2012\)](#) considered two supply chains of one manufacturer and one retailer that sell substitutable products with quality and pricing competition between these supply chains as decision variables. With the help of game theory [Li et al. \(2013\)](#) determined the optimal prices and shelf-space allocation decisions for substitutable products in two competing retailers. [Huang et al. \(2013\)](#) investigated a two-echelon supply chain where one manufacturer produces substitutable products for multiple retailers. The decision variable for their model is the wholesale price for each of the retailers determined by a non-cooperative game. [Zhao et al. \(2014\)](#) analyzed how different competitive strategies of two manufacturers affect the optimal pricing decisions of substitutable products in a two-echelon supply chain with firms' different channel powers structures. [Wei and Zhao \(2016\)](#) also assumed that both the customer demand and the manufacturing cost for each of the substitutable products are fuzzy variables. Their supply chain consisted of two manufacturers and one retailer and different game strategies are compared in several scenarios.

One important factor in our research is warranty. According to [Blischke, \(1993\)](#) free replacement warranties have been discussed in the literature often. Different aspects of warranty, including economic, operational, behavioral, marketing, and so much more, have been introduced and reviewed by [Murthy and Djameludin \(2002\)](#). They also introduced several models previously presented in literature that analyze costs. Another review has been done by [Chukova et al. \(2005\)](#) which presented some statistical models and methods used to analyze warranty claims data. [Wu \(2012b\)](#) summarized different types of data that are required in order to analyze warranty length, and later in another review [Wu \(2013\)](#) considered coarse warranty data. In a subsequent paper, [Wu \(2014\)](#) discussed warranty management with regard to return policies in products for which claim causes are unknown.

[Chun and Tang \(1995\)](#) developed a warranty model that determines the optimal price for the warranty considering the manufacturer's and the customers' risk. [DeCroix \(1999\)](#) dealt with the problem of durable products manufacturers in an oligopoly and determined the optimal solutions for product warranty, price, and reliability. He concluded that under general assumptions, each firm may set its reliability and warranty independently of price and other firms' actions. [Li et al. \(2011\)](#) discussed a supply chain with two competing manufacturers that each offer warranties on their respective product. [Dai et al. \(2012\)](#) utilized Nash equilibrium in a supply chain when order quantity is controlled by manufacturer and product quality by the supplier. They also compared warranty periods set by either the manufacturer, or the supplier in centralized and decentralized systems in order to determine optimal conditions under which better product quality as well as longer warranty is offered. [Chen et al. \(2012\)](#) reviewed the issues regarding pricing strategies in a supply chain comprised of a manufacturer and two competing retailers, in a Stackelberg game with the manufacturer as the leader, when the demand depends on warranty period. [Wu \(2012a\)](#) modeled and studied the equilibrium characteristics of effort and price in a supply chain with two manufacturers and a retailer. [Lan et al. \(2014\)](#) modeled a supply chain contract problem that considers pricing and warranty as buyer's decision variables under vague information which are presented as fuzzy variables in their model. [Tsao et al. \(2014\)](#) developed an aggregated model that considers pricing and inventory decisions for products with high technology under replacement warranty policy. [Wei et al. \(2015\)](#) used game theory approach to determine optimal price and warranty period of two complementary products in a duopoly supply chain with one common retailer. [Modak et al. \(2015\)](#) proposed a two-echelon supply chain with one manufacturer and one retailer considering that the demand function of customers depends on warranty, quality, and sales price of the product offered. They analyzed the supply chain under two centralized and decentralized scenarios.

The last important area that needs attention is the study of gray

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