Beyond Price Mechanisms: How Much Can Service Help Manage the Competition from Gray Markets?

Foad Iravani*[a], Sriram Dasu[b], Reza Ahmadi[c]

[a]Foster School of Business, University of Washington, Seattle, WA 98004, USA
[b]Marshall School of Business, University of Southern California, CA, 90089, USA
[c]Anderson School of Management, University of California, Los Angeles, CA, 90024, USA

Abstract

Companies operating global supply chains in various industries struggle with parallel importers diverting goods from authorized channels to gray markets. While the existing gray market literature mainly focuses on pricing, in this paper we develop a model to examine the role of demand enhancing services as non-price mechanisms for coping with gray markets. We consider a manufacturer that sells a product in two markets and a parallel importer that transfers the product from the low-price market to the high-price market and competes with the manufacturer on price and service. We show that parallel importation forces the manufacturer to provide more service in both markets. We explore the value of service and the effects of competition intensity and market responsiveness to service on the manufacturer's policy. We find that a little service can go a long way in boosting the profit of the manufacturer. Investing in service enables the manufacturer to differentiate herself from the parallel importer and to achieve the ideal price discrimination. In addition, service increases the value of strategic price discrimination when facing parallel importation. We also analyze the case when the manufacturer sells through a retailer in the high price market and can delegate service provision to the retailer or provide service herself. We find that delegating service to the retailer reduces double marginalization and can simultaneously benefit the manufacturer and the retailer, *even* if the retailer is not as efficient as the manufacturer.

Keywords: Supply chain management, gray market, parallel imports, demand enhancing services, uniform pricing.

1 Introduction

Companies in various industries are increasingly challenged by the diversion of their products to unauthorized distribution channels known as gray markets which resell genuine products

*Corresponding author, Tel: +12066169114, Email addresses: firavani@uw.edu (Foad Iravani), dasu@marshall.usc.edu (Sriram Dasu), rahmadi@anderson.ucla.edu (Reza Ahmadi)

legally purchased from authorized distributors. Gray markets are mainly the product of regional price differentials arising from supply chains that promote geographic pricing aimed at expanding commerce. Regional price differentials combined with diminishing trade barriers all but ensure gray market trade, also known as parallel importation, by which products purchased cheaply in one region are imported by individuals or enterprises to undercut higher pricing in another region.

Globalization and on-line sales feed gray markets, which in 2008 cost the U.S. IT industry alone approximately $58 billion and accounted for as much as 30% of total sales, according to a study by international auditing firm KPMG (KPMG 2008). A 2009 Deloitte study found that gray market imports annually cost U.S. manufacturers upwards of $63 billion in sales (*Bloomberg* 2009). Gray markets trade in a broad set of products including electronics, pharmaceuticals, college textbooks, beverages, cigarettes, automobile parts, luxury watches, jewelry, chocolates, and perfumes (Schonfeld 2010).

Most gray market sales are legal under the first sale doctrine, which allows purchasers to resell, display, or dispose of legally acquired items. Moreover, because gray market goods are genuine—unlike black market counterfeit products—companies are limited as to the legal strategies available to fight them. Although gray markets generate a new stream of demand, manufacturers generally consider gray markets harmful because products diverted to gray markets end up competing with those sold by authorized distributors and brand value may erode as products become available to segments that the manufacturer deliberately avoided. Gray markets also free ride on advertising and other manufacturer efforts to increase sales (Gallini and Hollins 2000).

Since price differentials drive gray markets, brand owner efforts tend to focus mostly on pricing mechanisms. Some luxury brands, TAG Heuer and Christian Dior for example, have gone so far as to forgo the advantages of geographic pricing altogether. They have instituted uniform pricing policies, charging the same amount for their products worldwide (Antia et al. 2004). Strategies like uniform pricing, price reduction, and price matching can lower the pressure from gray markets, but there is a limit to the amount brand owners can compromise on what they charge. Price manipulation can reduce brand equity by confusing consumers, damaging the brand reputation, and lowering profit margins.

One promising alternative for controlling gray markets is boosting authorized channel demand by investing in demand enhancing activities commonly referred to as "service" or sales effort in the marketing and operations literature (e.g. Winter 1993, Iyer 1998, Tsay and Agrawal 2000, Taylor 2002, Krishnan et al. 2004, Xia and Gilbert 2007). Service broadly represents all marketing efforts to increase product demand such as merchandising, advertising, promotions, attractive in-store demonstration, after-sales support and service offerings, and

providing information and guidance to consumers. As a non–price mechanism, value adding services significantly help companies to increase their revenue, enhance customer satisfaction, and promote repeat business. The contribution of service to profits has substantially grown in many industries. In 2011, Deloitte Research reported that after-sales services contributed 19%-47% to revenues across various industries (Kumar and Sailesh 2011).

Service can play a major role in encouraging consumers to buy products from authorized channels instead of gray markets. The ubiquity and rapid growth of gray markets in recent years and the limitations of price mechanisms have drawn the attention of many companies to demand enhancing services. In 2011, Mercedes–Benz reported that the percentage of Benzes sold in Thailand that were supplied by the gray market had risen from 13% in 2008 to 51%. In response to this rapid growth of the gray market, Mercedes-Benz cut the prices of seven models by between 2–5% and offered more leasing alternatives to induce demand. In addition, the company announced that it would no longer honor after sales services to gray market vehicles to protect its brand image, unless owners of such vehicles paid a one-time fee and register the vehicle with official Mercedes-Benz dealers (*Bangkok Post* 2011a and 2011b). BMW also confronted a burgeoning gray market in Thailand and decided to deny service to gray market vehicles (Harman 2010).

Automotive giant Hyundai wrestled with the same parallel importation problem as Mercedes-Benz in the Philippines. By 2002, gray market Starex vans were pouring into the country via unauthorized channels, and their owners were requesting Hyundai service. Hyundai responded by lowering its prices several times, but the parallel importers immediately slashed theirs as well. Eventually, the auto maker offered a three-year, 100,000-kilometer warranty which was an aggressive service package for deterring parallel importers (Ocampo 2003).

In addition to offering post-sale services, providing services before and during the sale can greatly boost demand for authorized channels. Nike and Apple are among reputable brands that invest heavily on creating a pleasant shopping experience for customers in their retail stores by educating customers about the brand and providing information about products that address customers' needs (Quinn 2013). In a study of gray markets, Galstian (2000) states that point-of-purchase service dimensions such as attractive in-store product demonstrations are highly effective in building a strong brand image to infuse emotion into products, elicit the emotional and social dimensions of shopping, and deter gray markets.

The entities that develop and engage in gray market activities are not limited to unknown individuals who buy one unit of a product and then resell it on the internet. Nowadays many parallel importers are well-established companies with a centralized planning system that buy large quantities of products from authorized dealers and resell them to customers. For exam-

ple, Amazon, eBay, Kmart, and Costco are among the famous retailers known to have sold gray goods (Bucklin 1993, Schonfeld 2010). Although these gray market retailers primarily compete with authorized channels on price, they also invest in different types of services to promote their products. Other examples of such gray marketers are Authenticwatches.com, Jomashop.com, and Prestigetime.com that sell genuine luxury watches, B&H Photo, Video & Pro Audio that sells electronics, audio and video equipment, and professional cameras, and New Zealand's big retailer, The Warehouse (Krause 2012). These companies provide services to their customers.

Motivated by these observations in practice, in this paper we analyze the impacts and effectiveness of value adding services in controlling the competition from gray markets. To our best knowledge, our paper is the first quantitative analysis of service mechanisms in the context of parallel importation. We expand the existing framework for analyzing parallel importation (e.g., Ahmadi and Yang 2000, Xiao et al. 2011) by incorporating service competition between a manufacturer selling a product in two markets and a parallel importer. The manufacturer determines her[1] price and service in each market. If the price differential between the markets is sufficiently large, the parallel importer may buy a quantity of the product in the low-price market and resell it in the high-price market. The parallel importer behaves strategically, maximizing his total profit by way of quantity, resale price, and service offerings. We formulate the competition between the manufacturer and the parallel importer using a Stackelberg game and explore the following:

1. **Manufacturer's decisions:** We show that parallel importation compels the manufacturer to provide more service in the high-price market to combat the competition from the parallel importer *and* to increase the amount of service in the low-price market to make up for raising the price in that market.

2. **Manufacturer's policy and the value of service:** We find that a little investment in service can significantly help the manufacturer to curb the competition from the gray market and increase her profit. Demand enhancing services enable the manufacturer to differentiate herself from the parallel importer, especially when the gap between consumers' perception of the parallel import channel and their perception of the authorized channel shrinks.

   Moreover, we examine the simultaneous effects of consumers' responsiveness to service and the strength of competition between the authorized and gray market channels on the manufacturer's policy (allow or block) towards the parallel importer. We find that the manufacturer is better off allowing parallel imports when competition is moderate

[1]We use 'she' for the manufacturer and 'he' for the parallel importer and the retailer in Section 4.

and is better off blocking parallel imports when the level of competition is either low or very high. More importantly, whereas companies that only use price to manage gray market activities have very limited ability to achieve their ideal price discrimination policy, companies that take advantage of service mechanisms have more power to implement a perfect price discrimination policy, even if the gray market is a mild or strong competitor for the authorized channel.

We also compare the manufacturer's optimal profit to her profit when she adopts a uniform pricing policy. We find that choosing prices and services strategically is significantly more valuable than following a myopic uniform pricing policy. In addition, the value of strategic decision–making in the presence of parallel importation generally increases when service plays a bigger role in enhancing demand.

3. **Effects of service control in decentralized supply chain:** We study a decentralized supply chain in which the manufacturer sells the product through a retailer in the high price market. We explore the impacts of service control (by manufacturer or retailer) on service investment, gray market volume, and supply chain profits. Manufacturers may delegate services to a retailer if service activities such as in-store product demonstrations and providing a high-quality shopping experience have a strong influence on consumers. Manufacturers may also delegate services to a retailer if the retailer can penetrate the market and communicate with consumers more effectively. On the other hand, a manufacturer may retain control of the service decision and only delegate the pricing decision to the retailer. The automobile industry is an example for the first scenario while the consumer electronics industry provides examples for both scenarios (Xia and Gilbert, 2007). We also observe both scenarios in Best Buy. Efforts for promoting sales of Apple products in Best Buy are managed by Best Buy salespeople, whereas Samsung recently partnered with Best Buy to open 500 Samsung Experience Shops within Best Buy stores. These shops are operated by Samsung salespeople who provide assistance to customers (Gara, 2013).

   Interestingly, we find that delegating service to the retailer can benefit *both* the manufacturer and the retailer, *even if* the retailer is not more efficient in providing service than the manufacturer. Therefore, entrusting the retailer with service can lead to a win–win situation. In our experiments, we observed an average profit increase of approximately 6% for the manufacturer and 13% for the retailer. This provides insights into managing demand enhancing services for managers that operate decentralized supply chains and face gray markets. To our best knowledge, we are the first to analyze the effects of service control in a supply chain that faces competition from gray markets.

This paper proceeds as follows. Section 2 reviews the literature. In Section 3, we formulate and solve the Stackelberg game model, and describe the impact of service and parallel importation on decisions. We also explore the effects of service responsiveness and competition intensity on the manufacturer's policy, and examine the added value of strategic price and service decisions in the presence of parallel importation. Section 4 explores the effects of service control when the supply chain is decentralized in the high price market. Section 5 summarizes the results and concludes with future research directions. The appendix contains all proofs.

2 Literature Review

Our research is related to and bridges the gap between three streams of literature: the price and service (sales effort) competition literature and the gray markets literature. The price and service literature mainly studies competition and/or coordination of price and service decisions. Iyer (1998) analyzes coordination in a distribution channel with two authorized retailers competing on price and service. Tsay and Agrawal (2000) study a manufacturer selling to two retailers who compete on price and service and find that the intensity of competition and the degree of cooperation affect total sales and profitability. Taylor (2002) and Krishnan et al. (2004) study contracting and coordination of sales effort and inventory decisions. In their analysis of revenue–sharing contracts, Cachon and Lariviere (2005) consider a case in which retailers exert sales effort. Xia and Gilbert (2007) investigate how a dealer's organizational structure affects a manufacturer's decision to invest in demand enhancing services or to delegate services to the dealer. Jin et al. (2015) study the combined effect of contract type and the decision right of sales promotion. None of these papers considers gray market activities.

Existing research on gray markets primarily focuses on public policy and pricing. Empirical evidence of gray markets and their causes can be found in Bucklin (1993), Myers (1999), Maskus (2000), and Antia et al. (2004). Ahmadi and Yang (2000) study a supply chain with a price-setting manufacturer and parallel importer. They show that parallel importation can increase manufacturer profit if the distribution cost in the high-price market is sufficiently greater than the distribution cost in the low-price market. Xiao et al. (2007) show that the structure of the authorized channel is critical to determining the profitability of parallel importation. Autrey et al. (2014) consider two firms selling in a domestic and emerging markets in the presence of gray market. They show that when the products are highly substitutable, adopting a decentralized structure in the emerging market is advantageous. Autrey et al. (2015) later show that firms may be better off with gray markets if they invest

in emerging market development and sell complementary products. Ahmadi et al. (2015) investigate the impacts of market conditions and product characteristics on a manufacturer's policy towards parallel importation.

Dasu et al. (2012) consider a decentralized supply chain with a retailer that can sell excess inventory to the gray market. Altug (2014) determines when product diversion to a domestic gray market (as opposed to parallel importation) by a large number of retailers that face stochastic demand will benefit a manufacturer. Hu et al. (2013) look at how a reseller can exploit the gray market to benefit from supplier quantity discounts. Su and Mukhopadhyay (2011) consider a manufacturer offering quantity discounts to one dominant retailer, encouraging multiple fringe retailers to get involved in gray market activity.

Despite the crucial role of services, this mechanism has received little attention in the gray market literature. Dutta et al. (1994) study retailers who sell across their territories (bootleg) and show that the optimal policy is to tolerate some level of bootlegging. Although they have a service decision variable in their model, they use a transaction cost approach and focus on deployment of an exclusive territory distribution system. Chen (2002) explores the relationships between parallel importers and trademark owners from the viewpoint of social welfare. Chen (2009) later considers a manufacturer contending with parallel importation and analyzes the effects of demand function and price elasticity on profits. Although Chen's studies incorporate a service variable, they only focus on manufacturer decisions regarding the authorized channel in the region to which gray goods are imported and ignore the price and service decisions for the region where the parallel importer acquires the product. They also assume that the parallel importer either is not a strategic decision maker and the quantity of imports is exogenous, or he does not provide service. In addition, the studies do not analyze service control by the manufacturer or the retailer.

Our paper also relates to the channel conflict literature which studies the competition between manufacturer-owned direct channels and retailer-owned indirect channels. Tsay and Agrawal (2004) and Chiang et al. (2003) are representatives of this literature. They show that under certain conditions a dual distribution channel can actually benefit a manufacturer. Our model is similar to dual channel models in that the parallel importer and the manufacturer may simultaneously offer the product in a market. However, there is a key difference between dual channel models and our parallel importation model. In dual channel management, a manufacturer has full control over the design of her distribution channels. She can choose to sell her product through an independent retailer if the circumstances prove that selling through direct and indirect channels simultaneously increases her profit. Otherwise, the manufacturer can refuse to sell her product to the retailer. In contrast, in our model the manufacturer does not have full control over the parallel import channel because

it *emerges as a result* of the price gap between two markets. Moreover, in practice manufacturers cannot identify parallel importers (Antia et al. 2004), and therefore they cannot refuse to sell to parallel importers. Instead, manufacturers can only decide how they want to cope with the existence of parallel importers and adjust their decisions, such as prices and services, accordingly.

The research questions we address distinguish our work from the aforementioned studies because we (1) determine when a manufacturer should allow or block parallel importation by her price and service decisions and explore the leverage the manufacturer derives from providing service when she encounters parallel importation; (2) study the impact of parallel importation on manufacturer decisions and the impact of service investment on the manufacturer; (3) explore the effects of competition intensity and high-price market's responsiveness to service on the manufacturer's policy towards parallel imports; and (4) analyze the service control decision in a decentralized supply chain in the presence of parallel importation.

3 Model and Analysis

Consider a manufacturer who operates in two separate regions (hereafter referred to as market 1 and market 2). Initially, we assume that the manufacturer sells through a vertically-integrated authorized distribution channel. Table 1 lists the notations used throughout the paper. The manufacturer produces the product at constant marginal cost c and offers the product at price p_i in markets $i = 1, 2$. For a simpler exposition, we do not consider the manufacturer's variable selling cost in each market, though these parameters can be easily added to the model and they do not impact the qualitative nature of the results in general. The manufacturer provides service s_i in market i. Demand for the product in market i is deterministic, linear, decreasing in price, and increasing in the amount of investment in demand enhancing services and is defined as $d_i(p_i, s_i) = N_i - b_i p_i + \theta_i s_i$ in which N_i is the market base and $b_i, \theta_i > 0$ represent market responsiveness to price and manufacturer service, respectively.[2]

The cost of providing service s_i is $\lambda_i \frac{s_i^2}{2}$. Quadratic service cost functions are commonly used in the literature (Iyer 1998, Tsay and Agrawal 2000, Xia and Gilbert 2007, Taylor 2002, Krishnan et al. 2004). Service cost will be quadratic if the service has a significant store-level inventory component. For other types of service, managers usually invest in the

[2]Although mathematically the demand function $d = N - bp + \theta s$ can result in a total demand that exceeds N, we assume this outcome does not occur in equilibrium. Achieving a total demand greater than N requires setting a very low price and/or providing an abundance of service which is not practical due to financial risks and service cost. Service investment clearly helps increase demand but not to the extent of exceeding the market base.

lowest-hanging fruit so that further increments in the service level become progressively more costly (Tsay and Agrawal 2000).

Table 1: Notation ($i = 1, 2$)

N_i, b_i, θ_i	market base and market responsiveness to price and manufacturer service
θ_G	market responsiveness to parallel importer service
λ_i, λ_G, λ_2	manufacturer, parallel importer, and retailer service cost parameters
c, c_G	manufacturer production cost and parallel importer transfer cost
δ	consumers' relative perception of parallel imports
p_i, s_i	price and service
ω	manufacturer wholesale price
q_G, p_G, s_G	parallel importer's quantity, resale price, and service
π_m, π_r, π_G	manufacturer, retailer, and parallel importer profit
$(\cdot)^n$	optimal decisions when there are no parallel imports
$(\cdot)^*$, $\widehat{(\cdot)}$	optimal decisions when there are parallel imports with and without service

We assume that the manufacturer's services only enhances authorized channel demand. In practice, many demand enhancing services such as promotions, free installation, after–sales support, and warranty are only offered to customers who buy the product from authorized distributors. In addition to BMW, Mercedes-Benz, and Hyundai service policies described earlier, Nikon, Sigma, and Ticino are examples of companies that deny warranty and after-sales services to customers who obtain their products from gray markets.[3] Nevertheless, some services such as advertising and in-store demonstration may also increase the demand in gray market channels. We discuss the effect of relaxing this assumption in the conclusion.

The interaction between the manufacturer and the parallel importer is modeled with a Stackelberg game in which the manufacturer is the leader and the parallel importer is the follower. The sequence of events is depicted in Figure 1: (1) The manufacturer sets her price and the amount of service in both markets; (2) If the parallel importer decides to transfer the product, he chooses his quantity, resale price, and amount of service to provide in the high-price market.

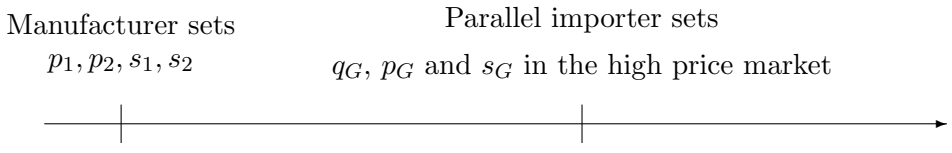

Figure 1: Sequence of events

[3]See Nikon, Sigma, and Ticino web sites.

3.1 Without Parallel Importation

To analyze the impact of parallel importation on the manufacturer, we first consider the case where there is no parallel importation. The manufacturer maximizes total profit by solving

$$\max_{p_1,p_2,s_1,s_2} \sum_{i=1}^{2} \left[(p_i - c)\, d_i(p_i, s_i) - \lambda_i \frac{s_i^2}{2} \right]. \tag{1}$$

Assumption 1 *$N_i > b_i c$ and $\theta_i < \sqrt{2\lambda_i b_i}$ for $i = 1, 2$.*

The first inequality ensures that the market bases are large enough to offset the production cost. The second inequality ensures that investing in services to promote sales is sufficiently costly. The lower bounds rule out the unrealistic scenario in which the manufacturer can achieve unbounded profit by investing in an infinite amount of service. The optimal decisions in the absence of parallel importation are

$$p_i^n = \frac{\lambda_i N_i + c\,(\lambda b_i - \theta_i^2)}{2\lambda_i b_i - \theta_i^2}, \qquad s_i^n = \frac{(N_i - b_i c)\theta_i}{2\lambda_i b_i - \theta_i^2}, \qquad i = 1, 2. \tag{2}$$

3.2 With Parallel Importation

After the manufacturer sets her prices and services, the parallel importer may consider buying the product in the low-price market and reselling it in the high-price market. We assume, *without loss of generality*, that if the manufacturer sets her prices without taking parallel importation into consideration, then price in market 2 will be larger than price in market one and the direction of imports will be from market 1 to market 2.[4] The parallel importer transfers q_G units from market 1 to market 2 at cost c_G per unit and resells each unit at price p_G. He also invests in service s_G at cost $\lambda_G \frac{s_G^2}{2}$.

When the parallel importer offers the product in market 2, consumers have options to buy the product from the manufacturer, buy from the parallel importer, or not buy the product at all. The first step of analysis is to model the segmentation of market 2 consumers. We adopt and expand the market segmentation approach in Ahmadi and Yang (2000) and Xiao et al. (2011) in order to compare our results with the existing literature and investigate the impact of demand enhancing services. More specifically, we define consumer surplus functions that depend on three components: (1) consumers' valuation of the authorized channel and the gray market; (2) the prices offered by the manufacturer and the parallel importer; and (3)

[4]Remember that parallel importation will emerge *only if* price is higher in one market than the other. Thus, this assumption is *necessary* for analysis. The direction of imports remains intact for the equilibrium prices of the game.

the amount of services provided by the manufacturer and the parallel importer. Consumers make the decision that maximizes their surplus. We assume the surplus for not buying the product is zero.

First we define consumer surplus for purchasing the product from the manufacturer as $\psi_m = \nu + \frac{\theta_2 s_2}{N_2} - \frac{b_2 p_2}{N_2}$, where ν is uniformly distributed between 0 and 1 and represents heterogeneity in consumers' valuation of the authorized products sold by the manufacturer. Consumer surplus increases with the amount of service and decreases with price. Note that since the surplus for not buying is zero, in the absence of parallel importation, ψ_m results in a total demand of $N_2 - b_2 p_2 + \theta_2 s_2$ or $d_2(p_2, s_2)$ for the manufacturer, which is the demand function used for the benchmark scenario in Section 3.1. Next, we define $\psi_G = \delta\left(\nu + \frac{\theta_G s_G}{N_2}\right) - \frac{b_2 p_G}{N_2}$ as the consumer surplus for buying from the gray market when the parallel importer offers the product at price p_G and provides service s_G, where θ_G represents market responsiveness to the parallel importer's service. Similar to ψ_m, in ψ_G parallel importer's service enhances consumer's valuation of the gray market. The parameter $0 < \delta < 1$ reflects consumers' perception of the gray market relative to the authorized channel. It captures the notion that consumers have a lower perception of gray markets compared to authorized channels (but *not* a lower surplus necessarily). This assumption has been used in previous analytical models (e.g. Ahmadi and Yang 2000; Altug and van Ryzin 2014; Xiao et al. 2011). Moreover, empirical studies of gray markets such as Huang et al. (2004) and Thompson (2009) have observed that consumers value the peace of mind they get when they buy from authorized channels. Nevertheless, consumers ultimately decide to buy from the manufacturer or the parallel importer based on their surplus which measures the net effect of consumers' perception as well as the price and service decisions of the manufacturer and the parallel importer. In other words, a given consumer will buy from the manufacturer if $\psi_m > \psi_G$; otherwise, the consumer will buy from the parallel importer.

To derive the size of each segment, we solve $\psi_m = \psi_G$ to find the valuation of the consumer who is indifferent between buying from the manufacturer and buying from the parallel importer (ν_1). Then we solve $\psi_G = 0$ to find the valuation of the consumer who is indifferent between buying from the parallel importer and not buying the product (ν_2). The size of the segment that buys from the manufacturer equals $N_2(1 - \nu_1) = N_2 - \frac{b_2(p_2 - p_G) - \theta_2 s_2 + \delta\theta_G s_G}{1-\delta}$, and the size of the segment that buys from the parallel importer equals

$$q_G = N_2(\nu_1 - \nu_2) = \frac{b_2(\delta p_2 - p_G) - \delta\theta_2 s_2 + \delta\theta_G s_G}{\delta(1-\delta)}. \tag{3}$$

Thus, we can formulate the parallel importer's profit maximization problem as

$$\max_{p_G, s_G} \quad \pi_G = (p_G - p_1 - c_G)\left(\frac{b_2\left(\delta p_2 - p_G\right) - \delta\theta_2 s_2 + \delta\theta_G s_G}{\delta\left(1-\delta\right)}\right) - \lambda_G \frac{s_G^2}{2}. \tag{4}$$

The first order conditions provide the parallel importer's best response

$$\begin{aligned} p_G(p_1, p_2, s_2) &= \frac{\lambda_G(1-\delta)[b_2(\delta p_2 + p_1 + c_G) - \delta\theta_2 s_2] - \delta\theta_G^2(p_1 + c_G)}{2(1-\delta)\lambda_G b_2 - \delta\theta_G^2}, \\ q_G(p_1, p_2, s_2) &= \max\left\{0, \frac{\lambda_G b_2[b_2\left(\delta p_2 - p_1 - c_G\right) - \delta\theta_2 s_2]}{\delta[2(1-\delta)\lambda_G b_2 - \delta\theta_G^2]}\right\}, \\ s_G(p_1, p_2, s_2) &= \frac{\delta\theta_G}{\lambda_G b_2} q_G(p_1, p_2, s_2). \end{aligned} \tag{5}$$

The parallel importer's best response indicates that the gray market will emerge if $b_2(\delta p_2 - p_1 - c_G) > \delta\theta_2 s_2$. Although the parallel importer exploits the price gap to profit from transferring the product, consumers have a lower perception of parallel imports and the manufacturer invests in service. Therefore, $\delta p_2 - p_1$ needs to be sufficiently large to compensate for the importer's transfer cost and the manufacturer's services that enhance the authorized channel demand.

When the parallel importer transfers the product, the manufacturer's sales in market 1 go up by $q_G(p_1, p_2, s_2)$, the quantity purchased by the parallel importer. On the other hand, the manufacturer's sales in market 2 change by $N_2(1-\nu_1) - d_2\left(p_2, s_2\right) = -\frac{b_2(\delta p_2 - p_G) - \delta\theta_2 s_2 + \delta\theta_G s_G}{1-\delta} = -\delta q_G(p_1, p_2, s_2)$. Thus, we can formulate the manufacturer's problem as

$$\begin{aligned} \max_{p_1, p_2, s_1, s_2} \pi_m = {} & (p_1 - c)(d_1(p_1, s_1) + q_G(p_1, p_2, s_2)) + (p_2 - c)(d_2(p_2, s_2) - \delta q_G(p_1, p_2, s_2)) \\ & - \sum_{i=1}^{2} \lambda_i \frac{s_i^2}{2}. \end{aligned} \tag{6}$$

The manufacturer's optimal price and service *decisions*, denoted by $(p_1^*, s_1^*, p_2^*, s_2^*)$, result in two *policies* towards the parallel importer: Either the manufacturer allows a certain quantity of parallel imports; or she sets her prices and services such that parallel importation becomes unprofitable. For brevity, we have deferred the formulas for the optimal prices and service decisions to the appendix. The manufacturer can maintain her ideal price discrimination policy, meaning charge p_i^n and use s_i^n in (2), when either the parallel importer does not exist at all or when consumers in market 2 have such a low valuation of the gray market channel that parallel importation is not profitable. However, if consumers view parallel imports as a viable alternative (meaning δ is not too low), then the parallel importer can

potentially profit from transferring the product from market 1 to market 2. In this situation, the manufacturer needs to react and adjust her decisions to protect her market share. In Section 3.3, we provide more insights about manufacturer's policy towards parallel imports.

Proposition 1 *Whether the manufacturer allows or blocks parallel importation, she provides more service in both markets.*

In the presence of parallel importation, the manufacturer promotes the authorized channel more aggressively in *both* markets. Although the manufacturer reacts to parallel importation by increasing the price in market 1 and reducing the price in market 2 (thereby reducing the price gap), she also provides more service in market 2 to counteract the competition from the parallel importer and also increases the amount of service in market 1 to compensate for increasing the price in that market.

Proposition 2 *(a) The optimal service level increases in both markets with the consumers' relative perception of parallel imports.*
(b) If one of the following conditions holds, then service helps the manufacturer block the parallel importer's entry: Either θ_1 *is greater than a certain threshold denoted by* $\widetilde{\theta}_1$*, or* θ_2 *is greater than a certain threshold denoted by* $\widetilde{\theta}_2$*.*

As δ increases, consumers' perception of the gray market relative to the authorized channel goes up and the gray market becomes more credible to consumers. In particular, when $\delta \approx 1$, consumers become almost indifferent between the manufacturer and the gray market, thereby intensifying the competition. In this situation, the manufacturer uses demand enhancing services as an additional lever to differentiate the authorized channel from the gray market and attract more consumers.

The conditions for θ_1 and θ_2 in part (b) underscore the important role of service in managing the competition from parallel importers. The functional form of $\widetilde{\theta}_1$ and $\widetilde{\theta}_2$ are provided in the appendix, and it is easy to show that both $\widetilde{\theta}_1$ and $\widetilde{\theta}_2$ satisfy Assumption 1. It will not be profitable for the parallel importer to transfer the product if service is sufficiently valued by customers in both markets. If market 1's responsiveness to service is sufficiently high (above $\widetilde{\theta}_1$), then the manufacturer will provide more service and can afford to increase the price in market 1. This increases the parallel importer's purchasing cost and makes parallel importation unprofitable.

In a similar manner, the condition for θ_2 highlights the value of providing service in the high price market where the manufacturer and the parallel importer vie for consumers.

If market 2's responsiveness to service is sufficiently high (above $\widetilde{\theta}_2$), then by providing service the manufacturer can attract more customers to the authorized channel and win the competition from the parallel importer. Moreover, we can show that $\widetilde{\theta}_2$ decreases with δ. As δ increases, consumers start to perceive the authorized channel and the parallel import channel almost equally. In this situation, investing in more demand enhancing services (as recommended by part (a) of the proposition) gives the manufacturer significant leverage in block gray market activities.

Next we analyze the effect of service on manufacturer's prices in the presence of parallel importation.

Proposition 3 *Suppose the manufacturer's optimal price and service decisions result in the same policy—either to allow or block parallel importation—whether she does or does not invest in service. Then, the optimal prices when service is provided are higher than the optimal prices when no service is provided.*

Price in market 1 as well as price in market 2 will be higher when the manufacturer invests in service provided that the manufacturer uses the same policy (either allow or block) both when she only uses price and when she uses price and service together to control gray market activities.

For the rest of our analysis, we focus on the case of $q_G^* > 0$. This is the scenario in which the parallel importer actually transfers product and competes with the manufacturer. The next proposition describes how consumers' responsiveness to manufacturer service in market 2 and relative perception of parallel imports affect manufacturer decisions.

Proposition 4 *The price gap between markets 1 and 2 increases with high price market's responsiveness to manufacturer service.*

Proposition 4 explains an interesting observation; the price gap is increasing in market 2's responsiveness to manufacturer service. This is because providing service in market 2 enables the manufacturer to attract more customers to the authorized channel; therefore, the manufacturer can afford to increase the price gap. In other words, demand enhancing services alleviate the pressure on the manufacturer to reduce her price gap.

3.3 Value of Service

Having looked at the impact of service and parallel importation on manufacturer decisions, in this section we further explore the role of service in managing gray market activity.

We also provide managerial insights about the effects of responsiveness to service and the degree of competition between the authorized channel and the parallel import channel on the manufacturer's policy towards the gray market. Finally, we compare the performance of the price and service decisions proposed by our model to the uniform pricing policy that is used in practice by some companies.

We conducted numerical experiments to measure the extent of the additional profit the manufacturer gains by investing in service when she faces parallel importation. The parameter values are listed in the Appendix. The value of manufacturer's service parameters were selected in a way that if there were no parallel imports, investing in service would increase the profit of the manufacturer by 3%, 5%, 10%, and 15%. Figure 2 shows the results of our experiments and reports the percentage of increase in the manufacturer's profit when she uses both price and service to cope with parallel importation compared to when she only uses price. When δ is very low, the additional profit is constant because consumers' perception of parallel imports is too low for the gray market to emerge, regardless of whether the manufacturer offers service or not. As δ increases and the parallel importer becomes more competitive, service significantly helps the manufacturer to promote the authorized channel and earn higher profit. Figure 2 clearly shows that a little service can go a long way and provides significant leverage in coping with gray markets. Thus, It is crucial for companies to recognize the importance of service and incorporate this non-price mechanism in their reaction to gray markets.

Managers who are challenged by parallel importers face an important question: what policy should they adopt towards parallel importers? Do they need to change their price and service decisions? If yes, should they adjust their decisions such that they allow and tolerate parallel imports, or should they block parallel imports? Since the focus of this research is service, we provide insights about the effects of service responsiveness and the level of competition between the authorized and gray market channels on the manufacturer's optimal policy towards the gray market. More specifically, we capture the degree of competition by the parameter δ. When δ is low (closer to 0), the parallel importer is not a strong competitor for the manufacturer because consumers essentially perceive the authorized channel to be superior to the gray market channel. On the other hand, when δ is high (closer to 1), consumers' perception of the gray market channel is close to their perception of the authorized channel; therefore, the parallel importer creates intense competition for the manufacturer. To capture the effect of service, we use the value of θ_2 which represents consumers' responsiveness to manufacturer's service in market 2 where the authorized and gray market channels compete.

We conducted various numerical experiments using different combination of parameter

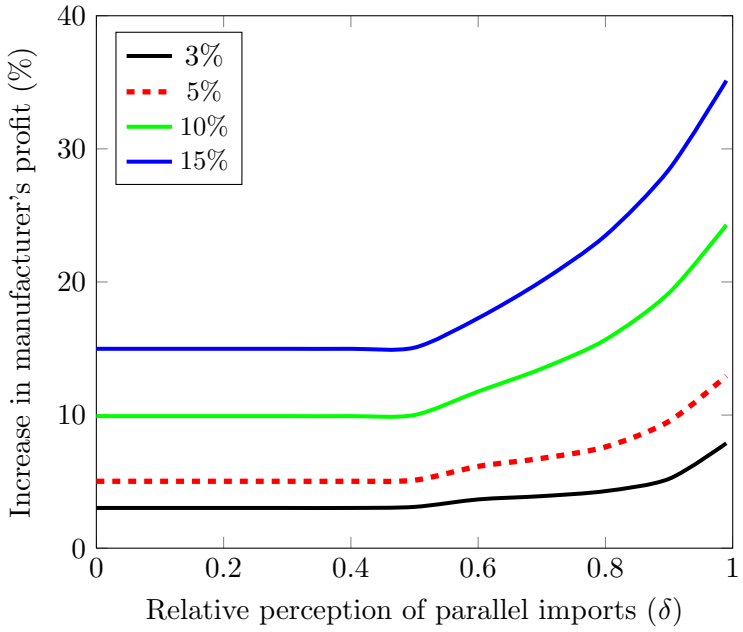

Figure 2: The value of demand enhancing services when facing parallel importation

values. We gradually varied the values of δ and θ_2 and found the manufacturer's optimal policy. Noting that for specific values of parameters, one should consult Proposition 1 to precisely determine the optimal policy, Figure 3 qualitatively summarizes the overall effects of responsiveness to service and competition intensity on the optimal policy towards parallel imports.

The first pattern we observe in Figure 3 is the sequence of policies along the horizontal axis for different levels of competition. Ideally, companies that sell products in multiple countries want to charge different prices in the markets, based on markets' responsiveness to price and service, to maximize their profit. The presence of parallel importers challenges the ability of companies to price discriminate, forcing them to deviate from their ideal decisions and reduce the price gap. Generally speaking, we observe that when parallel imports are intrinsically viewed by consumers as an inferior channel, the manufacturer is able to implement her ideal price discrimination policy (i.e., charge the prices in (2)) without worrying about the presence of the parallel importer. As competition starts to pick up, the manufacturer is compelled to change her decisions. When the level competition is somewhat high, the manufacturer reduces her price gap a little bit and provides a bit more service just to block the parallel importer. For moderately high competition, however, blocking parallel imports is no longer the optimal policy because it would require a steep reduction in the price gap which would hurt profits in the authorized channels. Therefore, the manufacturer is better off allowing a

certain quantity of parallel imports. Finally, when consumers view the gray market channel as a viable option and, as a result, the parallel importer creates fierce competition for the authorized channel, the manufacturer blocks the parallel importer with her price and service decisions to avoid a sever loss of market share.

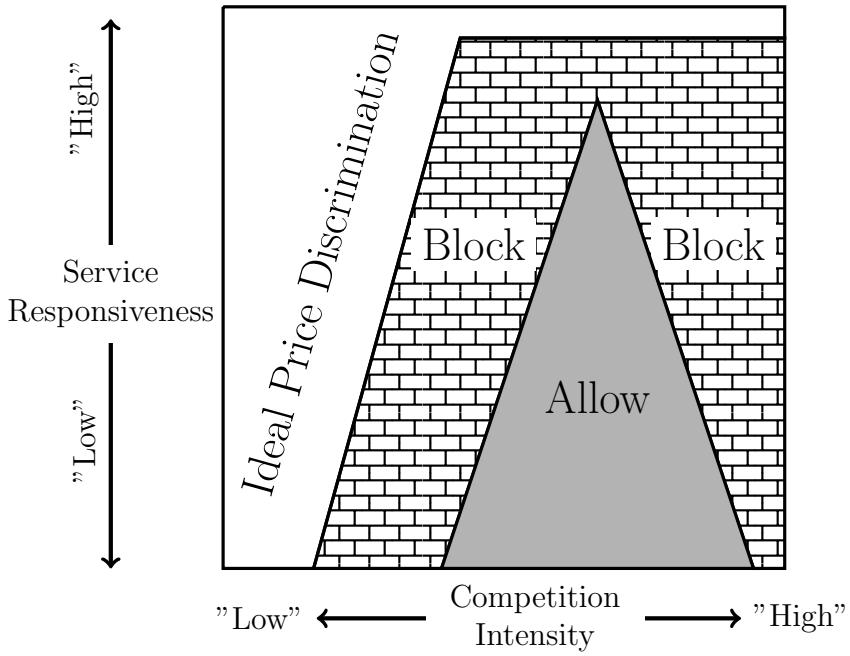

Figure 3: Effects of competition intensity and service responsiveness on manufacturer's policy

The second observation from Figure 3 highlights the value and effectiveness of service in coping with gray market activities. If the manufacturer only relies on the price mechanism for coping with parallel imports, or consumers' responsiveness to service is very low, it will be extremely difficult for the manufacturer to achieve the ideal price discrimination, unless the gray market channel is a very weak competitor (the lower left corner). In contrast, when consumers' responsiveness to service is moderate or high, through investing in services the manufacturer can actually achieve her ideal price discrimination policy, even if the parallel importer creates moderate or strong competition for the authorized channel. In other words, investing in demand enhancing services lessens the pressure on the manufacturer to compromise on her decisions. As a matter of fact, our observation is corroborated by the motivating examples in the introduction. When Hyundai and Benz faced price competition from parallel importers in Southeast Asia, they initially used price to protect their market share. However, both companies ultimately resorted to service mechanisms to draw customers to their authorized channels. The new service offerings by Hyundai and Benz forced the parallel importers to either stop importing vehicles or turn into authorized dealers for the automobile manufacturers.

We close this section by providing managerial insights about the value of making price and service decisions strategically in the presence of parallel importers. Implementing the optimal price and service decisions prescribed by our model requires estimating the value of parameters related to the gray market, such as the relative perception of parallel imports, parallel importer's transfer cost, and market responsiveness to parallel importer's service. In practice, some companies such as TAG Heuer and Christian Dior have adopted a uniform pricing policy and charge the same price for their products across all markets to eliminate gray markets entirely. Although the uniform pricing policy requires less information and facilitates price coordination, companies that adopt this policy forgo the benefits of price discrimination in the strategic policy. To explore the value of using a strategic policy as opposed to a myopic uniform pricing policy, we compare the manufacturer's profit under the strategic price and service policy to her profit under the uniform pricing policy, which is obtained from maximizing $\sum_{i=1}^{2}[(p^u - c)\, d_i(p^u, s_i) - \lambda_i \frac{s_i^2}{2}]$ over p^u, s_1, s_2.

Figure 4 reports the profit gap (in percent) between the strategic price and service policy and the uniform pricing policy for four service parameter values. First, we observe that the strategic policy is significantly more profitable than the uniform pricing policy. The profit gap ranges from 6% to 29% and is higher when δ is not too close to 1. As δ approaches 1, in the strategic policy the manufacturer reduces the price gap and increases her services in reaction to the intense competition from the parallel importer. In this situation, the loss of profit from charging a uniform price in both markets will be lower (relative to when δ is not close to 1). Nevertheless, the profit gap is still considerable. Therefore, adopting a strategic price and service policy instead of a uniform policy is worthwhile as it enables companies to significantly increase their profit through appropriate price discrimination while controlling the extent of gray market activities.

Second, we observe from Figure 4 that when δ is sufficiently close to 1, the profit gap between the strategic and myopic policies increases with the contribution of service to profit. When δ is close to 1, the authorized channel and the gray market are almost identical in the eyes of the consumers, and competition is intense. In this situation, the strategic policy allows the manufacturer to provide the right amount of services to differentiate herself from the parallel importer. The uniform pricing policy, however, results in suboptimal price and amount of services that impede the manufacturer's ability to confine the volume of parallel imports to the desired level. Therefore, when service has a great potential for boosting demand in the authorized channel, the strategic price and service policy is even more valuable to companies than the uniform pricing policy.

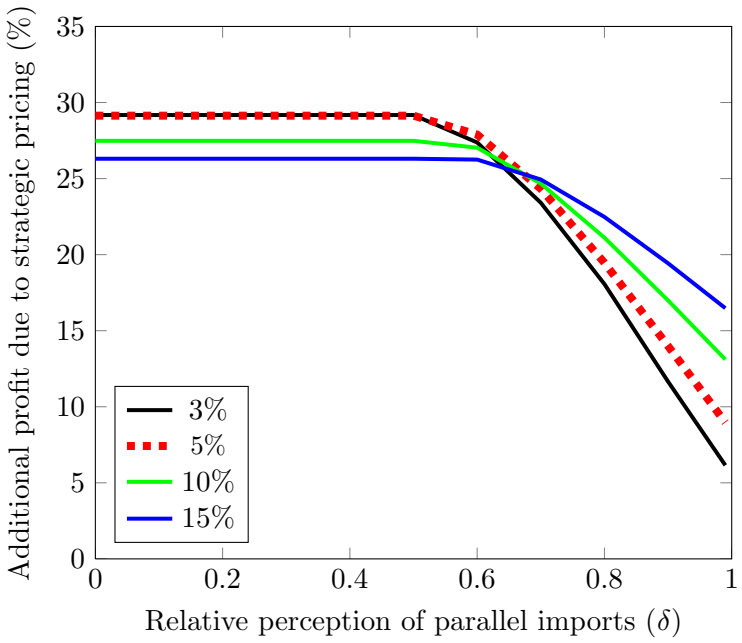

Figure 4: The value of strategic price and service policy

4 Service Control in Decentralized Supply Chain

In our analysis thus far, we have assumed that the manufacturer operates a centralized supply chain. In this section, we study the effects of service control on the competition between the manufacturer and the parallel importer when the manufacturer's distribution channel is decentralized. Service control refers to whether the manufacturer controls service herself or delegates service to her authorized retailer. For simplicity, we focus on the supply chain structure in market 2 where the manufacturer and the parallel importer compete. We assume the manufacturer sells through a retailer in market 2 and sells directly in market 1. To analyze service control, we study two decentralized models: (1) Retailer service (Model R) and (2) Manufacturer service (Model M). In both models, the manufacturer charges the retailer wholesale price ω and the retailer determines the retail price p_2. Service in market 2 is decided by the manufacturer in model M and by the retailer in model R. The sequence of events for both models is described in Figure 5. We assume the retailer's service cost parameter is equal to λ_2. This allows us to control for the effect of service cost efficiency and focus our analysis on the effect of service control decision. The optimal decisions of models R and M are denoted by superscripts R and M, and are provided in the appendix.

Retailer service (Model R): We first analyze the scenario in which the retailer controls service. Since service control by the retailer does not impact the segmentation of market 2,

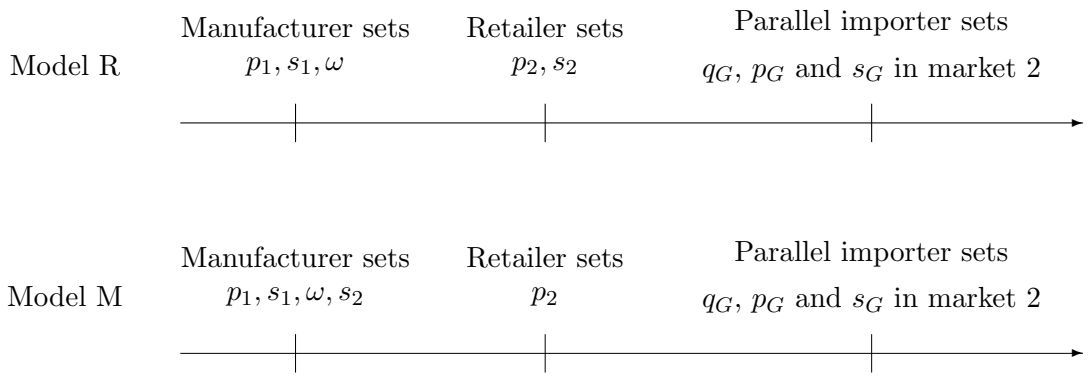

Figure 5: Sequence of events for models R and M

the parallel importer's optimal decisions have the same functional form as (5). Following backward induction, in stage 2 the retailer solves

$$\max_{p_2,s_2} \quad \pi_r = (p_2 - \omega)\left(d_2(p_2, s_2) - \delta q_G(p_1, p_2, s_2)\right) - \lambda_2 \frac{s_2^2}{2}.$$

Taking the retailer's best response into account, in stage 1 the manufacturer solves

$$\max_{\omega,p_1,s_1} \pi_m = (p_1 - c)\left(d_1(p_1, s_1) + q_G(p_1, p_2, s_2)\right) + (\omega - c)\left(d_2(p_2, s_2) - \delta q_G(p_1, p_2, s_2)\right) - \lambda_1 \frac{s_1^2}{2}.$$

Manufacturer service (Model M): We now assume the manufacturer retains control of service in market 2. Thus, the retailer only determines p_2 in stage 2 as follows:

$$\max_{p_2} \quad \pi_r = (p_2 - \omega)\left(d_2(p_2, s_2) - \delta q_G(p_1, p_2, s_2)\right).$$

Taking into account the retailer's reaction, in stage 1 the manufacturer solves

$$\max_{\omega,p_1,s_1,s_2} \pi_m = (p_1 - c)\left(d_1(p_1, s_1) + q_G(p_1, p_2, s_2)\right) + (\omega - c)\left(d_2(p_2, s_2) - \delta q_G(p_1, p_2, s_2)\right) - \sum_{i=1}^{2} \lambda_i \frac{s_i^2}{2}.$$

The next proposition compares the decentralized models with the centralized supply chain.

Proposition 5 *The decentralized models compare to the centralized model as follows: (a)*

The amount of service provided in market 2 in the decentralized models decreases by at least 50%. More specifically, $s_2^R/s_2^* = 0.5$ *and* $s_2^M/s_2^* < 0.5$.

(b) The sales volume and profit of the parallel importer are higher when the supply chain is decentralized.

The amount of service provided by the decentralized supply chains is at most 50% of the amount of service provided in the centralized supply chain. The double marginalization phenomenon in the wholesale price contract, caused by the self–optimizing behavior of the supply chain members, increases the purchasing cost of the product for the retailer and forces him to reduce the investment in service. The inefficiency due to double marginalization also results in the manufacturer providing less service in Model M. The sharp reduction in the amount of service provides an opportunity for the parallel importer to attract more customers; therefore, parallel importer's sales volume and profit go up in both models.

4.1 Decentralized Models Comparison

We now compare the two decentralized models to better understand the effects of the service control decision.

Proposition 6 *(a) The wholesale price is lower in Model R than in Model M.*

(b) The amount of service in market 2 is higher in Model R than in Model M.

(c) The volume of parallel imports is lower in Model R than in Model M.

Part (a) of the proposition indicates that the manufacturer charges the retailer a lower wholesale price when the retailer is in charge of service compared to when the manufacturer herself controls service. The reason is that when the cost of service is borne by the manufacturer, she is compelled to increase her wholesale price to recover the cost of service. Delegating service to the retailer reduces the manufacturer's cost and softens double marginalization.

Part (b) of the proposition shows that the amount of service provided by the retailer in Model R is higher than the amount of service provided by the manufacturer in Model M. This is because the retailer pays a lower wholesale price when he is in charge of service; therefore, he can afford to increase his investment in service. The increase in the amount of service induces more consumers to buy the product from the authorized channel in Model R. Consequently, the volume of parallel imports is lower when the retailer is in charge of service as stated in part (c).

Proposition 7 *Both the manufacturer and the retailer are better off when service is controlled by the retailer. This statement continues to hold as long as the retailer's service cost coefficient is below a threshold* $\overline{\lambda}$*, where* $\lambda_2 < \overline{\lambda} < 2\lambda_2$*.*

Proposition 7 describes an interesting result. When the manufacturer sells her product through a retailer, delegating the service decision to the retailer benefits *both* the manufacturer and the retailer. The driver of this result is the finding in part (a) of Proposition 6 that the manufacturer charges the retailer a lower wholesale price when the cost of service is borne by the retailer. The lower wholesale price alleviates double marginalization and incentivizes the retailer to provide more service. The increase in the amount of service enhances authorized channel demand and reduces the competition from the parallel importer. Thus, the savings from a higher market share and a lower wholesale price outweigh the cost of providing more service and increase the retailer's profit. Higher market share for the authorized channel also outweighs the reduction in the wholesale price for the manufacturer and increases her profit. Therefore, allowing the retailer to manage service results in a win–win situation. Moreover, *even if* the retailer is somewhat less efficient than the manufacturer in providing service, service control by the retailer continues to benefit both members of the supply chain as long as it is not excessively more costly for the retailer to provide service. Using various parameter values in our numerical experiments, we observed an average profit increase of 6% for the manufacturer and 13% for the retailer as a result of delegating service to the retailer. This result is valuable to managers of global companies that distribute their products through authorized retailers and face parallel importation; such companies should delegate the service decision to their retailers. This strategy will be welcomed by retailers because it creates a win-win outcome.

5 Conclusion

Service can function as a pivotal non–price mechanism in managing the competition from gray markets. In this paper, we used a Stackelberg game model to capture the price and service competition between a manufacturer and a parallel importer. We found that the emergence of the gray market forces the manufacturer to increase the level of service in both high-price and low-price markets.

We then explored the value of service for coping with the gray market and found that even a little service can help the manufacturer a great deal. In fact, when consumers perceive the authorized channel and the gray market channel almost equally, service helps the manufacturer differentiate herself from the parallel importer. In addition, we investigated

the combined effects of service responsiveness in the high price market and the degree of competition between the authorized and gray market channel on the manufacturer's policy. We observed that the manufacturer is better off allowing parallel importation when the level of competition is moderately high. Moreover, investing in demand enhancing services helps the manufacturer to implement her ideal price discrimination policy more easily. We also compared our strategic decision–making policy with the uniform pricing policy that some companies have adopted in practice to eliminate parallel importation completely. We observed that making price and service decisions strategically is significantly more valuable than using the myopic uniform pricing policy. Even though the uniform pricing policy may be easier to implement, it is important that companies use a more sophisticated policy for controlling parallel importation.

We also investigated the effects of service control when the manufacturer sells her product through a retailer in the high price market. We found that delegating service to the retailer alleviates double marginalization and can result in a win-win situation in which the profits of both the manufacturer and the retailer go up, even if the retailer is not more efficient than the manufacturer.

Our research can be extended in several directions. We assumed that manufacturer's services only benefit authorized channel customers. Nevertheless, some services, such as advertising and in–store demonstration, may inevitably increase the demand of the gray market channel as well. Our experiments indicated that when the parallel importer can freeride on some services, the authorized channel reduces the price gap further to protect its market share. Due to limited space, we did not present those experiments. An interesting extension would be to consider multiple authorized retailers that compete on price and service. Another extension might be to incorporate demand uncertainty. Finally, our analysis of decentralized scenarios takes into account only the wholesale price contract. The effects of other types of contracts on competition merits further consideration. We leave these directions for future research.

References

Ahmadi, R., B. R. Yang. 2000. Parallel imports: Challenges from unauthorized distribution channels. *Marketing Sci.* **19**(3) 279–294.

Ahmadi, R., F. Iravani, H. Mamani. 2015. Coping with gray markets: The impacts of market conditions and production characteristics. *Production & Operations Management.* **24**(5) 762–777.

Altug, M. 2014. Opportunity or threat? The impact of domestic gray markets on supply chains. *working paper.*

Antia, K. D., S. Dutta, M. Bergen. 2004. Competing with gray markets. *Sloan Management Review.* **46**(1) 63-69.

Autrey, R., F. Bova, D. A. Soberman. 2014. Organizational structure and gray markets. *Marketing Sci.* **33**(6) 849–870.

Autrey, R., F. Bova, D. A. Soberman. 2015. When gray is good: Complementary goods and emerging markets. *Production & Operations Management.* **24**(4) 547–559.

Bangkok Post. 2011a. Benz cutting prices to foil grey market. Retrieved July 25, 2014, `http://www.bangkokpost.com/auto/autoscoop/255693/benz-cutting-prices-to-foil-grey-market`

Bangkok Post. 2011b. Mercedes-Benz to defend market share from direct imports. Retrieved July 25, 2014, `http://www.bangkokpost.com/business/marketing/256095/mercedes-benz-to-defend-market-share-from-direct-imports`

Bloomberg. 2009. Losing $63 billion to gray market is sleuth obsession. Retrieved August 20, 2013, `http://www.bloomberg.com`

Bucklin, L. P. 1993. Modeling the international gray market for public policy decisions. *International Journal of Research in Marketing*. **10** 387-405.

Cachon, G. P., M. Lariviere. 2005. Supply chain coordination with revenue-sharing contracts: Strengths and limitations. *Management Science*. **51**(1) 30–44.

Chen, H. 2002. Gray marketing and unfair competition. *Atlantic Economic J.* **30**(2) 196–204.

Chen, H. 2009. Gray marketing: Does it hurt the manufacturers? *Atlantic Economic Journal*. **37**(1) 23–35.

Chiang, W. K., D. Chhajed, J. D. Hess. 2003. Direct marketing, indirect profits: A strategic analysis of dual-channel supply-chain design. *Management Science*. **49**(1) 1–20.

Dasu, S., R. Ahmadi, S. Carr. 2012. Gray markets: A product of demand uncertainty and excess inventory. *Production & Operations Management.* **21**(6) 1102–1113.

Dutta, S., M. Bergen, G. John. 1994. The governance of exclusive territories when dealers can bootleg. *Marketing Science*. **13**(1) 83–99.

Gallini, N. T., A. Hollis. 1999. A contractual approach to the gray market. *International Review of Law and Economics*. **19**(1) 1–21.

Galstian. A. G. 2000. Protecting against the gray market in the new economy, Retrieved August 25, 2014, http://digitalcommons.lmu.edu/cgi/viewcontent.cgi?article=1503&context=ilr.

Gara, A. 2013. Best Buy's new life after takeover trauma. Retrieved August 20, 2013, http://www.thestreet.com/story/11888542/1/best-buys-new-life-after-takeover-trauma.html?cm_ven=forbeslinks.

Harman, A. 2010. BMW Thailand to No Longer Service Gray-Market Vehicles. *WardsAuto*. Retrieved July 25, 2014, http://wardsauto.com/news-amp-analysis/bmw-thailand-no-longer-service-gray-market-vehicles

Huang, J., B. C.Y. Lee., S. H. Ho. 2004. Consumer attitude toward gray market goods. *International Marketing Review*. **21**(6) 598–614.

Hu, M., M. Pavlin, M. Shi. 2013. When gray markets have silver linings: All-unit discounts, gray markets and channel management. *Manufacturing & Serv. Oper. Management*, **15**(2) 250–262.

Iyer, G. 1998. Coordinating channels under price and nonprice competition. *Marketing Sci.* **17**(4) 338–355.

Jin, Y., S. Wang, Q Hu. 2015. Contract type and decision right of sales promotion in supply chain management with a capital constrained retailer. *Eur. J. of Oper. Research*. **240**(2) 415–424.

KPMG. 2008. Effective channel management is critical in combating the gray-market and increasing technology companies bottom line. Retrieved January 17, 2015, http://www.agmaglobal.org/.

Krause, N. 2012. Red Sheds go big on parallel importing. *Stuff.co.nz*. Retrieved July 25, 2014, http://www.stuff.co.nz/business/industries/6943051/Red-Sheds-go-big-on-parallel-importing.

Krishnan, H., R. Kapuscinski, D. A. Butz. 2004. Coordinating contracts for decentralized supply chains with retailer promotional effort. *Management Science*. **50**(1) 48–63.

Kumar, C. N. S., S. A. B. Sailesh. 2011. Leveraging after-sales service to gain competitive advantage. Retrieved July 25, 2014, http://www.infosys.com/supply-chain/white-papers/Documents/leveraging-after-sales.pdf

Maskus, K. E. 2000. Parallel imports. *World Economy*. **23**(9) 1269-1284.

Myers, M. B. 1999. Incidents of gray market activity among U.S. exporters: Occurrences, characteristics, and consequences. *Journal of International Business Studies*. **30**(1) 105–126.

Ocampo, J. 2003. Beating the gray. *The Phillipine Star*. Retrieved July 25, 2014, `http://www.philstar.com/motoring/195990/beating-gray`.

Quinn, M. 2013. Teach customers why they need a product before trying to sell it to them. *Business Insider*. Retrieved July 25, 2014, `http://www.businessinsider.com/how-brands-can-educate-customers-2013-4`.

Schonfeld, M. 2010. Fighting grey goods with trade mark law. *Managing Intellectual Prop.* Retrieved April 14, 2013, `http://www.agmaglobal.org/press_events/fight_grey_goods.pdf`

Su X., S. K. Mukhopadhyay. 2011. Controlling power retailer's gray activities through contract design. *Production & Operations Management.* **21**(1) 145–160.

Thompson, S. 2009. Gray power: An empirical investigation of the impact of parallel imports on market prices. *J. Ind. Compet. Trade.* **9**(3) 219–232.

Taylor, T. A. 2002. Supply chain coordination under channel rebates with sales effort effects. *Management Science*. **48**(8) 992–1007.

Tsay, A. A., N. Agrawal. 2004. Channel conflict and coordination in the E-commerce age. *Production & Operations Management*. **13**(1) 93–110.

Tsay, A. A., N. Agrawal. 2000. Channel dynamics under price and service competition. *Manufacturing & Serv. Oper. Management*. **2**(4) 372–391.

Winter, R. 1993. Vertical control and price versus non-price competition. *Quarterly J. Econom.* **108**(1) 61–67.

Xia, Y., S. M. Gilbert. 2007. Strategic interactions between channel structure and demand enhancing services. *Eur. J. of Oper. Research*. **181**(1) 252–265.

Xiao, Y., U. Palekar, Y. Liu. 2011. Shades of gray – the impact of gray markets on authorized distribution channels. *Quantitative Marketing and Economics.* **9** 155–178.

Appendix

For ease of exposition, we define $\rho_1 = (2-\delta)\lambda_G b_2 - \delta\theta_G^2$ and $\rho_2 = 2(1-\delta)\lambda_G b_2 - \delta\theta_G^2$.

Optimal Decisions For the Centralized Model. Define

$$s_1^* = \frac{\delta\left(N_1 - b_1 c\right)\rho_1 + \lambda_G b_2(\delta N_2 - b_2 c - b_2 c_G)}{\delta\left(2\lambda_1 b_1 - \theta_1^2\right)\rho_1 + 2\lambda_1\lambda_G b_2^2}\theta_1, \tag{7}$$

$$s_2^* = \frac{\left(N_2 - b_2 c\right)\rho_1 - \lambda_G b_2(\delta N_2 - b_2 c - b_2 c_G)}{2\lambda_2 b_2\rho_2 - \rho_1\theta_2^2}\theta_2, \tag{8}$$

$$p_1^* = c + \lambda_1\frac{s_1^*}{\theta_1}, \quad p_2^* = c + \frac{1}{\rho_1}\left(\frac{\lambda_G b_2\lambda_1 s_1^*}{\theta_1} + \rho_2\frac{\lambda_2 s_2^*}{\theta_2}\right) \tag{9}$$

$$q_G^* = \frac{\lambda_G b_2}{\rho_1}\left[\frac{\delta N_2 - b_2(c + c_G)}{\delta} - \frac{\lambda_1 b_2 s_1^*}{\delta\theta_1} - \frac{\lambda_2 b_2 s_2^*}{\theta_2}\right]. \tag{10}$$

If $q_G^* > 0$ and $s_2^* > 0$, then the manufacturer allows parallel importation. Otherwise, the manufacturer blocks parallel importation. If $q_G^* < 0$, then the solution to the game is obtained by solving (1) subject to $b_2(\delta p_2 - p_1 - c_G) = \delta\theta_2 s_2$, which leads to the following price and service decisions

$$\begin{aligned}
p_1^* &= \frac{\delta^2\lambda_2 b_2\left[\lambda_1 N_1 + \left(\lambda_1 b_1 - \theta_1^2\right)c\right] - \lambda_1 b_2\left(2\lambda_2 b_2 - \theta_2^2\right)c_G}{b_2\gamma_2} + \frac{\delta\lambda_1\left[\left(\lambda_2 b_2 - \theta_2^2\right)N_2 + \lambda_2 b_2^2 c\right]}{b_2\gamma_2},\\
p_2^* &= \frac{\delta^2\theta_2^2\left(2\lambda_1 b_1 - \theta_1^2\right)N_2 + \delta b_2\left(\lambda_2 b_2 - \theta_2^2\right)\gamma_1 + \lambda_1 b_2^2\left[\lambda_2 N_2 + \left(\lambda_2 b_2 - \theta_2^2\right)c\right]}{b_2^2\gamma_2},\\
s_1^* &= \frac{\delta^2\lambda_2 b_2\left(N_1 - b_1 c\right) + \delta\left[\left(\lambda_2 b_2 - \theta_2^2\right)N_2 + \lambda_2 b_2^2 c\right] - b_2\left(2\lambda_2 b_2 - \theta_2^2\right)(c + c_G)}{b_2\gamma_2}\theta_1,\\
s_2^* &= \frac{-\delta^2 N_2\left(2\lambda_1 b_1 - \theta_1^2\right) + \delta b_2\gamma_1 - \lambda_1 b_2(N_2 - b_2 c)}{b_2\gamma_2}\theta_2,
\end{aligned} \tag{11}$$

where $\gamma_1 = \lambda_1 N_1 + (\lambda_1 b_1 - \theta_1^2)c + (2\lambda_1 b_1 - \theta_1^2)\,c_G$ and $\gamma_2 = \lambda_1\left(2\lambda_2 b_2 - \theta_2^2\right) + \lambda_2\delta^2\left(2\lambda_1 b_1 - \theta_1^2\right)$.

Parameter Values for Numerical Experiments. For the numerical experiments, we used the following common parameter values: $N_1 = N_2 = 10,000$, $b_1 = 24$, $b_2 = 10$, $c = 100$, $c_G = 5$, $\theta_G = 3$ and $\lambda_G = 36$. For the manufacturer's service parameters we used four sets of values: (1) $\theta_1 = 3$, $\theta_2 = 4$, $\lambda_1 = 12$, $\lambda_2 = 24$; (2) $\theta_1 = 4$, $\theta_2 = 5$, $\lambda_1 = 10$, $\lambda_2 = 24$; (3) $\theta_1 = 4$, $\theta_2 = 6$, $\lambda_1 = 10$, $\lambda_2 = 17$; and (4) $\theta_1 = 5$, $\theta_2 = 7$, $\lambda_1 = 12$, $\lambda_2 = 16$. When there are no parallel imports, these service parameters correspond to 3%, 5%, 10%, and 15% higher profits for the manufacturer due to investing in service. We identified the pattern in Figure 3 by increasing the values of δ and θ_2 incrementally, while holding the other parameter values constant.

Optimal Decisions For Model R. When manufacturer is the leader and the retailer

controls service, the manufacturer charges the following wholesale price

$$\omega^R = \frac{1}{\rho_1}\left[\frac{\lambda_G b_2\left[(2N_2+b_2c)(1-\delta)+b_2(2c+c_G)\right]-\delta(N_2+b_2c)\theta_G^2}{2b_2}+\frac{\lambda_G b_2\lambda_1 s_1^R}{\theta_1}\right],$$

and the price of the product and the level of retailer's service in market 2 will be

$$\begin{aligned}
s_2^R &= \frac{(N_2-b_2c)\,\rho_1-\lambda_G b_2(\delta N_2-b_2c-b_2c_G)}{2\left(2\lambda_2 b_2\rho_2-\rho_1\theta_2^2\right)}\theta_2,\\
p_2^R &= \frac{(3N_2+b_2c)\rho_2+\lambda_G b_2^2\left[(3+\delta)c+3c_G\right]}{4b_2\rho_1}+\frac{\lambda_G b_2\lambda_1 s_1^R}{\theta_1\rho_1}+\frac{\theta_2 s_2^R}{2b_2},
\end{aligned}$$

where s_1^R is equal to (7) and $p_1^R = c+\lambda_1\frac{s_1^R}{\theta_1}$. The volume of parallel imports will be

$$q_G^R = \frac{\lambda_G b_2}{\rho_1}\left[\frac{\delta N_2-b_2(c+c_G)}{\delta}-\frac{\lambda_1 b_2 s_1^R}{\delta\theta_1}-\frac{\lambda_2 b_2 s_2^R}{\theta_2}\right].$$

Optimal Decisions For Model M. When the manufacturer is the leader and controls service, the optimal decisions are

$$\begin{aligned}
s_2^M &= \frac{(N_2-b_2c)\,\rho_1-\lambda_G b_2(\delta N_2-b_2c-b_2c_G)}{4\lambda_2 b_2\rho_2-\rho_1\theta_2^2}\theta_2,\\
\omega^M &= \frac{1}{\rho_1}\left[\frac{\lambda_G b_2\left[(2N_2+b_2c)(1-\delta)+b_2(2c+c_G)\right]-\delta(N_2+b_2c)\theta_G^2}{2b_2}+\frac{\lambda_G b_2\lambda_1 s_1^M}{\theta_1}\right]+\frac{\theta_2 s_2^M}{2b_2},\\
p_2^M &= c+\left(\frac{3}{4}\right)\frac{\lambda_G b_2\left[(2N_2-b_2c)(1-\delta)+b_2c_G\right]-\delta(N_2-b_2c)\theta_G^2}{b_2\rho_1}+\frac{\lambda_G b_2\lambda_1 s_1^M}{\theta_1\rho_1}+\frac{3\theta_2 s_2^M}{4b_2},\\
q_G^M &= \frac{\lambda_G b_2}{\rho_1}\left[\frac{\delta N_2-b_2(c+c_G)}{\delta}-\frac{\lambda_1 b_2 s_1^M}{\delta\theta_1}-\frac{\lambda_2 b_2 s_2^M}{\theta_2}\right].
\end{aligned}$$

where s_1^M is equal to (7) and $p_1^M = c+\lambda_1\frac{s_1^M}{\theta_1}$.

Proof of Proposition 1. Suppose the optimal policy is to allow parallel importation. To prove $p_2^* < p_2^n$, we note that q_G^* is increasing in b_1 whereas $\Delta p_2 = p_2^* - p_2^n$ is decreasing in b_1. Let $\widehat{b}_1$ be the value of b_1 for which $\Delta p_2 = 0$ and $\overline{b}_1$ be the value of b_1 for which $q_G^* = 0$. Then

after some algebra, we can show that

$$q_G^*\left(\widehat{b}_1\right) = -\frac{2\lambda_G b_2\left(\lambda_2 b_2 - \theta_2^2\right)\left[\lambda_2\left(c\left(1-\delta\right)+c_G\right)b_2^2 + \frac{1}{2}\theta_2^2\left(\delta N_2 - b_2\left(c+c_G\right)\right)\right]}{\delta\left(2\lambda_2 b_2 - \theta_2^2\right)\left(2\lambda_2 b_2\rho_2 - \rho_1\theta_2^2\right)},$$
$$\Delta p_2\left(\overline{b}_1\right) = \frac{\delta}{b_2} q_G^*\left(\widehat{b}_1\right).$$

Because of Assumption 1 and Proposition 2, $q_G^*\left(\widehat{b}_1\right)$ and $\Delta p_2\left(\overline{b}_1\right)$ are negative. This means that the smallest b_1 that makes q_G^* positive makes Δp_2 negative. Therefore $p_2^* < p_2^n$ holds for all solutions that allow parallel importation. For service in market 2, we have

$$s_2^* - s_2^n = \frac{\lambda_G b_2\left[2\lambda_2 b_2^2(b_2 c_G + b_2 c\left(1-\delta\right)) + \theta_2^2\left(\delta N_2 - b_2 c - b_2 c_G\right)\right]}{\left(2\lambda_2 b_2\rho_2 - \rho_1\theta_2^2\right)\left(2\lambda_2 b_2 - \theta_2^2\right)}\theta_2 > 0.$$

For service in market 1,

$$s_1^* - s_1^n = \frac{\lambda_G b_2\left[\left(2\lambda_1 b_1 - \theta_1^2\right)\left(\delta N_2 - b_2(c+c_G)\right) - 2\lambda_1 b_2\left(N_1 - b_1 c\right)\right]}{\left[\delta\left(2\lambda_1 b_1 - \theta_1^2\right)\rho_1 + 2\lambda_1\lambda_G b_2^2\right]\left(2\lambda b_1 - \theta_1^2\right)}\theta_1.$$

If $s_1^* - s_1^n \leq 0$, then we will have

$$\theta_1^2 \geq 2\lambda_1 b_1 - \frac{2\lambda_1 b_2\left(N_1 - b_1 c\right)}{\delta N_2 - b_2 c - b_2 c_G},$$

which contradicts with part (b) of Proposition 2. Thus, $s_1^* > s_1^n$. Finally, because $p_1^* = c + \lambda_1\frac{s_1^*}{\theta_1}$ and $p_1^n = c + \lambda_1\frac{s_1^n}{\theta_1}$, $s_1^* > s_1^n$ implies $p_1^* > p_1^n$.

Now suppose the optimal policy is to block parallel importation. Then there exists a positive Lagrangian multiplier $\mu > 0$ such that $(p_1^*, s_1^*, p_2^*, s_2^*)$ in (11) and μ satisfy the following optimality conditions

$$\begin{aligned}
N_1 - 2b_1 p_1 + c b_1 + \theta_1 s_1 + b_2\mu &= 0,\\
N_2 - 2b_2 p_2 + c b_2 + \theta_2 s_2 - \delta b_2\mu &= 0,\\
(p_1 - c)\theta_1 - \lambda_1 s_1 &= 0,\\
(p_2 - c)\theta_2 - \lambda_2 s_2 + \delta\theta_2\mu &= 0.
\end{aligned}$$

Because $(p_1^n, s_1^n, p_2^n, s_2^n)$ satisfy the above equations when $\mu = 0$, by replacing the solution for s_1 from the third equation in the first equation and using Assumption 1, we conclude that $p_1^* > p_1^n$ which means $s_1^* > s_1^n$. Next, we find s_2 in the fourth equation and replace it in the

second equation and use Assumption 1 and $\theta_2 < \sqrt{\lambda_2 b_2}$ to conclude that $p_2^* < p_2^n$. Finally, if we equate the solution for μ in the second and fourth equations, we get $s_2 = \frac{N_2 - b_2 p_2}{\lambda_2 b_2 - \theta_2^2}\theta_2$. Because $s_2^n = \frac{N_2 - b_2 p_2^n}{\lambda_2 b_2 - \theta_2^2}\theta_2$ and we showed that $p_2^* < p_2^n$, s_2^* is larger than s_2^n.

Proof of Proposition 2. For part (a), we have

$$\frac{d}{d\delta}s_1^* = \frac{-\lambda_G b_2 \zeta}{\left[\delta\left(2\lambda b_1 - \theta^2\right)\rho_1 + 2\lambda\lambda_G b_2^2\right]^2}\theta_1 > 0,$$
$$\frac{d}{d\delta}s_2^* = \frac{(2\lambda_2 b_2 - \theta_2^2)(c + c_G)\theta_G^2 + \lambda_G\left[(2N_2 - b_2 c)\theta_2^2 + (4\lambda_2 b_2 - \theta_2^2)b_2 c_G\right]}{\left(2\lambda b_2 \rho_2 - \rho_1 \theta_2^2\right)^2}(\lambda_G b_2^2 \theta_2) > 0,$$

where $\zeta = -\delta(\lambda_G b_2 + \theta_G^2)[(2\lambda_1 b_1 - \theta_1^2)(\delta N_2 - b_2(c + c_G)) - 2\lambda_1 b_2(N_1 - b_1 c)] - b_2\rho_1[(2\lambda_1 b_1 - \theta_1^2)c_G + 2\lambda_1 N_1 - c\theta_1^2] - 2\lambda_1\lambda_G b_2^2 N_2$. We have $\zeta < 0$ because $(2\lambda_1 b_1 - \theta_1^2)(\delta N_2 - b_2(c + c_G)) - 2\lambda_1 b_2(N_1 - b_1 c) > 0$ due to the necessary condition for θ_1 in Proposition 2, and $2\lambda_1 N_1 - c\theta_1^2 > 0$ due to Assumption 1.

To derive the conditions in part (b), we first note that $q_G^* > 0$ requires $\delta p_2^* > p_1^*$. From equations (9) we have

$$\delta p_2^* - p_1^* = \frac{\rho_2}{\rho_1}\left(\frac{\delta\lambda_2 s_2^*}{\theta_2} - \frac{\lambda_1 s_1^*}{\theta_1}\right) - (1 - \delta).$$

Thus, $\delta p_2^* - p_1^* > 0 \Longrightarrow \frac{\delta\lambda_2 s_2^*}{\theta_2} - \frac{\lambda_1 s_1^*}{\theta_1} > 0$, which gives us

$$0 < q_G^* < \frac{\lambda_G b_2}{\rho_1}\left[\frac{\delta N_2 - b_2(c + c_G)}{\delta} - \frac{2\lambda_1 b_2 s_1^*}{\delta\theta_1}\right] \Longrightarrow \theta_1 < \sqrt{2\lambda_1 b_1 - \frac{2\lambda_1 b_2(N_1 - b_1 c)}{\delta N_2 - b_2 c - b_2 c_G}} \equiv \widetilde{\theta}_1$$

For the third condition, $\widetilde{\theta}_2 \equiv \sqrt{\min\left\{\lambda_2 b_2, 2\lambda_2 b_2 \frac{\rho_2}{\rho_1}\right\}}$. Define $R(\theta_2) = b_2\left(\delta p_2^n - p_1^n - c_G\right) - \delta\theta_2 s_2^n$. Then $\frac{d}{d\theta_2}R(\theta_2) = \frac{-2\lambda_2 b_2\theta_2(N_2 - cb_2)\delta}{(2\lambda b_2 - \theta_2^2)^2} < 0$ and $R\left(\sqrt{\lambda_2 b_2}, \delta\right) = -b_2\left(\delta c - p_1^n - c_G\right) < 0$. Therefore, if $\theta_2 \geq \sqrt{\lambda_2 b_2}$, then the optimal prices and service in the absence of parallel importation automatically eliminate the gray market. The second term in $\widetilde{\theta}_2$ ensures that s_2^* is positive and bounded.

Proof of Proposition 3. We define a special case of (6) when the manufacturer does not invest in demand-enhancing services and only reacts to the parallel importer with prices as follows

$$\max_{p_1, p_2}\ \pi_m = (p_1 - c)\left(N_1 - b_1 p_1 + q_G(p_1, p_2)\right) + (p_2 - c)\left(N_2 - b_2 p_2 - \delta q_G(p_1, p_2)\right), \qquad (12)$$

where $q_G(p_1, p_2) = \max\{0, \frac{b_2(\delta p_2 - p_1 - c_G)}{2\delta(1-\delta)}\}$ is the volume of parallel imports when no service is offered (equivalently, $\theta_2 = \theta_G = 0$). Let $\widehat{p_1}$ and $\widehat{p_2}$ be the optimal solutions to (12). If the optimal policy is to allow parallel importation, the result follows because p_1^* and p_2^* are convex and increasing in θ_1 and θ_2 and reduce to $\widehat{p_1}$ and $\widehat{p_2}$ when $\theta_1 = \theta_2 = 0$. For the block policy, if s_1 and s_2 are exogenously determined, then the optimality equations reduce to the equations for $\widehat{p_1}$ and $\widehat{p_2}$ with N_1 replaced with $N_1 + \theta_1 s_1$ and N_2 replaced with $N_2 + \theta_2 s_2$, which are increasing in N_1 and N_2. Therefore, when service variables are optimized, p_1^* and p_2^* must be larger than $\widehat{p_1}$ and $\widehat{p_2}$.

Proof of Proposition 4. Part (a) follows from s_2^*/θ_2 being increasing in θ_2. The details are omitted.

Proof of Proposition 5. For part (a), we have For part (a), we have $\frac{s_2^R}{s_2^*} = \frac{2\lambda_2 b_2 \rho_2 - \rho_1 \theta_2^2}{2(2\lambda_2 b_2 \rho_2 - \rho_1 \theta_2^2)} = \frac{1}{2}$ and $\frac{s_2^M}{s_2^*} = \frac{2\lambda_2 b_2 \rho_2 - \rho_1 \theta_2^2}{4\lambda_2 b_2 \rho_2 - \rho_1 \theta_2^2} < \frac{1}{2}$. For part (b), we have $q_G^R - q_G^* = \frac{\lambda_G \lambda_2 b_2^2}{\rho_1 \theta_2} \left(s_2^* - s_2^R\right)$ and $q_G^M - q_G^* = \frac{\lambda_G \lambda_2 b_2^2}{\rho_1 \theta_2} \left(s_2^* - s_2^M\right)$ which are positive because $s_2^R < s_2^*$ and $s_2^M < s_2^*$. Because the profit of the parallel importer is an increasing function of its sales volume, his profit in both decentralized models is higher than his profit in the centralized model.

Proof of Proposition 6. The inequalities are obtained via the optimal solutions for each of the four scenarios. We omit the details.

Proof of Proposition 7. The critical value $\overline{\lambda}$ is obtained from comparing the profits of the manufacturer and the retailer in Model R with those in Model M. The details are omitted. Note that due to part (c) of Proposition 2, the denominator of $\overline{\lambda}$ is positive and $\overline{\lambda} < 2\lambda_2$.