Manufacturing & Service Operations Management

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Combating Strategic Counterfeiters in Licit and Illicit Supply Chains

Soo-Haeng Cho, Xin Fang, Sridhar Tayur

To cite this article:
Soo-Haeng Cho, Xin Fang, Sridhar Tayur (2015) Combating Strategic Counterfeiters in Licit and Illicit Supply Chains. Manufacturing & Service Operations Management 17(3):273-289. http://dx.doi.org/10.1287/msom.2015.0524

M&SOM MANUFACTURING & SERVICE OPERATIONS MANAGEMENT
Vol. 17, No. 3, Summer 2015, pp. 273–289
ISSN 1523-4614 (print) | ISSN 1526-5498 (online)

informs

http://dx.doi.org/10.1287/msom.2015.0524

Combating Strategic Counterfeiters in Licit and Illicit Supply Chains

Soo-Haeng Cho
Tepper School of Business, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213, soohaeng@andrew.cmu.edu

Xin Fang
Lee Kong Chian School of Business, Singapore Management University, Singapore 178899, xfang@smu.edu.sg

Sridhar Tayur
Tepper School of Business, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213, stayur@andrew.cmu.edu

Counterfeit goods are becoming more sophisticated, from shoes to infant milk powder to aircraft parts, creating problems for consumers, firms, and governments. By comparing two types of counterfeiters—deceptive, so infiltrating a licit (but complicit) distributor, or nondeceptive in an illicit channel—we provide insights into the impact of anticounterfeiting strategies on a brand-name company, a counterfeiter, and consumers. Our analysis highlights that the effectiveness of these strategies depends critically on whether a brand-name company faces a nondeceptive or deceptive counterfeiter. For example, by improving quality, the brand-name company can improve her expected profit against a nondeceptive counterfeiter when the counterfeiter steals an insignificant amount of brand value. However, the same strategy does not work well against the deceptive counterfeiter unless high quality facilitates the seizure of deceptive counterfeits significantly. Similarly, reducing price works well in combating the nondeceptive counterfeiter, but it could be ineffective against the deceptive counterfeiter. Moreover, the strategies that improve the profit of the brand-name company may benefit the counterfeiter inadvertently and even hurt consumer welfare. Therefore, firms and governments should carefully consider a trade-off among different objectives in implementing an anticounterfeiting strategy.

Keywords: game theory; global operations management; supply chain management
History: Received: May 3, 2012; accepted: December 17, 2014. Published online in *Articles in Advance* April 15, 2015.

1. Introduction

Trademarks, also called brands, represent the most valuable assets of many firms, requiring significant investment in research and development as well as years of efforts in maintaining high product quality and careful brand management. Famous global brands such as General Electric, Nike, and Nestlé are popular because they offer a guarantee of quality, which is vital to consumers when they make purchasing decisions. For those goods for which the mere display of a particular brand confers prestige on their owners, such as luxury watches and fashion apparel, many consumers purchase branded goods to demonstrate that they are consumers of the particular brand. These intrinsic values of trademarks create incentives for counterfeiting.

Nowadays counterfeits have developed into a substantial threat to many industries. The Organisation for Economic Co-operation and Development (OECD) estimates that international trade in counterfeits could amount to $250 billion, or 1.95% of world trade in 2007 (OECD 2009); if including domestically produced and consumed products, the total magnitude could be several hundred billion dollars more (OECD 2008). The International Chamber of Commerce expects the value of counterfeit goods globally to exceed $1.7 trillion by 2015 (Hargreaves 2012). The problem is no longer limited to prestigious and easy-to-manufacture products, such as designer clothing, branded sportswear, and fashion accessories. It affects nearly all product categories, including items that have an impact on personal health and safety such as pharmaceuticals, food, drink, toys, medical equipment, and automotive parts (OECD 2008).

Counterfeits are broadly categorized into two types: nondeceptive and deceptive (Grossman and Shapiro 1988a). A nondeceptive counterfeit is the counterfeit a consumer can distinguish from the brand-name product at the time of purchase. This type of counterfeits tends to be sold at a substantial discount through an unauthorized sales channel. For example, counterfeiters in the Chinese footwear industry used cheap materials to produce shoes and charged a small fraction of the authentic product's price to attract customers (Qian 2008). Consumers could easily tell that $10 Nike shoes sold by street vendors are counterfeits. In contrast, a deceptive counterfeit is the counterfeit

a consumer believes to be authentic at time of purchase even if it is, in fact, counterfeit. To deceive consumers, this type of counterfeit good has to infiltrate licit supply chains. A deceptive counterfeit is usually sold at the price that is the same as or close to that of its branded product so as to deceive consumers. Although it appears to function properly at the time of purchase, it lacks durability and often involves health and safety risks to consumers. Examples of deceptive counterfeits abound in both developing and developed countries. In Thailand, a Scotch whisky company suffered a significant loss due to counterfeit sales. Green and Smith (2002) report that the counterfeiters received the active cooperation of many of the licit supply chain members. The licit supply chain members were lured by the higher profits from selling counterfeits, which they could obtain for a fraction of the brand-name company's wholesale price, yet charge the same price to consumers. In the United States, a number of physicians and drug distributors have been prosecuted recently for the purchase or sale of non-Federal Drug Administration–approved cancer treatments including fake Avastin. Doctors generated more profits by purchasing the drugs at discounted price, while billing insurance, Medicare, and patients at the same price they would for legitimate treatments (Imber 2014).

To stop or at least to reduce the incidence of counterfeits, brand-name companies are spending millions of dollars. They hire full-time employees, invest in new technologies, and redesign their products to make counterfeiting more difficult. However, the anticounterfeiting strategies found to be useful to one product may not work for another or can even unintentionally make counterfeits flourish more in the market. For example, Chinese shoe manufacturers successfully addressed their counterfeiting issues by improving the quality of their products (Qian 2008). This is the outcome of the competition in which high-quality authentic products defeat low-quality nondeceptive counterfeits. However, the same strategy backfired against the Scotch whisky company mentioned above (Green and Smith 2002). At the peak of the company's sales in 1988, 42% of its premium Scotch whisky sales was stolen by deceptive counterfeits. High quality made the products more popular and attracted more counterfeits. After the initial attempt to combat counterfeits through quality improvement had failed, the company eventually succeeded in radically reducing the incidence of counterfeiting by establishing a system that monitors supply chains: the company focused on identifying members in its supply chain that were selling the counterfeits, facilitating seizure of counterfeits, and punishing counterfeiters.

These contrasting results illustrate a need for anticounterfeiting strategies that are tailored to specific products. Yet because of the limited understanding of relations between the types of counterfeits and the effectiveness of anticounterfeiting strategies, the OECD (2008, p. 21) calls for research that strengthens the analysis of counterfeiting and states, "Assessing the factors driving production and consumption of counterfeit and pirated products can generate insights into the types of products that are most likely to be infringed, . . . , and lead to more efficient and effective [anticounterfeiting] strategies."

This paper attempts to provide such an analysis by providing insights into the following questions: (1) What anticounterfeiting strategies should a brand-name company (referred to as "she") use to improve her own profit? (2) What is the impact of anticounterfeiting strategies on the profit of a counterfeiter? (3) What is the impact of counterfeits on consumer welfare? (4) Do consumers also benefit from the strategies that are effective in combating counterfeits?

To answer these questions, we develop a normative model of licit and illicit supply chains, in which a brand-name company competes with her potential counterfeiter. The counterfeiter (referred to as "he") in our model is either nondeceptive or deceptive, and decides the level of functional quality and wholesale price of his goods after observing the quality and price of the brand-name product. Depending on his type, the counterfeiter faces different opportunities and risks. The nondeceptive counterfeiter competes directly with a brand-name company for price and quality. Thus, the counterfeiter has to invest in improving the quality of his goods although large investment may not lead to any return if it is caught by the authorities. Conversely, the deceptive counterfeiter may not need to invest as much in improving the quality as the nondeceptive counterfeiter (as long as he can deceive consumers successfully at time of purchase), but he has to infiltrate a licit supply chain via a legitimate distributor who sources both brand-name and counterfeit products. The legitimate distributor then faces a trade-off between a greater profit margin and a risk of getting punished for selling counterfeits.

After finding the equilibrium decisions of the counterfeiter and the distributor, we evaluate the following anticounterfeiting strategies, of which the effectiveness depends on the subsequent reaction of the strategic counterfeiter: (i) quality strategy that alters the quality of brand-name products against a counterfeiter, (ii) pricing strategy that alters the price of brand-name products against a counterfeiter, (iii) marketing campaign that educates consumers about the dangers of counterfeits, (iv) enforcement

strategy that increases the chances to seize the production of counterfeits, and (v) technology strategy that makes the brand-name product more difficult to counterfeit. Our analysis highlights that the optimal strategy of the brand-name company differs depending on whether she faces the nondeceptive or deceptive counterfeiter. Although it is ideal to see the strategies that increase the profit of the brand-name company also reduce the profit of the counterfeiter and benefit consumers, our analysis shows that this is not the case for most strategies. It is therefore imperative for industries and governments to understand the type of potential counterfeiters and to carefully consider a trade-off among different objectives in implementing an anticounterfeiting strategy.

2. Literature Review

Traditional supply chain management research focuses on licit supply chains in which members interact by exchanging goods and services legally. In this era of globalization, supply chains are no longer confined within one country, as more and more companies offshore and outsource their operations to less developed countries. However, this has caused an ever-rising flood of counterfeit items coming into markets. This paper is intended to shed light on counterfeit problems in both licit and illicit supply chains and to analyze the effectiveness of anticounterfeiting strategies.

The majority of studies on counterfeiting are conceptual and descriptive. They provide frameworks for fighting counterfeiting, usually based on case studies (e.g., see Staake and Fleisch 2008 for an extensive review). Marketing researchers have conducted empirical studies on counterfeits. They mainly focus on the demand side of counterfeits and try to answer questions such as why consumers purchase counterfeits and how to educate consumers not to purchase counterfeits. Eisend and Schuchert-Guler (2006) review this literature and conclude that further investigation is needed to develop a general framework that integrates existing results consistently. Recently, using data from Chinese shoe companies, Qian (2008) finds that brand-name companies tend to improve their product quality after the entry of nondeceptive counterfeiters.

There are only a handful of analytical studies that present prescriptive models of counterfeits. Grossman and Shapiro (1988a, b) develop equilibrium models of trades between brand-name firms in a home country and low-quality producers in a foreign country. To sell their goods as counterfeits in the home market, foreign producers must pass the goods through the home-country border, hence facing the risk of confiscation. Grossman and Shapiro (1988a) analyze the consequences of deceptive counterfeits in a market where consumers cannot observe the quality of a product and provide a welfare analysis of border inspection policy. Grossman and Shapiro (1988b) also present a Cournot competition model between brand-name products and nondeceptive counterfeits, given their exogenous quality levels. Because nondeceptive counterfeits can contribute positively to consumer welfare as a result of their lower price, the authors conclude that policies that discourage foreign counterfeiting need not improve welfare, which is consistent with our finding. Scandizzo (2001) views competition between brand-name firms and nondeceptive counterfeiters as a patent race over time. Liu et al. (2005) study the decision of an inventory manager who can source both genuine and deceptive counterfeit products. Sun et al. (2010) study a global firm's decision of outsourcing the production of its components to a foreign country, in which the firm faces a trade-off between lower labor cost and increased risk of imitation by a foreign firm. Zhang et al. (2012) analyze the case when a brand-name firm faces nondeceptive counterfeits; they show that a nondeceptive counterfeit lowers the price and profit of the brand-name product, and a brand-name firm has more incentive to improve her own quality rather than reducing that of a counterfeit.

We draw on and contribute to this stream of research by addressing the following important issues in counterfeiting problems:

(1) Strategic counterfeiters: The common assumption used in the literature is that the quality is fixed a priori. Today, thanks to outsourcing and offshoring of numerous global firms, counterfeiters benefit greatly from increasingly easy access to modern production facilities (Staake and Fleisch 2008). Moreover, consumers also demand high quality from counterfeits (e.g., Nylander 2013). Because of this change in both supply and demand sides of the counterfeit market, Schmidle (2010) notes that today's counterfeiters come in varying levels of quality, depending on their intended markets. In our model, a counterfeiter decides the functional quality and wholesale price of his product by considering a trade-off between the benefit from stealing brand value and the risk of confiscation. Our analysis shows that the effectiveness of anticounterfeiting strategies depends critically on the strategic response of a counterfeiter to those strategies.

(2) Licit and illicit supply chains: The previous analytical papers assume that a counterfeiter is capable of selling his counterfeits directly to consumers regardless of his type. Although this is quite possible for nondeceptive counterfeits, a deceptive counterfeiter has to infiltrate a licit supply chain; today,

very few consumers would be deceived by the counterfeits sold by street vendors or unknown websites. We take into account this fundamental difference in supply chains of nondeceptive and deceptive counterfeits and demonstrate that an effective strategy against a nondeceptive counterfeiter may not be effective against a deceptive counterfeiter.

(3) Consumer characteristics: As consumers learn more about counterfeit problems from the media, they become more aware of the presence of counterfeits, and some even become more proactive by taking into account the likelihood of receiving deceptive counterfeits unknowingly when they purchase branded products from licit distributors. Our survey (presented in §3) indicates that a proportion of proactive consumers in the United States is substantially lower than that in China. Our analysis provides insights into how this characteristic of consumers affects the effectiveness of anticounterfeiting strategies.

(4) Evaluation of anticounterfeiting strategies: We evaluate the aforementioned strategies by examining their impacts on a brand-name company, a counterfeiter, and consumers. Our analysis complements Grossman and Shapiro (1988a, b) for border inspection policies and Zhang et al. (2012) for the effect of altering the quality of a brand-name good or a nondeceptive counterfeit on the profit of a brand-name firm.

Finally, we note that a counterfeiter's decision of his distribution channel is analogous to that of a legitimate firm (e.g., Xu et al. 2010), although the benefit and risk associated with each channel of counterfeits are unique as described above. Also, a research question similar to counterfeiting arises in the literature of parallel importing (or gray market) and software piracy. Parallel importing is the practice of purchasing authentic products in a lower-priced region and shipping them to a higher-priced region (e.g., Hu et al. 2013 and references therein). In contrast, counterfeits are not authentic, having lower quality, and deceptive counterfeits are often sold at the same price. Software piracy can be viewed as a special case of counterfeiting, in which counterfeit products have almost the same functional quality as authentic ones but their cost of development and production is very low. Some of our results can be extended to software piracy problems; for example, consumers could be better off without piracy protection, which is consistent with Conner and Rumelt (1991).

In summary, the literature considers only one type of counterfeits with fixed quality that are sold directly to consumers. In contrast, our model captures recent changes in counterfeiting supply and demand by noting the fundamental differences between nondeceptive and deceptive counterfeits in consumers' awareness and distribution channels, and by considering counterfeiters' strategic decisions regarding price and functional quality in a market with different consumer characteristics. Our analysis provides novel insights into the effectiveness of several anticounterfeiting strategies.

3. Model

We consider a market served by a brand-name company and her potential counterfeiter. The type of the counterfeiter is either nondeceptive or deceptive. We use subscript $i = B$ to denote the brand-name product, $i = N$ to denote the nondeceptive counterfeit, and $i = D$ to denote the deceptive counterfeit. A consumer in this market purchases at most one unit of a product. In making a purchasing decision about product i, a consumer considers his or her utility $u_i = \theta\phi_i - p_i$, where θ represents his or her taste, ϕ_i represents the quality of the product a consumer *perceives* at time of purchase, and p_i represents the retail price of the product. All consumers prefer high quality for a given price, but a consumer with a higher θ is more willing to pay to obtain a high-quality product. We assume that θ is uniformly distributed over $[0, 1]$ and that the size of the market is one. A consumer purchases a product only if the utility from purchasing the product is nonnegative in which case the consumer selects a product that provides the highest utility. This is the standard vertical differentiation model, which is also used by Qian (2008) and Zhang et al. (2012). We next present our model components that capture the unique aspects of counterfeiting.

Depending on the counterfeit type, the quality of product i a consumer *perceives* at time of purchase, ϕ_i, may differ from its *real* quality q_i. (Throughout this paper, unless mentioned specifically as the perceived quality, quality refers to real quality.) For the nondeceptive counterfeit as well as the brand-name product, consumers know what product they are purchasing, so the perceived quality of either product is the same as its real quality; i.e., $\phi_B = q_B$ and $\phi_N = q_N$. However, for the deceptive counterfeit, consumers cannot distinguish it from the brand-name product at time of purchase. There are two types of consumers. First, some consumers may not consider the likelihood of purchasing counterfeits at legitimate stores, or they may not be aware of counterfeits at all. They perceive the quality of any product in the market as q_B; i.e., $\phi_B = \phi_D = q_B$. On the other hand, other consumers may be "proactive" in the sense that they take into account the likelihood of receiving deceptive counterfeits unknowingly even when purchasing products from legitimate stores. Let $\xi_s \in [0, 1]$ denote their expectation about the fraction of deceptive counterfeits in the market. Then proactive consumers perceive the quality of a product in

Table 1 Consumer Survey Results in the United States and China

	United States (%)		China (%)	
	Aware	Proactive	Aware	Proactive
Alcohol	14	4	94	56
Car parts	25	4	54	34
Medical drugs	41	5	86	51
Food, drinks	22	5	90	63
Average	26	4	81	51

the market as a weighted average of the quality of the brand-name product and that of the deceptive counterfeit; i.e., $\phi_B = \phi_D = (1-\xi_s)q_B + \xi_s q_D$. Let λ ($\in [0,1]$) denote the fraction of proactive consumers in the market. In practice, λ may vary depending on the characteristic of the market. For example, our survey of 166 consumers over four product categories popular for deceptive counterfeits reveals that 51% of consumers in China are proactive, whereas only 4% of consumers in the United States are proactive (see Table 1 and online appendix (available as supplemental material at http://dx.doi.org/10.1287/msom.2015.0524) for more details). The low value of λ in the United States reflects the view of Rockoff and Weaver (2012), who say, "Most Americans don't question the integrity of the drugs they rely on. They view drug counterfeiting, if they are aware of it at all, as a problem for developing countries."

Since the counterfeit bears the trademark of the brand-name product, a consumer enjoys the brand image even when the consumer purchases the counterfeit. Thus we may represent the quality of the counterfeit as $q_i = f_i + \beta q_B$ ($i = N$ or D), where f_i (>0) is the functional quality of the counterfeit i and βq_B (where $\beta > 0$) is the brand value that the counterfeit steals from the brand-name product. The parameter β captures the following two factors. First, β captures a fraction of the brand value in the quality of the brand-name product, q_B. For example, this fraction may be high for luxury goods because a brand plays a significant role when consumers purchase such products, whereas it may be low for fast-moving consumer goods because a brand is less of a concern to consumers for such goods. Second, β captures a discount factor of the original brand value for the counterfeit because the counterfeit draws only a part of the brand value from the brand-name product. Following the literature, we assume that the quality of the brand-name product is superior to that of the counterfeit; i.e., $q_B > q_N$ and $q_B > q_D$.

Either type of counterfeiter i ($=N$ or D) makes two decisions sequentially to maximize his expected profit: functional quality f_i and wholesale price w_i to a distributor. We assume that the counterfeiter makes these decisions after observing the quality q_B and price p_B of a brand-name product because counterfeiters always enter a market following a brand-name company, often after the brand-name product becomes popular. Different types of counterfeiters use different distribution channels to sell their goods, as we describe next.

The nondeceptive counterfeiter ($i = N$) distributes his goods through an *illicit distributor*, who then decides the retail price of the nondeceptive counterfeit to consumers, p_N. In this case, consumers will choose between the brand-name product and the counterfeit. Both products carry the same brand, but they have different qualities and prices. Competition between the nondeceptive counterfeiter and the brand-name company is analogous to duopoly in a vertically differentiated market, but it is not the same because the nondeceptive counterfeit steals brand value from the brand-name product and the members of the illicit supply chain bear the risks associated with counterfeiting. The nondeceptive counterfeiter and the illicit distributor make their decisions in three sequential stages as follows. In stage 1, the nondeceptive counterfeiter chooses his functional quality $f_N \in [\underline{f}, \bar{f}]$ (where $\bar{f} > \underline{f} \geq 0$), and invests tf_N^2 (where $t > 0$) to develop and produce goods having f_N. The upper bound $\bar{f}$ may represent the functional quality of the brand-name product. We assume $\bar{f} < (1-\beta)q_B$ such that $q_B > q_N$. The lower bound $\underline{f}$ may represent the minimum level of quality at which a product functions or appears to function properly. The unit production cost of the counterfeit is normalized to zero. Because it is illegal to produce counterfeits, there are some chances that the counterfeiter will be caught by the authorities. Suppose this occurs with probability $\gamma \in (0,1)$, which captures the monitoring efforts of the government and the brand-name company on counterfeit production. In that case, the counterfeiter cannot sell his goods to the market, while getting his investment confiscated and paying a fine h_N. With probability $(1-\gamma)$, the game proceeds to stage 2, in which the nondeceptive counterfeiter decides his wholesale price w_N for the illicit distributor. For simplicity, we represent all distributors/retailers in the illicit supply chain as one illicit distributor. In stage 3, the illicit distributor decides the retail price of the nondeceptive counterfeit for consumers, p_N. The illicit distributor has to pay a penalty of l_N if he is caught by the authorities with probability α_N.

The deceptive counterfeiter ($i = D$) breaks into a licit supply chain by distributing his goods through a *licit distributor*, who then sells both brand-name products and deceptive counterfeits to consumers at the same price p_B. In this case, consumers cannot distinguish deceptive counterfeits from brand-name products. Like the nondeceptive counterfeiter, in stage 1, the deceptive counterfeiter determines his functional quality $f_D \in [\underline{f}, \bar{f}]$, while facing the risk of having his

investment tf_D^2 confiscated and paying a fine h_D. In stage 2, the deceptive counterfeiter decides his wholesale price w_D to the licit distributor. In stage 3, the licit distributor determines a proportion $s \in [0, 1]$ of the deceptive counterfeit among all products he sells to consumers and then sells all products at the price p_B.

We focus on the interesting case when $s > 0$. We model the risk of the licit distributor selling deceptive counterfeits with a likelihood α_D of getting caught and a penalty l_D. Since α_D tends to increase with more counterfeits in the market, we set α_D equal to the fraction of deceptive counterfeits, s. In §7, we consider a more general case in which α_D is a function of f_D as well as s.

We make the following assumptions to simplify our analysis. First, we assume that the retail price of a brand-name product p_B is exogenous to the licit distributor in a market with deceptive counterfeits and that the licit distributor earns a fixed markup $k \in [0, 1)$ from selling the brand-name product. This might be a result of the sales price maintenance that is employed in several industries such as consumer electronics, luxury brands, franchise stores, and some pharmaceutical markets (e.g., Netessine and Zhang 2005). Without loss of generality, we normalize $k = 0$, implying that the licit distributor does not make a profit from selling authentic products; we later show that the deceptive counterfeiter chooses a wholesale price w_D in equilibrium that guarantees a positive markup to the licit distributor. In the online appendix, we also analyze the case where the licit distributor decides the retail price endogenously and show that our main results are directionally true. Second, we normalize $h_N = 0$ and $l_N = 0$, while having $h_D = h > 0$ and $l_D = l > 0$. In practice, many nondeceptive counterfeiters are small workshops, and illicit distributors are usually street vendors or Internet sites. Since their potential loss from seizure is small, when they get caught, they tend to close their stores temporarily and then reopen the same stores or open new ones later (e.g., Yatai Xinyang market in Shanghai, China (Naumann 2009)). In contrast, punishment on deceptive counterfeiters and licit distributors tends to be ery severe. For example, the Chinese court sentenced the head of a manufacturing and distribution network for fake pills to 17 years in prison (Bennett 2010) and the U.S. court sentenced the owner of McCleod Blood and Cancer Center in Tennessee, who imported illegal cancer drugs, to serve two years and to pay $2.6 million (Imber 2014). Third, for both types of counterfeits, we assume that the probability of counterfeits getting confiscated at the production level (γ) is independent of that at the distribution level (α_N or α_D). In the example of the Scotch whisky company, the locations of many counterfeit production facilities were unknown even when the counterfeits flooded the market (Green and Smith 2002). The enforcement operations resulted in 56 arrests across nine Turkish cities in 2013 for producing counterfeit cancer drugs (Taylor 2014), which were conducted independently of the arrest of a Turkish drug wholesaler who smuggled those drugs into the United States (Whalen 2014). Table 2 summarizes our notation.

Table 2 Summary of Key Notation

Symbol	Definition
i	Brand-name product ($= B$), nondeceptive counterfeit ($= N$), deceptive counterfeit ($= D$)
θ	Taste of consumers; $\theta \sim U[0, 1]$
p_i	Retail price of product i to consumers
q_i	Real quality of product i
ϕ_i	Perceived quality of product i
f_i	Functional quality of counterfeit product i; $f_i \in [\underline{f}, \bar{f}]$
π_i	Expected profit from selling product i
w_i	Wholesale price of product i to a distributor
t	Cost parameter used in the cost of developing functional quality
β	Fraction of the quality of brand-name products that counterfeits steal; $\beta \in (0, 1 - \bar{f}/q_B)$
γ	Probability that a counterfeiter's investment will be confiscated; $\gamma \in (0, 1)$
l	Fine to the licit distributor if getting caught for selling deceptive counterfeits; $l > 0$
h	Fine to the deceptive counterfeiter if getting caught; $h > 0$
λ	Fraction of proactive consumers in the market; $\lambda \in [0, 1]$
s	Fraction of deceptive counterfeits among all products the licit distributor sells; $s \in [0, 1]$

4. Equilibrium Analysis

In this section, we present our equilibrium analysis. In §4.1 we present equilibrium, denoted by superscript *, in a market with a nondeceptive counterfeiter. In §4.2 we present equilibrium, denoted by superscript **, in a market with a deceptive counterfeiter. All proofs are provided in the online appendix.

4.1. Nondeceptive Counterfeits

In the market where nondeceptive counterfeits exist, there are three segments of consumers: (i) consumers who value the quality of a product highly and purchase the brand-name product, (ii) consumers who value the quality less and purchase the nondeceptive counterfeit, and (iii) consumers who value the quality the least and do not purchase any product. By determining the consumer who is indifferent between any two segments, we can obtain the market shares of the brand-name product and the counterfeit (see the online appendix for details). Using these market shares, denoted by m_i for $i = B$ or N, we solve the game backward to derive subgame-perfect Nash equilibrium. In stage 3, the illicit distributor determines the retail price p_N by solving

$$\max_{p_N}(p_N - w_N)m_N = (p_N - w_N)\left\{\frac{p_B - p_N}{(1-\beta)q_B - f_N} - \frac{p_N}{f_N + \beta q_B}\right\}.$$

One can easily obtain an optimal retail price $p_N^*(w_N, f_N) = ((\beta q_B + f_N)p_B + q_B w_N)/2q_B$. By anticipating the best response of the illicit distributor, in stages 2 and 1, the nondeceptive counterfeiter determines his wholesale price w_N and functional quality f_N, respectively, to maximize his expected profit:

$$\pi_N(w_N, f_N) = (1-\gamma)\left\{w_N\left(\frac{p_B - p_N^*}{(1-\beta)q_B - f_N} - \frac{p_N^*}{f_N + \beta q_B}\right) - tf_N^2\right\} - \gamma t f_N^2.$$

Lemma 1. *In equilibrium, the nondeceptive counterfeiter chooses wholesale price* $w_N^* = p_B(f_N^* + \beta q_B)/2q_B$ *and functional quality* $f_N^* = \underline{f}$ *if* $t < (1-\gamma)p_B^2/8\{(1-\beta)q_B - f_N\}^3$ *and* $\pi_N^*(\underline{f}) \geq \pi_N^*(\bar{f})$; *otherwise* f_N^* *can be* $\bar{f}$ *or* $f_N^* \in (\underline{f}, \bar{f})$ *that satisfies* $(\partial \pi_N^*/\partial f_N)|_{f_N = f_N^*} = 0$. *The resulting expected profit is* $\pi_N^* = (p_B^2(1-\gamma)(f_N^* + \beta q_B))/8q_B\{(1-\beta)\cdot q_B - f_N^*\} - t(f_N^*)^2$.

A key implication of Lemma 1 is that the nondeceptive counterfeiter may not always choose the lowest quality in contrast to the common assumption used in the literature (e.g., Grossman and Shapiro 1988a, b). In the *past*, nondeceptive counterfeits with low functional quality such as brand-name costumes, footwear, and accessories dominated a counterfeit market. Their functional quality is just enough for consumers to use them, but their durability and performance are substandard. Consumers who purchase such counterfeits are those who want to enjoy the snob appeal of brands, but do not want to pay the high price of genuine goods. However, in *today*'s counterfeit markets, counterfeiters come in varying levels of quality, depending on their intended markets. For example, although most of counterfeit shoes in China are of low quality, there are high-end fakes designed primarily for export, which are so sophisticated that it is difficult to distinguish the real ones from the counterfeits (Schmidle 2010). These counterfeiters usually face the least pressure from local enforcement agencies and some are likely to turn into licit competitors once intellectual property rights become more strictly enforced (Staake and Fleisch 2008). Our result is consistent with this observation of today's counterfeit markets.

4.2. Deceptive Counterfeits

In the market where deceptive counterfeits exist, both brand-name products and deceptive counterfeits are sold at price p_B. Although proactive consumers with proportion λ perceive the quality of a product in the market as $(1-\xi_s)q_B + \xi_s q_D$, the rest of consumers perceive the quality of a product in the market as q_B. Similar to Grossman and Shapiro (1988a), we assume that the expectation of proactive consumers about the fraction of deceptive counterfeits in the market is rational and hence is equal, in equilibrium, to the actual fraction of counterfeits; i.e., $\xi_s = s$. These consumers may build rational expectations through repeated interactions in the marketplace (especially when they have been in the market with counterfeits for a long period of time) and through learning from the media. This notion of rational expectations equilibrium is also used in the recent operations management literature (e.g., Su and Zhang 2008, Cachon and Swinney 2009).

In this market, there are only two segments of consumers: (i) those who purchase products and (ii) those who do not purchase any product. Among those consumers who purchase products, a fraction s of them receives deceptive counterfeits unknowingly. We solve the model backward as follows. In stage 3, the licit distributor solves the following problem to determine s^{**}:

$$\max_{s\in[0,1]} (1-s)\left[s(p_B - w_D)\left\{1 - \frac{\lambda p_B}{(1-s)q_B + s(f_D + \beta q_B)} - \frac{(1-\lambda)p_B}{q_B}\right\}\right] - sl,$$

where $(1-s)$ represents the likelihood that the distributor will not be detected for selling counterfeits and the next term in the bracket represents the distributor's profit in that case. When there is a seizure with probability s, the licit distributor does not sell any products (hence making no profits) and pays a penalty l. In stages 2 and 1, the deceptive counterfeiter decides his wholesale price w_D and functional quality f_D, respectively, to maximize his expected profit, given by

$$\pi_D(w_D, f_D) = (1-\gamma)\left[w_D s^{**}\left\{1 - \frac{\lambda p_B}{(1-s^{**})q_B + s^{**}(f_D + \beta q_B)} - \frac{(1-\lambda)p_B}{q_B}\right\} - tf_D^2\right] - \gamma(tf_D^2 + h).$$

Lemma 2. (a) *When no consumers are proactive (i.e.,* $\lambda = 0$*), in equilibrium, the deceptive counterfeiter chooses wholesale price* $w_D^{**} = p_B - \sqrt{lp_B/(1-p_B/q_B)}$ *and functional quality* $f_N^* = \underline{f}$, *getting the expected profit of* $\pi_D^{**} = \frac{1}{2}(1-\gamma)\{\sqrt{p_B(1-p_B/q_B)} - \sqrt{l}\}^2 - t\underline{f}^2 - \gamma h$.

(b) *When proactive consumers exist (i.e.,* $\lambda > 0$*), there exists* $\bar{t}$ (>0) *such that if* $t \geq \bar{t}$, *the deceptive counterfeiter chooses* $f_D^{**} = \underline{f}$; *otherwise* f_D^{**} *can be* $\bar{f}$ *or* $f_D^{**} \in (\underline{f}, \bar{f})$ *that satisfies* $(\partial \pi_D^{**}/\partial f_D)|_{f_D = f_D^{**}} = 0$. (*In this case, no closed-form expressions exist for* w_D^{**} *or* π_D^{**}.)

In the market with no proactive consumers, Lemma 2(a) shows that the deceptive counterfeiter always chooses the lowest functional quality $\underline{f}$ because improving quality does not increase counterfeit sales. Although such a counterfeit is visually

identical to its brand-name product, its low quality may endanger consumers' health and safety. Typical examples are food, beverage, pharmaceuticals, and automotive spare parts (OECD 2008). It is also interesting to note that the deceptive counterfeiter's expected profit increases with $p_B(1 - p_B/q_B)$, which is the revenue of the brand-name company without counterfeits. This is because the perceived quality and price of the deceptive counterfeit are the same as those of the brand-name product.

In the market where some consumers are proactive, although consumers cannot distinguish the deceptive counterfeit from the brand-name product, the deceptive counterfeiter can still find it optimal to improve his functional quality f_D above the minimum level $\underline{f}$. This is because when f_D is improved, both aggregate demand for brand-name and counterfeit products and the fraction of deceptive counterfeits are increased. Thus the marginal benefit of improving functional quality is positive. If the marginal benefit exceeds the marginal cost, then the deceptive counterfeiter will choose his functional quality f_D^{**} above $\underline{f}$. In practice, some deceptive counterfeits reveal different levels of functional quality; for example, some fake drugs have the right active ingredients and they may even have the right amounts, whereas others may contain the wrong ingredients including toxic compounds (Israel 2014).

Having analyzed the equilibrium decisions of counterfeiters and distributors in licit and illicit supply chains, we next examine the effectiveness of anticounterfeiting strategies: quality and pricing strategies in §5, and marketing, enforcement, and technology strategies in §6.

5. Anticounterfeiting Strategies: Quality and Price

We examine the effectiveness of quality and pricing strategies against the nondeceptive counterfeiter in §5.1 and against the deceptive counterfeiter in §5.2. Then we compare them in §5.3. In each of §§5.1 and 5.2, we proceed with our analysis as follows. First, we examine whether the brand-name company should choose higher/lower quality or price than the case with no counterfeiter to maximize her expected profit against the counterfeiter. We analyze quality and pricing strategies separately and discuss the combined strategy toward the end of this section. In practice, quality may not be changed in a short period of time because it often involves a change of product design and specifications, whereas price can usually be changed more easily. Thus, when a counterfeit problem is urgent and requires immediate actions, the brand-name company may adjust the price of her product to combat counterfeits. For example, Wertheimer et al. (2003) propose reducing drug prices to make counterfeiting less profitable. In other cases, the brand-name company may not change her price due to the presence of counterfeits (Wee et al. 1995). For example, when luxury brands reduce their prices, they may damage their prestige, so many luxury brands rarely reduce prices (Bastien and Kapferer 2013). Instead, they improve the quality of their products by adding more features to combat counterfeits (Poddar et al. 2012). Given price p_B, let q_B^m denote the optimal quality of the brand-name product with no counterfeiter in the market, and let q_B^* (respectively, q_B^{**}) denote the optimal quality of the brand-name product in the presence of the nondeceptive (respectively, deceptive) counterfeiter. Similarly, given quality q_B, let p_B^m denote the optimal price of the brand-name product with no counterfeiter, and let p_B^* (respectively, p_B^{**}) denote the optimal price in the presence of the nondeceptive (respectively, deceptive) counterfeiter. Second, knowing that the strategies of choosing q_B^* and p_B^* (respectively, q_B^{**} and p_B^{**}) instead of q_B^m and p_B^m improve the expected profit of the brand-name company, we examine how these strategies affect the expected profit of the nondeceptive (respectively, deceptive) counterfeiter. Finally, we investigate how those strategies affect expected consumer welfare, which is defined as follows.

When only brand-name products exist in the market, we can define consumer welfare as $CS_B = \int_{p_B/q_B}^1 (\theta q_B - p_B)\,d\theta$. Similarly, we can define CS_N or CS_D as consumer welfare in the market where nondeceptive or deceptive counterfeits coexist with brand-name products, respectively, as follows:

$$CS_N = \int_{\hat{\theta}}^{\tilde{\theta}} (\theta q_N - p_N)\,d\theta + \int_{\tilde{\theta}}^{1} (\theta q_B - p_B)\,d\theta,$$

$$\text{where } \hat{\theta} = \frac{p_N}{f_N + \beta q_B} \text{ and } \tilde{\theta} = \frac{p_B - p_N}{(1-\beta)q_B - f_N};$$

$$CS_D = s\int_{\bar{\theta}}^{1} (\theta q_D - p_B)\,d\theta + (1-s)\int_{\tilde{\theta}}^{1} (\theta q_B - p_B)\,d\theta,$$

$$\text{where } \bar{\theta} = \frac{\lambda p_B}{(1-s)q_B + s q_D} + \frac{(1-\lambda)p_B}{q_B}.$$

The first term of CS_N represents the surplus of those consumers who purchase the nondeceptive counterfeit; the second term represents the surplus of those consumers who purchase the brand-name product. The first term of CS_D represents the surplus of those consumers who are cheated and receive the deceptive counterfeit, and the second term represents the surplus of those consumers who purchase and receive the brand-name product. Considering the chances that counterfeits do not reach the market due to seizure, we can further define ECS_N or ECS_D as the

expected consumer welfare when the counterfeiter is nondeceptive or deceptive, respectively, as follows:

$$ECS_N = (1-\gamma)CS_N + \gamma CS_B \quad \text{and}$$
$$ECS_D = (1-\gamma)CS_D + \gamma CS_B.$$

Let ECS_N^* or ECS_D^{**} denote the corresponding expected consumer welfare in equilibrium. We can show that $ECS_D^{**} < CS_B < ECS_N^*$. Intuition from this result is as follows. When nondeceptive counterfeits exist in the market, a consumer has a cheap alternative to the brand-name product. In equilibrium, the nondeceptive counterfeiter sets his price and functional quality such that he offers a higher utility to those consumers who enjoy the brand value of the brand-name product but do not appreciate its high quality or cannot afford its high price. Therefore, nondeceptive counterfeits improve consumer welfare. In contrast, when deceptive counterfeits exist, some consumers are cheated to receive low-quality deceptive counterfeits, resulting in a welfare loss. Note that we do not consider the socioeconomic effects of counterfeiting on criminal activities, employment, innovation, tax revenues, and so on. If taking into account these indirect or long-term effects, then nondeceptive counterfeits may also decrease consumer welfare.

5.1. Nondeceptive Counterfeits

This subsection examines the brand-name company's strategies against the nondeceptive counterfeiter. We first examine the brand-name company's *quality* strategy to combat the nondeceptive counterfeiter. In the following, we present the results for the case when the quality of the nondeceptive counterfeit is either low (i.e., $f_N^* = \underline{f}$) or high (i.e., $f_N^* = \bar{f}$), since the exposition of our results is much simpler in this case, while presenting the results for the case when $f_N^* \in (\underline{f}, \bar{f})$ in the online appendix (which involves complex conditions for parts (a) and (c) of Proposition 1).

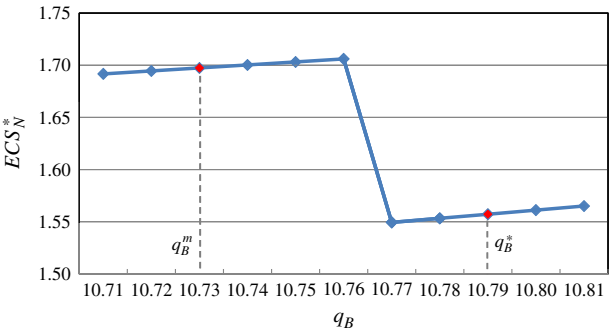
Proposition 1. *Suppose the quality of the nondeceptive counterfeit is either low (i.e., $f_N^* = \underline{f}$) or high (i.e., $f_N^* = \bar{f}$). Then*:

(a) *To combat the nondeceptive counterfeiter, the brand-name company should choose a higher quality than that without counterfeits (i.e., $q_B^* > q_B^m$) if and only if $\beta < 1 - \{(q_B^m - q_N^*(q_B^m))/q_B^m\}^2$.*

(b) *When the brand-name company chooses a higher (respectively, lower) quality than that without counterfeits, the nondeceptive counterfeiter obtains a lower (respectively, higher) expected profit (π_N^*).*

(c) *When the brand-name company chooses a higher (respectively, lower) quality than that without counterfeits, the expected consumer welfare (ECS_N^*) is higher (respectively, lower) unless the nondeceptive counterfeiter reduces his quality level from high to low.*

Figure 1 **(Color online) Expected Consumer Welfare as a Function of the Brand-Name Product Quality when Nondeceptive Counterfeits Are Present in the Market**



Note. Parameters used: $t = 0.01$, $p_B = 5$, $\beta = 0.1$, $\gamma = 0.58$, $c_B = 0.05$, $h = 0$, $\underline{f} = 0.1$, and $\bar{f} = 8$, where c_B is the marginal cost of the brand-name product.

We first consider the case when the nondeceptive counterfeit draws an insignificant amount of brand value from the brand-name product (i.e., $\beta < 1 - \{q_B^m - q_N^*(q_B^m)\}^2/(q_B^m)^2$). In this case, Proposition 1(a) shows that the brand-name company should set her product quality higher than q_B^m to combat the nondeceptive counterfeiter. This strategy not only improves the expected profit of the brand-name company, but also decreases the expected profit of the nondeceptive counterfeiter (Proposition 1(b)). In this case, even though the improved quality of the brand-name product also improves the quality of the nondeceptive counterfeit, the difference in quality between two competing products becomes larger because the counterfeit steals only a small part of the brand value. Consequently, the nondeceptive counterfeiter will lose its quality competition against the brand-name company. This result may explain how the shoe manufacturers mentioned in §1 successfully addressed their counterfeiting issues by improving the quality of their products. Finally, Proposition 1(c) shows that, although this strategy improves the expected profit of the brand-name company and reduces the expected profit of the nondeceptive counterfeiter, it does *not always* benefit consumers. This is because this strategy can lead the nondeceptive counterfeiter to lower his functional quality. In this case, consumers who purchase nondeceptive counterfeits suffer from lower functional quality, resulting a welfare loss. For example, Figure 1 illustrates that the expected consumer welfare ECS_N^* falls when the brand-name product's quality q_B is increased from $q_B^m = 10.73$ to $q_B^* = 10.79$.

Next, we consider the case when the nondeceptive counterfeit draws a significant amount of brand value from the brand-name product (i.e., $\beta > 1 - \{q_B^m - q_N^*(q_B^m)\}^2/(q_B^m)^2$). In this case, Proposition 1(a) shows it is optimal for the brand-name company to lower her product quality because the costly improvement

of the brand-name product will benefit the nondeceptive counterfeiter significantly. Although this strategy improves the expected profit of the brand-name company, it can inadvertently help the nondeceptive counterfeiter earn higher expected profit (Proposition 1(b)) and make consumers suffer from poor quality (Proposition 1(c)). Therefore, in this case, the brand-name company may not use this strategy to combat the nondeceptive counterfeiter.

The following proposition shows how the brand-name company can combat the nondeceptive counterfeiter through her *pricing* strategy.

Proposition 2. (a) *To combat the nondeceptive counterfeiter, the brand-name company should choose a lower price than that without counterfeits (i.e., $p_B^* < p_B^m$) for all β.*

(b) *When the brand-name company chooses a lower price than that without counterfeits, the nondeceptive counterfeiter obtains a lower expected profit (π_N^*).*

(c) *When the brand-name company chooses a lower price than that without counterfeits, the expected consumer welfare (ECS_N^*) is higher unless the nondeceptive counterfeiter reduces his quality level from high (i.e., $f_N^* = \bar{f}$) to low (i.e., $f_N^* = \underline{f}$) or $\partial f_N^*/\partial p_B$ is sufficiently high for $f_N^* \in (\underline{f}, \bar{f})$.*

In contrast to the quality strategy, Proposition 2(a) shows that for any β, the brand-name company should set her price lower than p_B^m to combat the nondeceptive counterfeiter. This is because a lower price enables the brand-name company to compete better against nondeceptive counterfeits that are cheap alternatives of brand-name products. This strategy helps the brand-name company to gain more market share by inducing some consumers to switch from nondeceptive counterfeits to brand-name goods. As a result, this strategy also reduces the expected profit of the nondeceptive counterfeiter (Proposition 2(b)). We further find that the larger β is, the faster the expected profit of the nondeceptive counterfeiter will decrease. This is because the brand-name company relies more on price to compete with the nondeceptive counterfeiter when the quality levels of two products are not so distinguished because of the larger β. However, similar to the quality strategy, Proposition 2(c) shows that reducing price p_B can hurt consumers by inducing the nondeceptive counterfeiter to reduce his quality level. This strategy has been used in practice: for example, to combat rampant DVD piracy in Russia (Arvedlund 2004).

5.2. Deceptive Counterfeits

This subsection examines the brand-name company's anticounterfeiting strategies against the deceptive counterfeiter. As we will show in this section, most effects of these strategies are monotonic when no proactive consumers exist in the market (i.e., $\lambda = 0$), whereas all effects of these strategies are nonmonotonic when proactive consumers exist in the market (i.e., $\lambda > 0$). Thus, we first examine the former case analytically to establish monotonic results and then conduct a numerical study for the latter case to show nonmonotonicity. This approach will enable us to isolate the effect of λ and explore dominant effects of anticounterfeiting strategies when positive λ creates nonmonotonic effects. Note that the results under $\lambda = 0$ also bear some practical relevance (asymptotically) because only a small fraction of consumers may be proactive in developed countries; for example, $\lambda = 0.04$ in the United States in our survey results, shown in Table 1.

Let us first analyze the case when no consumers are proactive. The following proposition shows, counterintuitively, that by setting the *quality* level lower than that without counterfeits in the market, the brand-name company can improve her expected profit, reduce the expected profit of the deceptive counterfeiter, and even improve expected consumer welfare.

Proposition 3. *Consider the market in which no consumers are proactive (i.e., $\lambda = 0$).*

(a) *To combat the deceptive counterfeiter, the brand-name company should choose a lower quality than that without counterfeits (i.e., $q_B^{**} < q_B^m$).*

(b) *When the brand-name company chooses a lower quality than that without counterfeits, the deceptive counterfeiter obtains a lower expected profit (π_D^{**}).*

(c) *When the brand-name company chooses a lower quality than that without counterfeits, the expected consumer welfare (ECS_D^{**}) is higher, as long as the quality of deceptive counterfeits (q_D^{**}) is sufficiently low.*

Proposition 3(a) states that the brand-name company should choose a lower quality level to combat the deceptive counterfeiter. Because consumers cannot distinguish deceptive counterfeits from brand-name products, this strategy reduces the perceived quality of all products in the market and thus reduces the aggregate demand for both brand-name and counterfeit goods. However, the reduced aggregate demand discourages the licit distributor from taking the risk of selling deceptive counterfeits. The result stated in Proposition 3(a) shows that the latter (positive) effect dominates the former (negative) effect, so this strategy improves the expected profit of the brand-name company. This result highlights the importance of modeling the incentive of the licit distributor in this supply chain: Without the licit distributor, the positive effect of this strategy would not exist and therefore the result opposite to Proposition 3(a) would be obtained. Because this strategy reduces both the aggregate demand and the proportion of deceptive counterfeits sold by the licit distributor, it will also reduce the expected profit of the deceptive

counterfeiter (Proposition 3(b)). More generally, even when consumers are proactive (i.e., $\lambda > 0$), we show in the proof that the expected profit of the deceptive counterfeiter increases with the quality of the brand-name product because the deceptive counterfeit gets a free ride on the brand name of the genuine product. Therefore, the brand-name company should be aware of this adverse effect when confronting a deceptive counterfeiter. For example, as the market size of the Scotch whisky company mentioned in §1 grew from 180,000 cases to 380,000 cases, the counterfeiters substantially broadened their activities and took 42% of sales (Green and Smith 2002). Similarly, in the pharmaceutical industry, high-demand drugs have the most serious counterfeit problem (*Bull World Health Organ.* 2010). Finally, contrary to our first intuition that lower quality will hurt consumers, Proposition 3(c) suggests that this strategy can improve consumer welfare. To understand this result, note that there are two opposing effects of having lower quality of brand-name products on consumer welfare: Consumers suffer from lower quality and fewer consumers buy products, but at the same time fewer consumers are deceived to buy low-quality counterfeits. Proposition 3(c) shows that when the quality of deceptive counterfeits is sufficiently low, the latter effect outweighs the former effect, benefiting consumers.

We next examine the effectiveness of the *pricing* strategy against the deceptive counterfeiter.

Proposition 4. *Consider the market in which no consumers are proactive* (*i.e.*, $\lambda = 0$).

(a) *To combat the deceptive counterfeiter, the brand-name company should choose a higher price than that without counterfeits* (*i.e.*, $p_B^{**} > p_B^m$).

(b) *When the brand-name company chooses a higher price than that without counterfeits, the deceptive counterfeiter can obtain a higher or lower expected profit* (π_D^{**}).

(c) *When the brand-name company chooses a higher price than that without counterfeits, the expected consumer welfare* (ECS_D^{**}) *is higher as long as the quality of deceptive counterfeits* (q_D^{**}) *is sufficiently low.*

With no proactive consumers in the market, Proposition 4(a) states that the brand-name company should increase her price to improve her expected profit against the deceptive counterfeiter (for reasons similar to Proposition 3(a)). Unlike the quality strategy, however, this pricing strategy has a nonmonotonic impact on the expected profit of the deceptive counterfeiter (Proposition 4(b)). To understand this result, note that there are two effects of raising her price p_B: (i) it reduces the aggregate demand for brand-name and counterfeit goods; and (ii) it increases the distributor's margin from selling deceptive counterfeits. Because of the latter effect, the strategy of raising the price does not always reduce the proportion of deceptive counterfeits the licit distributor sells, nor does it always reduce the deceptive counterfeiter's market share and his expected profit. Therefore, in implementing this pricing strategy, one should carefully consider these two counterbalancing effects of raising/reducing price. In practice, we observe instances of both raising and reducing prices: Wertheimer et al. (2003) propose reducing drug prices to make counterfeiting less attractive by reducing the profit margins of fake drugs (i.e., the opposite effect of (ii)), and Russia plans to raise vodka prices to put out of business makers of counterfeit alcohol (via effect (i)), although it will also affect licit companies (*Reuters* 2012). Finally, Proposition 4(c) suggests that this strategy can improve consumer welfare when the quality of deceptive counterfeits is sufficiently low. We can interpret this result similarly to Proposition 3(c).

Next, we analyze the case in which proactive consumers exist in the market (i.e., $\lambda > 0$). As we have mentioned earlier, this additional factor causes all the effects of the anticounterfeiting strategies to become nonmonotonic. Specifically, the brand-name company's quality q_B^{**} (respectively, p_B^{**}), can be higher or lower than q_B^m without counterfeits (respectively, p_B^m); furthermore, the deceptive counterfeiter's expected profit π_D^{**} and the expected consumer welfare ECS_D^{**} are nonmonotonic with a change of q_B or p_B. Because the closed-form expressions of s^{**}, w_D^{**}, and f_D^{**} do not exist in this case, no simple conditions can be derived analytically for monotonic results (see remarks on the proofs of Propositions 3 and 4 in the online appendix). For this reason, we conduct a numerical study to compare the results under $\lambda = 0$ with those under $\lambda > 0$, and explore dominant effects. The numerical experiments are conducted with the following settings: for each of $\lambda = 0, 0.25$, or 0.5, we constructed 1,024 scenarios using the following parameter values: $t \in \{0.005, 0.01, 0.015, 0.02\}$, $\beta \in \{0.1, 0.2, 0.3, 0.4\}$, $\gamma \in \{0.1, 0.2, 0.3, 0.4\}$, $l \in \{0.005, 0.01, 0.015, 0.02\}$, $c_B \in \{0.1, 0.2, 0.3, 0.4\}$, $h = 0$, $\underline{f} = 0.1$, and $\bar{f} = (1-\beta)q_B - 0.1$. The parameters are chosen so that they cover various possible scenarios. We present a summary of the results in Table 3, which reads as follows: for example, when $\lambda = 0.5$, $q_B^{**} < q_B^m$ was observed in 97.3% of 1,024 scenarios, and choosing q_B^{**} reduced π_D^{**} in 97.3% of 1,024 scenarios and increased ECS_D^{**} in 5.3% as compared to choosing q_B^m.

From Table 3, we can observe the following:

(1) The results obtained under $\lambda = 0$ continue to hold in most scenarios under $\lambda > 0$. However, in some scenarios, the brand-name company finds it optimal to set $q_B^{**} > q_B^m$ or $p_B^{**} < p_B^m$. We can explain this result as follows. First, recall from our discussions that setting lower-quality q_B^{**} or higher-price p_B^{**} reduces the aggregate demand for brand-name and counterfeit

Table 3 **Effects of Quality and Pricing Strategies Against Deceptive Counterfeits**

	Effects of choosing q_B^{**} vs. q_B^m			Effects of choosing p_B^{**} vs. p_B^m		
	$q_B^{**} < q_B^m$	$\pi_D^{**} \downarrow$	$ECS_D^{**} \uparrow$	$p_B^{**} > p_B^m$	$\pi_D^{**} \downarrow$	$ECS_D^{**} \uparrow$
$\lambda = 0$	1	1	0.032	1	0.097	0.016
$\lambda = 0.25$	0.961	0.961	0.052	0.989	0.398	0.048
$\lambda = 0.5$	0.973	0.973	0.053	0.984	0.454	0.039

goods and that the reduced aggregate demand discourages the licit distributor from taking the risk of selling counterfeits. Propositions 3(a) and 4(a) suggest that the latter (positive) effect always dominates the former (negative) effect when $\lambda = 0$. However, with proactive consumers in the market (i.e., $\lambda > 0$), the deceptive counterfeiter may improve his functional quality f_D^{**} in response to the reduced demand (see Lemma 2). This additional factor makes the licit distributor more willing to sell counterfeits, so that the positive effect does not always dominate the negative effect.

(2) In those scenarios where $q_B^{**} > q_B^m$, the strategy of setting higher quality q_B^{**} will increase the deceptive counterfeiter's expected profit π_D^{**} by making counterfeits flourish more in the market. This happens because the improved quality of the brand-name product results in an increase of the aggregate demand of brand-name and counterfeit goods, which in turn incentivizes the licit distributor to procure more deceptive counterfeits. This may be the cause of the initial failure of the Scotch whisky company, which improved her quality to combat deceptive counterfeits (see §1). Also, from the table, we confirm that the deceptive counterfeiter's expected profit is nonmonotonic in price p_B for any $\lambda \geq 0$, which can be explained similarly to Proposition 4(b).

(3) The expected consumer welfare ECS_D^{**} has increased in more scenarios in the market with $\lambda > 0$ than in the market with $\lambda = 0$. Similar to our explanation given in (1) above, this is because the counterfeiter may improve his functional quality f_D^{**} with proactive consumers. In general, for any $\lambda \in [0, 1]$, we can show that if an anticounterfeiting strategy improves the average product quality in the market, then it improves the expected consumer welfare.

(4) Anticounterfeiting strategies are *not necessarily* more effective, as more consumers are proactive. We observe that the number of scenarios in which the deceptive counterfeiter's expected profit is decreased or the expected consumer welfare is increased is not necessarily monotonic in λ. For example, a change from q_B^m to q_B^{**} decreases the expected profit in all scenarios when $\lambda = 0$, in 96.1% when $\lambda = 0.25$, and in 97.3% when $\lambda = 0.5$. Similarly, we can show that more proactive consumers in the market do not necessarily benefit the brand-name company. This is because proactive consumers purchase products only when their expected utility is nonnegative, considering the likelihood of receiving deceptive counterfeits unknowingly. As a result, with more proactive consumers, fewer consumers will purchase products. This reduced aggregate demand for products discourages the licit distributor from taking the risk of selling deceptive counterfeits. Thus, depending on which of the two effects (i.e., reduced aggregate demand and reduced proportion of counterfeits) dominates, the expected profit of the brand-name company as well as her market share may increase or decrease with more proactive consumers.

Table 4 **Effects of Anticounterfeiting Strategies: Nondeceptive vs. Deceptive**

Nondeceptive counterfeits			Deceptive counterfeits		
Optimal strategy	π_N^*	ECS_N^*	Optimal strategy	π_D^{**}	ECS_D^{**}
$q_B^* > q_B^m$ (low β)	$\downarrow$	$\uparrow$	$q_B^{**} < q_B^m$	$\downarrow$	$\uparrow$ (low q_D^{**}) or $\downarrow$ (high q_D^{**})
$q_B^* < q_B^m$ (high β)	$\uparrow$	$\downarrow$			
$p_B^* < p_B^m$	$\downarrow$	$\uparrow$	$p_B^{**} > p_B^m$	$\updownarrow$	$\uparrow$ (low q_D^{**}) or $\downarrow$ (high q_D^{**})

5.3. Comparison

We now compare the effect of each strategy against the nondeceptive counterfeiter with that against the deceptive counterfeiter. Using the results presented in §§5.1 and 5.2, we summarize in Table 4 whether the brand-name company should choose higher/lower quality or price than the case with no counterfeiter to maximize her expected profit, and how such anticounterfeiting strategies affect the expected profit of the counterfeiter and the expected consumer welfare. (If a dominant effect exists for a nonmonotonic case, Table 4 reports only the dominant effect.)

From Table 4, we can draw the following insights:

(1) The optimal strategy of the brand-name company (that maximizes her expected profit) differs depending on whether she faces the nondeceptive or deceptive counterfeiter. For example, reducing price is optimal against the nondeceptive counterfeiter, whereas raising the price is optimal against the deceptive counterfeiter.

(2) Even when the optimal strategy of the brand-name company is the same against both types of counterfeiters, its impact on the counterfeiter's expected profit and the expected consumer welfare may not be the same. For example, when the nondeceptive counterfeit draws a significant amount of brand value (i.e., high β), setting a lower quality level than that without counterfeits improves the brand-name company's expected profit against either type of counterfeiter. This strategy is effective against

the deceptive counterfeiter (i.e., reduces π_D^{**}), but it does not work well against the nondeceptive counterfeiter (i.e., increases π_N^*). Moreover, its impact on the expected consumer welfare may not be the same across the two types of counterfeiters, either.

(3) An ideal anticounterfeiting strategy should improve the brand-name company's expected profit, reduce the counterfeiter's expected profit, and improve the expected consumer welfare. The pricing strategy is such an ideal strategy against the nondeceptive counterfeiter. For the other cases, the brand-name company or the government should carefully consider a trade-off among those three objectives in implementing an anticounterfeiting strategy.

Lastly, we remark on two issues in the above analysis. First, our analyses so far have examined whether the brand-name company should choose higher/lower quality or price for each type of a counterfeiter. We show in the online appendix that when the brand-name company can save large costs of developing her product, the quality strategy is more profitable than the price strategy in combating either type of counterfeiter. Second, although we have analyzed the quality and pricing strategies separately, our results have implications for the anticounterfeiting strategy that combines both quality and pricing strategies. Consider a market with nondeceptive counterfeits that steal a significant amount of brand value (i.e., high β). In this case, the existence of nondeceptive counterfeits yields lower optimal quality and price of the brand-name product than those in the monopoly case (see Propositions 1(a) and 2(a)). It is well known that an optimal price of a product in a monopoly market increases with the product quality. If we apply this result to a market with nondeceptive counterfeits, the reduced quality of the brand-name product lowers its optimal price even further than the optimal monopoly price. This implies that the brand-name company should choose lower quality and lower price than the monopoly quality and price, respectively. Next, consider a market with nondeceptive counterfeits in which β is low. In this case, Propositions 1(a) and 2(a) have shown that the existence of nondeceptive counterfeits changes the quality and price of the brand-name product in opposite directions. Because an optimal price of a product in a monopoly market is increasing with the product quality, there is a counteracting force that may affect the price in the same direction as the quality. As a result, our numerical study shows that the optimal quality and price can be higher or lower than the monopoly quality and price, respectively. However, even when it is optimal for the brand-name company to set a higher price than the monopoly price, she may not raise her price too high because of Proposition 2(a). Likewise, in a market with deceptive counterfeits, where the existence of counterfeits changes the quality and price of the brand-name product in opposite directions, a brand-name company may increase or decrease quality and price simultaneously. Therefore, special care needs to be taken when implementing the combined strategy.

6. Marketing, Enforcement, and Technology Strategies

In this section, we consider three other anticounterfeiting strategies that are often used in practice. The first strategy is the marketing campaign that educates consumers about the adversity of counterfeit goods. For example, French luxury goods association Comite Colbert launched a campaign (using playful slogans such as "real ladies don't like fake") in response to the threat of the counterfeit (Wellman 2012). This strategy helps reduce the brand value the counterfeit steals from the brand-name product, i.e., reduce β. The second strategy is the direct enforcement effort to increase the chances to seize counterfeit products, γ. For example, the French police raided the clandestine workshops making Hermes counterfeit accessories, of which the surveillance was part of an investigation into the international crime ring that robs many brands (Wellman 2012). Lastly, the brand-name company may increase the technological complexity of her product to make it more difficult and expensive to counterfeit by increasing t. For example, the Scotch whisky company mentioned in §1 introduced a bottle with a special design so that the counterfeit cannot easily imitate the original product (Green and Smith 2002). In the following, we examine how reducing β or increasing γ or t will affect firms' expected profits and expected consumer welfare.

First, let us consider the market in which the brand-name company faces the nondeceptive counterfeiter. It is intuitive that all three strategies will improve the expected profit of the brand-name company and reduce the expected profit of the nondeceptive counterfeiter. However, we can show that these strategies will hurt expected consumer welfare for the following reasons. The market campaign makes those consumers who purchase nondeceptive counterfeits enjoy the counterfeit brand less, resulting in a welfare loss. The enforcement strategy makes counterfeits less likely to reach the market, so consumers will suffer from less availability of nondeceptive counterfeits, which are cheaper substitutes for brand-name goods. The technology strategy makes the nondeceptive counterfeiter more reluctant to invest in quality improvement, and thus consumers will suffer from lower quality of the product. As an alternative strategy, the brand-name company may consider introducing a low-price (and low-quality)

variant of the product. For example, East African Breweries launched a cut-price beer, called "Senator Keg," to help reduce the demand for illicit alcohol (*The Economist* 2010). This strategy may reduce the market share of the nondeceptive counterfeit because price-sensitive consumers may find such a low-price brand-name product a better alternative to the counterfeit. At the same time, this strategy may increase consumer welfare by introducing more competition into the market.

Next, we examine the effectiveness of these anti-counterfeiting strategies against the deceptive counterfeiter. The following proposition shows that the effectiveness of each strategy differs significantly from that against the nondeceptive counterfeiter. In the online appendix, we further study how different values of λ affect the effectiveness of these strategies numerically.

Proposition 5. *Consider the market in which deceptive counterfeits exist.*

(a) (*Marketing*) *When no consumers are proactive* (*i.e.*, $\lambda = 0$), *reducing* β *has no impact on the profits of the brand-name company* (π_B^{**}) *and the deceptive counterfeiter* (π_D^{**}), *whereas it decreases the expected consumer welfare* (ECS_D^{**}). *When some consumers are proactive* (*i.e.*, $\lambda > 0$), *reducing* β *decreases* π_D^{**} *but can increase or decrease* π_B^{**} *and* ECS_D^{**}.

(b) (*Enforcement*) *When* $\lambda = 0$, *increasing* γ *improves* π_B^{**}, *reduces* π_D^{**}, *and improves* ECS_D^{**}. *When* $\lambda > 0$, *increasing* γ *reduces* π_D^{**}, *but it can increase or decrease* π_B^{**} *and* ECS_D^{**}.

(c) (*Technology*) *When* $\lambda = 0$, *increasing* t *improves* π_B^{**}, *reduces* π_D^{**}, *and improves* ECS_D^{**}. *When* $\lambda > 0$, *increasing* t *reduces* π_D^{**}, *but it can increase or decrease* π_B^{**} *and* ECS_D^{**}.

Proposition 5(a) suggests that special care must be taken when implementing the marketing campaign against the deceptive counterfeiter. For the case when no consumers are proactive, the marketing campaign has no impact on the firms' expected profits because consumers do not take into account the possibility of receiving counterfeits unknowingly. This result is expected. In contrast, proactive consumers correctly expect that they will derive less utilities when receiving deceptive counterfeits unknowingly. Thus, when some consumers are proactive, the marketing campaign can reduce the expected profit of the deceptive counterfeiter by discouraging proactive consumers from purchasing products. However, it could backfire on the brand-name company because proactive consumers reduce their consumption of brand-name products as well. Finally, unlike the case when no consumers are proactive, this strategy could improve expected consumer welfare when some consumers are proactive. The reason is, as mentioned above, this strategy may reduce the overall demand for the authentic good and its deceptive counterfeit. As a result, although consumers enjoy the counterfeit less, fewer of them may receive low-quality deceptive counterfeits. When the latter effect outweighs the former effect, this strategy benefits consumers.

Proposition 5(b) shows that when no proactive consumers exist in the market, the enforcement strategy works well against the deceptive counterfeiter. However, contrary to a common belief, this strategy may reduce the expected profit of the brand-name company and also hurt expected consumer welfare in the market where proactive consumers exist. This result can be explained as follows. Similar to the impact of this strategy on the nondeceptive counterfeiter (discussed above), by increasing the risk of counterfeiting, this strategy makes the deceptive counterfeiter reluctant to invest in quality improvement. Although the lower quality of nondeceptive counterfeits helps the brand-name company regain its market share in quality competition, the lower quality of deceptive counterfeits reduces the perceived quality of products in the market with proactive consumers, hence reducing the aggregate demand for both brand-name goods and deceptive counterfeits. In this case, consumers also suffer from the lower quality of deceptive counterfeits although fewer consumers will receive deceptive counterfeits unknowingly.

Proposition 5(c) shows that the technology strategy has the same impact as the enforcement strategy. The enforcement strategy increases the expected loss of the counterfeiter from a potential seizure. Similarly, if the brand-name product becomes more complex, then it will be more costly for a counterfeiter to imitate the brand-name product, hence reducing his expected profit from selling counterfeits. Therefore, both anti-counterfeiting strategies will reduce the incentive of the counterfeiter to develop high-quality goods.

7. Extension: Alternative Models for Counterfeiting Risks

In this section, we extend our base model to the case where the probability of counterfeits getting confiscated is a decreasing function of their functional quality. This is plausible in some situations because those consumers who have suffered from the low quality of counterfeits can report them to the authorities, which may lead to the raid of counterfeit factories or distributors. For example, soon after the infusion of fake Avastin, a lung-cancer patient became nauseous and feverish (Whalen 2014). If fake Avastin had worked as well as its genuine one, it might have been difficult to infer that the Avastin the patient received was counterfeit.

Specifically, suppose that a counterfeiter will get caught by the authorities with the probability of

$\gamma - \delta_1 f_i$ for $i = N$ or D and that a licit distributor will get caught with the probability of $s - \delta_2 f_D$. We assume $\delta_1 > 0$ and $\delta_2 > 0$, so that the lower the quality of counterfeit goods, the higher the detection probabilities becomes. We do not consider the case where the probability of the illicit distributor getting caught for selling nondeceptive counterfeits decreases with the quality of nondeceptive counterfeits. Such a case is unlikely in practice because consumers already know what they purchase. Furthermore, this probability does not affect our results due to our assumption that the penalty to the illicit distributor $l_N = 0$ (see §3).

We first examine the counterfeiter's quality decision. As in Lemma 1, the nondeceptive counterfeiter chooses $f_N^* = \underline{f}$ or $f_N^* > \underline{f}$, depending on the value of t and whether $\pi_N^*(\underline{f}) \geq \pi_N^*(\bar{f})$. However, contrary to Lemma 2, the deceptive counterfeiter may choose $f_D^{**} > \underline{f}$ even without proactive consumers because high-quality counterfeits can induce the licit distributor to procure more counterfeits by reducing his probability of getting caught. These results lead to the following results regarding the effectiveness of anti-counterfeiting strategies.

Corollary 1. *Suppose the probability of a counterfeiter getting caught is $\gamma - \delta_1 f_i$ for $i = N$ or D, and the probability of a licit distributor getting caught is $s - \delta_2 f_D$, where $\delta_1 > 0$ and $\delta_2 > 0$. Then the following results hold*:

(a) *Proposition 1 continues to hold.*

(b) *Propositions 2–4 continue to hold except that the conditions in part (c) are different.*

(c) *Proposition 5 continues to hold except that increasing γ or t can increase or decrease the expected profit of the brand-name company (π_B^{**}) and the expected consumer welfare (ECS_D^{**}) when no consumers are proactive (i.e., $\lambda = 0$).*

Corollary 1 shows that the general risk model in this section affects only the impact of enforcement and technology strategies (that increase γ and t, respectively) on the expected profit of the brand-name company (π_B^{**}) and the expected consumer welfare (ECS_D^{**}) when combating the deceptive counterfeiter. In the base model, Proposition 5 has shown that these strategies always improve π_B^{**} and ECS_D^{**} when no consumers are proactive. However, Corollary 1(c) shows that they can either increase or decrease π_B^{**} and ECS_D^{**} even when no consumers are proactive. The intuition is as follows. In the base model, when no consumers are proactive, the optimal functional quality f_D^{**} of the deceptive counterfeiter is always $\underline{f}$. However, as we have discussed above, in the extended model, $f_D^{**} > \underline{f}$ is possible even when no consumers are proactive. In this case, as the investment for quality improvement becomes more risky with higher γ or t, the deceptive counterfeiter may find it optimal to reduce f_D^{**}. This in turn increases the risk of the licit distributor selling counterfeits (through $\delta_2 f_D$) as well as his own risk of getting caught (through $\delta_1 f_D$). As a result of these two opposing effects, we find that increasing γ or t can increase or decrease f_D^{**}. When f_D^{**} is increased, it will reduce the risk of the licit distributor selling deceptive counterfeits, hence increasing the fraction of deceptive counterfeits; consequently, it could hurt the expected profit of the brand-name company, π_B^{**}. On the other hand, when f_D^{**} is decreased, consumers will suffer from the lower quality of deceptive counterfeits; thus, it could reduce the expected consumer welfare ECS_D^{**}.

Lastly, note that the probability of deceptive counterfeits getting confiscated in our model does not depend on the quality of the brand-name product. For example, for products such as milk, gasoline, and drugs, consumers cannot verify active ingredients, so higher quality of a branded good does not require a counterfeiter to spend more money in masquerading as branded products to deceive consumers. However, in some cases (e.g., auto spare part), quality changes might be related to the characteristics that consumers can identify when they make purchases. In such cases, it may be plausible that the quality improvement of the brand-name product makes it more difficult for the deceptive counterfeiter to masquerade as the branded product. We may model this by setting the confiscation probability of a deceptive counterfeiter as $\gamma - \delta_1'(f_D - f_B)$ instead of $\gamma - \delta_1 f_D$, and by setting the confiscation probability of a licit distributor as $s - \delta_2'(f_D - f_B)$ instead of $s - \delta_2 f_D$, where f_B is the functional quality of the brand-name product. In this case, if δ_1' or δ_2' is sufficiently large, it is possible that the optimal quality of the brand-name product q_B^{**} is higher than q_B^m in the monopoly market; that is, the brand-name company may improve the quality so as to increase the probability of the deceptive counterfeit being detected.

8. Concluding Remarks

Today counterfeit products are being produced and consumed in virtually all economies (OECD 2008). Although easy-to-manufacture goods had dominated counterfeit supply until a decade ago, there has been an alarming expansion of product categories being infringed. As a result of outsourcing and offshoring, counterfeiters have easy access to modern technology and equipment, and they are capable of producing high-quality replicas. Consumers are not easily deceived by fake goods that are sold by vendors in open markets and unknown Internet sites. These changing business conditions require industry and governments to enhance their understanding of the current and potential counterfeiters and to develop strategies to limit their activities.

To aid the efforts of industry and governments to combat counterfeiting, we have developed a normative model of counterfeiting. Our model captures the recent changes in counterfeiting supply and demand that are not addressed in the previous literature. For example, the previous literature focuses on the pricing decision of a counterfeiter, assuming that the quality level of his goods is fixed, and he is capable of selling his goods, even deceptive ones, directly to consumers. In contrast, our model takes into account the strategic decisions of a counterfeiter regarding his price and functional quality; and the fundamental difference between nondeceptive and deceptive counterfeits in consumers' awareness, distribution channels, and penalty on illegal production and distribution. We have also considered the case when a fraction of consumers are proactive. Modeling these factors explicitly enables us to evaluate several anticounterfeiting strategies against both types of counterfeiters and to draw novel managerial insights.

Our analysis highlights that the strategies that are effective in combating the nondeceptive counterfeiter may not work well against the deceptive counterfeiter. Moreover, even if strategies help the brand-name company improve her expected profit, they may not be effective in limiting counterfeit activities, and they can even hurt consumers. Specifically;

—To combat the nondeceptive counterfeiter, the brand-name firm should improve her quality if the nondeceptive counterfeit steals an insignificant amount of brand value, and reduce the product price. The firm, governments and regulatory bodies can use marketing campaigns, enforcement and technology strategies to reduce the counterfeiter's profit, although these strategies may hurt consumers.

—To combat the deceptive counterfeiter, the brand-name company should lower her quality (unless high brand-name quality facilitates the seizure of deceptive counterfeits significantly) and raise the product price (unless a significant portion of consumers is proactive), although this may benefit the deceptive counterfeiter inadvertently. The firm, governments, and regulatory bodies can use marketing campaigns, enforcement, and technology strategies when there are few proactive consumers, but these strategies may hurt the brand-name firm and consumers when a significant portion of consumers is proactive.

In summary, industries and governments should understand the type of potential counterfeiters and the characteristics of consumers to design effective strategies to combat counterfeits. Without such understanding, anticounterfeiting strategies could be ineffective and hurt consumers.

There are several interesting future research avenues. First, it will be interesting to consider the effect of positive or negative externality of counterfeits on brand-name products. For some product categories, counterfeits help increase the size of the customer base of brand-name products, which refers to positive externality. A typical example is software piracy (Conner and Rumelt 1991). The negative externality of counterfeits refers to the negative impact of counterfeits on the value of a brand. The more counterfeits there are in the market, the less prestigious the brand becomes. Second, consumers show risk-prone or irrational behavior in some situations. For example, fraudsters use their phony pharmaceutical websites to take advantage of recent swine flu fears. Some consumers who are anxious for their children take risks of buying fake vaccines and bogus remedies from unknown websites (Taylor 2009). Behavioral research will help enrich our understanding of the risk attitudes of consumers. Third, it will be interesting to conduct a detailed cost-benefit analysis of anticounterfeiting technologies, such as those that authenticate products (e.g., NanoInk) and that track and trace the movement of products (e.g., radio frequency identification (RFID)). Our current model captures the role of these technologies to some degree: the former type of technologies is captured by the technology strategy (i.e., with such technologies installed, a counterfeiter needs to expend more effort to copy authentic goods) and the latter type of technologies is captured by the enforcement strategy (i.e., with RFID installed, the likelihood of seizing counterfeits increases). Finally, it will be interesting to validate our findings empirically using industry data. For example, the patent for Viagra, one of the most popular counterfeit drugs, has expired recently. As a result, many generic drugs have flooded the market, causing a price drop. It will be interesting to test how such a price drop has affected counterfeit sales. In general, it may be challenging to collect accurate data about counterfeit sales because of the illegal nature of the counterfeit business. Thus, one may collect data in a market where intellectual property rights are not strictly enforced or in an online market where data are easier to collect than an offline market.

Supplemental Material

Supplemental material to this paper is available at http://dx.doi.org/10.1287/msom.2015.0524.

Acknowledgments

The authors thank the editor, Stephen Graves, as well as the anonymous associate editor and referees, whose comments decidedly improved the paper.

References

Arvedlund EE (2004) Hollywood competes with the street in Russia: To combat rampant DVD piracy, U.S. film companies cut prices. *New York Times* (April 7), http://www.nytimes.com/2004/04/07/movies/hollywood-competes-with-street-russia-combat-rampant-dvd-piracy-us-film.html.

Bastien V, Kapferer J (2013) More on luxury anti-laws of marketing. Wiedmann KP, Hennigs N, eds. *Luxury Marketing: A Challenge for Theory and Practice* (Springer Gabler, Wiesbaden, Germany), 21–34.

Bennett S (2010) Pfizer: Civil suits for drug counterfeiters. *Bloomberg Businessweek* (July 8), http://www.bloomberg.com/bw/magazine/content/10_29/b4187021988297.htm.

Bull World Health Organ. (2010) Growing threat from counterfeit medicines. *Bull Word Health Organ.*88(4):247–248.

Cachon GP, Swinney R (2009) Purchasing, pricing, and quick response in the presence of strategic consumers. *Management Sci.* 55(3):497–511.

Conner K, Rumelt RH (1991) Software piracy: An analysis of protection strategies. *Management Sci.* 37(2):125–139.

Economist, The (2010) A special report on innovation in emerging markets. *Economist* (April 17), 5–6.

Eisend M, Schuchert-Guler P (2006) Explaining counterfeit purchases: A review and preview. *Acad. Marketing Sci. Rev.* 12(6):1–25.

Green RT, Smith T (2002) Executive insights: Countering brand counterfeiters. *J. Internat. Marketing* 10(4):89–106.

Grossman GM, Shapiro C (1988a) Counterfeit-product trade. *Amer. Econom. Rev.* 78(1):59–75.

Grossman GM, Shapiro C (1988b) Foreign counterfeiting of status goods. *Quart. J. Econom.* 103(1):79–100.

Hargreaves S (2012) Counterfeit goods becoming more dangerous. *CNN* (September 27), http://money.cnn.com/2012/09/27/news/economy/counterfeit-goods/.

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

Imber S (2014) Texas doctor pleads guilty to buying misbranded cancer drugs from supplier of fake Avastin: Black Market Cancer Drug Cases 2007–2013. Partnership for Safe Medicines.

Israel B (2014) Counterfeit contraceptives found in South America. Research News, Georgia Institute of Technology, April 18.

Liu K, Li JA, Wu Y, Lai KK (2005) Analysis of monitoring and limiting of commercial cheating: A newsvendor model. *J. Oper. Res. Soc.* 56(7):844–854.

Naumann S (2009) Top 16 Shanghai markets. Accessed March 25, 2015, http://gochina.about.com/od/shoppinginshanghai/tp/SH_Markets.01.htm.

Netessine S, Zhang F (2005) Positive vs. negative externality in inventory management: Implications for supply chain design. *Manufacturing Service Oper. Management* 7(1):58–73.

Nylander J (2013) Chinese fakes cash in on Dr. Dre's Beats headphones bonanza. *CNN* (October 13), http://www.cnn.com/2013/10/13/business/china-fake-headphones-dr-dre-beats/.

OECD (Organisation for Economic Co-operation and Development) (2008) *The Economic Impact of Counterfeiting and Piracy* (OECD Publishing, Paris).

OECD (Organisation for Economic Co-operation and Development) (2009) Magnitude of counterfeiting and piracy of tangible products: An update. Report, OECD, Paris. Accessed March 25, 2015, http://www.oecd.org/dataoecd/57/27/44088872.pdf.

Poddar A, Foreman J, Banerjee S, Ellen PS (2012) Exploring the Robin Hood effect: Moral profiteering motives for purchasing counterfeit products. *J. Bus. Res.* 65(10):1500–1506.

Qian Y (2008) Impacts of entry by counterfeiters. *Quart. J. Econom.* 123(4):1577–1609.

Reuters (2012) Russia to hike minimum vodka prices by a third. (December 26), http://www.reuters.com/article/2012/12/26/russia-vodka-idUSL5E8NQ2OQ20121226.

Rockoff JD, Weaver C (2012) Fake cancer drug found in U.S. *Wall Street Journal* (February 15), http://www.wsj.com/articles/SB10001424052970204795304577223472661091252.

Scandizzo S (2001) Counterfeit goods and income inequality. Working paper, International Monetary Fund, Washington, DC.

Schmidle N (2010) Inside the knockoff-tennis-shoe factory. *New York Times* (August 19), http://www.nytimes.com/2010/08/22/magazine/22fake-t.html?_r=0.

Staake T, Fleisch E (2008) *Countering Counterfeit Trade* (Springer-Verlag, Berlin).

Su X, Zhang F (2008) Strategic customer behavior, commitment, and supply chain performance. *Management Sci.* 54(10):1759–1773.

Sun J, Debo L, Kekre S, Xie J (2010) Component-based technology transfer: Balancing cost saving and imitation risk. *Management Sci.* 56(3):536–552.

Taylor M (2009) Cybercrime capitalizes on swine-flu fears. *Wall Street Journal* (November 18), http://blogs.wsj.com/digits/2009/11/18/cybercrime-capitalizes-on-swine-flu-fears/.

Taylor P (2014) Counterfeit Avastin shipped to Europe as well as US. *SecuringIndustry* (Feburary 14), http://www.securingindustry.com/pharmaceuticals/fake-avastin-reached-europe-as-well-as-us/s40/a1966/#.VRG3a_nF_XU.

Wee CH, Tan SJ, Cheok KH (1995) Non-price determinants of intention to purchase counterfeit goods. *Internat. Marketing Rev.* 12(6):19–46.

Wellman V (2012) Multi-million-dollar counterfeit Birkin ring revealed to be run by Hermes staff as police bust global knock-off operation. *Mail Online* (June 15), http://www.dailymail.co.uk/femail/article-2160021/Multi-million-dollar-counterfeit-Birkin-ring-revealed-run-Hermes-STAFF-police-bust-global-knock-operation.html.

Wertheimer AI, Chaney NM, Santella T (2003) Counterfeit pharmaceuticals: Current status and future projections. *J. Amer. Pharmacists' Assoc.* 43(6):710–717.

Whalen J (2014) Turkish drug exporter Ozay draws U.S. scrutiny. *Wall Street Journal* (April 7), http://www.wsj.com/articles/SB10001424052702303546204579435692215579758.

Xu Y, Gurnani H, Desiraju R (2010) Strategic supply chain structure design for a proprietary component manufacturer. *Production Oper. Management* 19(4):371–389.

Zhang J, Hong LJ, Zhang RQ (2012) Fighting strategies in a market with counterfeits. *Ann. Oper. Res.* 192(1):49–66.