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RESEARCH ARTICLE

MANAGING CONSUMER PRIVACY CONCERNS IN PERSONALIZATION: A STRATEGIC ANALYSIS OF PRIVACY PROTECTION[1]

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Advances in information technology and e-commerce enable firms to make personalized offers to individual consumers based on information about the consumers. However, the collection and use of private information have caused serious concerns about privacy invasion by consumers, creating a personalization–privacy tradeoff. The key approach to address privacy concerns is via the protection of privacy through the implementation of fair information practices, a set of standards governing the collection and use of personal information. In this paper, we take a game-theoretic approach to explore the motivation of firms for privacy protection and its impact on competition and social welfare in the context of product and price personalization. We find that privacy protection can work as a competition-mitigating mechanism by generating asymmetry in the consumer segments to which firms offer personalization, enhancing the profit extraction abilities of the firms. In equilibrium, both symmetric and asymmetric choices of privacy protection by the firms can result, depending on the size of the personalization scope and the investment cost of protection. Further, as consumers become more concerned about their privacy, it is more likely that all firms adopt privacy protection. In the perspective of welfare, we show that autonomous choices of privacy protection by personalizing firms can improve social welfare at the expense of consumer welfare. We further find that regulation enforcing the implementation of fair information practices can be efficient from the social welfare perspective mainly by limiting the incentives of the firms to exploit the competition-mitigation effect.

Keywords: Information privacy, consumer privacy concerns, personalization, privacy protection, fair information practices, game theory, competitive analysis

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The appendix for this paper is located in the "Online Supplements" section of the *MIS Quarterly*'s website (http://www.misq.org).

Introduction

Innovation in information technology and the widespread adoption of e-commerce enable firms to make personalized offers to individual consumers based on information about the consumer. For example, myShape.com and Zafu.com are among the first online fashion retailers with apparel offerings personalized to each customer (D'Innocenzio 2007; Reuters 2007, 2008). myShape.com provides each female customer with her own online Personal Shop in which everything on the virtual racks presumably fits her specific measurements, flatters her body shape, and matches her fit and style preferences. Similarly, customers at Zafu.com can answer questions about their body types, style preferences, and size. Then, Zafu.com develops personal profiles and provides personalized offerings based on the stated or implied preferences of the customers. Another firm that stands as an impressive example of personalization is Capital One (Anand et al. 2001; Kumar and Reinartz 2006). It keeps records on the demographics of, and every interaction with, its current and potential customers. With the resulting hundreds of terabytes of data, Capital One offers about 6,000 credit cards differing in product and price characteristics. The cards are personalized not only in terms of credit limit, design, rebate program, and cosigner requirements, but also in terms of annual fees and annual percentage rate.[2]

The collection and subsequent use of consumers' private information, however, have raised serious concerns about privacy invasion among consumers, resulting in a personalization–privacy tradeoff (Awad and Krishnan 2006; Hui et al. 2007; Kasanoff 2001; Weinberg et al. 2003).[3] Therefore, privacy protection to mitigate consumer privacy concerns is a central business issue for the personalizing firms that capitalize on personal information.[4]

The key approach to privacy protection is implementing *fair information practices* (FIPs). FIPs are a set of standards governing the collection and use of personal information, and are based on five core principles: notice, choice, access, security, and enforcement (Federal Trade Commission 2009).[5] The principles were developed to balance consumer privacy concerns with organizational need to use personal information and, if followed, signal to the consumer that the firm can be trusted with the information disclosed through the exchange (Culnan and Bies 2003). Although some firms have implemented FIPs, privacy invasion cases have continued to rise and extensive debate over the need for the legislation of privacy regulation to enforce firms to implement FIPs has not abated.[6]

Recent empirical studies on privacy have shown that firms implementing FIPs can mitigate consumer privacy concerns and induce consumers to provide personal information, suggesting that firms would adopt FIPs (e.g., Awad and Krishnan 2006; Culnan and Armstrong 1999; Hui et al. 2007; Xu et al. 2009). At the core of the consumer reaction to FIPs is a consumer privacy calculus—an assessment of the costs and benefits related to information disclosure (Dinev and Hart 2006; Xu et al. 2009). If mitigating privacy concerns is well-aligned with the economic incentives of the firm, as these studies imply, why are privacy invasion cases and debate over privacy protection prevalent? What is missing in these studies is the privacy calculus from the firm's perspective.

An economic approach can effectively incorporate the firm's calculus, an assessment of the costs and benefits related to privacy protection. The game-theoretic literature on personalization has shown that personalization based on personal information can cause competition to be localized to individual consumers (e.g., Chen et al. 2001; Choudhary et al. 2005; Dewan et al. 2000; Thisse and Vives 1988). The general outcome of enhanced price competition and lower profits in the literature implies that encouraging consumer information disclosure that enhances personalization capability may work against corporate interests. For example, Chen et al. (2001) argue that improving targetability (tar-

[2]According to a recent worldwide survey of 328 senior executives conducted by the Economist Intelligence Unit, half of the products and services offered by companies will be mostly or totally personalized in five years (Economist Intelligence Unit 2007).

[3]Some level of personalization may be achieved on the basis of nonpersonal attributes. For instance, a new Amazon customer considering a specific book may receive additional recommendations based on what other people have purchased in addition to the same book. We thank the AE for indicating this point. We limit our attention to the type of personalization for which personal information is requisite.

[4]At present, privacy-related consulting services are a $500-million-a-year business and have been growing at a rate in the double digits (Gomes 2009).

[5]*Notice* means that consumers should be given notice of an entity's information practices before any personal information is collected from them. *Choice* means giving consumers options as to how any personal information collected from them may be used. *Access* refers to an individual's ability both to access data about him/herself and to contest that data's accuracy and completeness. *Integrity* means that collectors must take reasonable steps to ensure data accuracy and security. Finally, *enforcement* requires that there should be a mechanism in place to enforce the principles (Federal Trade Commission 2009).

[6]Examples of privacy regulation include the Data Protection Directive in the European Union, the Personal Information Protection and Electronic Document Act (PIPEDA) in Canada, and the Health Insurance Portability & Accountability Act (HIPAA) and the Fair and Accurate Credit Transaction Act (FACTA) in the United States.

geting accuracy based on customer information) needs to be done on a limited basis to avoid a prisoner's dilemma outcome. However, these studies usually overlook the consumer's privacy calculus. They assume that consumer information is exogenously given to firms or readily available by incurring some costs.

To advance our understanding of the privacy protection issue, we need to consider the privacy calculus from the viewpoint of the firm as well as that of the consumer. In this paper, we take a game-theoretic approach to fill the gap in the existing literature by exploring firms' motivations for privacy protection and its impact on competition and social welfare when firms offer product and price personalization to consumers who differ in their level of privacy concerns. In particular, we address the following questions:

1. What is the role of privacy protection (i.e., implementation of FIPs) in the formulation of pricing strategy by personalizing firms? With privacy protection, a firm can expand the *personalization target*, the consumer segment to which it offers personalization, by affecting the privacy calculus of consumers. The question deals with how this change in the personalization target shapes the pricing strategy of firms.

2. What are the equilibrium privacy protection choices? This question pertains to the calculus from the perspective of the firm. Recent empirical findings show that compliance with FIPs by Fortune 500 firms varies across markets and even across firms in the same market (Schwaig et al. 2005, 2006). Considering the impact of privacy protection on pricing and competition, we examine optimal privacy protection strategies under competition for personalizing firms.

3. How does privacy protection affect social welfare, and can it be improved by a government regulation on privacy that enforces that firms implement FIPs? Given the growing concerns of consumers, one of the major public policy issues on privacy is pertinent to the efficiency of privacy regulation, which has been under substantial debate with little consensus reached (Culnan and Bies 2003; Hui and Png 2006; Tang et al. 2008). We formally investigate the welfare impact of privacy protection and regulation in a personalization setting.

The specific setting of this study, personalization, reflects a situation in which the privacy concern issue is most salient.[7] Consumer transactions include not only the *first exchange* (an exchange of goods or services in return for money) but also the *second exchange* (a non-monetary exchange of a consumer's personal information for value, such as personalized offers or discounts) (Culnan and Milberg 1998). Second exchange facilitates the ongoing flow of customer information needed to support the relationship between the firm and the customer and is central to understanding consumer privacy concerns (Culnan and Bies 2003; Culnan and Milberg 1998). Consequently, many studies on privacy concerns have adopted personalization as their research context (e.g., Awad and Krishnan 2006; Chellappa and Shivendu 2008; Cranor 2003; Sheng et al. 2008).

To address these research questions, we consider a stylized model where two firms decide whether to adopt privacy protection, and then compete for consumers by offering standard products to all consumers and personalized products and prices to those consumers who share information. Consumers have three different levels of privacy concerns: the privacy unconcerned, who willingly shares information with firms and is offered personalization in return; the privacy pragmatist, who shares information only with the firms that adopt privacy protection and is offered personalization; and the privacy fundamentalist, who never shares information and thus is offered only standard products.[8] The analysis of this framework generates the following important insights regarding the research questions.

First, we find that privacy protection can work as a competition-mitigating mechanism in personalization. When a consumer is a personalization target of two firms simultaneously, *localized competition* between the firms for the consumer results with the firms attempting to acquire the consumer by lowering the personalized prices for the consumer competitively. In essence, privacy protection facilitates

[7]The concepts of *personalization* and *customization* lack a common, clear distinction. A frequently adopted distinction between the two terms is based on which party is active in the process of tailoring (Arora et al. 2008; Knowledge@Wharton 2002). Specifically, with customization, customers are active, choosing what they want from the firm's offerings, whereas with personalization, customers are passive, with firms addressing individual customers based on their understanding of what customers want. In this study, we use the concept of personalization following this distinction. However, previous studies have not been consistent with the distinction. For example, while customers actively self-select in some customization models (e.g., Dewan et al. 2003; Syam and Kumar 2006), firms address individual consumers in others (e.g., Chen and Iyer 2002; Zhang and Krishnamurthi 2004). Second, some authors argue that one concept encompasses the other (e.g., Imhoff et al. 2001; Riemer and Totz 2003; Roberts 2003; Wind and Rangaswamy 2001). Finally, customization and personalization are sometimes used interchangeably (e.g., Peppers et al. 1999).

[8]For simplicity, we refer to the privacy unconcerned, the privacy pragmatists, and the privacy fundamentalists as the unconcerned, the pragmatists, and the fundamentalists, respectively.

the expansion of the personalization target by inducing information sharing from the pragmatists. In turn, the expansion produces the potential of localized competition for the consumers in both firms' personalization targets simultaneously as well as the potential of profit extraction from the consumers who belong to only one firm's personalization target.

Given such potential of protection, especially when one firm adopts protection but the other does not (termed *asymmetric privacy protection* choices), they can enhance the profit extraction ability and limit localized competition by generating asymmetry in personalization targets, a larger one for the protecting firm and a smaller one for the non-protecting firm. In this case, we find that both firms charge higher standard prices than they would in the absence of protection. Both firms' personalized prices for the unconcerned also increase with protection. Further, the protecting firm sets prices higher on average for pragmatists than it would in the absence of protection, when the proportion of the pragmatists is large. The presence of the competition-mitigating mechanism implies that privacy protection is not necessarily a passive reaction to address consumer privacy concerns; instead, it can be a proactive measure taken by profit-maximizing firms to exploit consumer information in the age of the information economy.

Second, our analysis shows that, in equilibrium, both symmetric and asymmetric choices of privacy protection can result, depending on the investment cost of protection and the degree of overlap between the personalization scopes of both firms.[9] We find that even when the investment cost is low, both firms do not necessarily adopt privacy protection. When the personalization scopes of the two firms do not overlap much, privacy protection enables each firm to extract substantial profit from the large segment of consumers who belong to the firm's personalization target only, which exceeds the low investment cost. Thus, both firms adopt privacy protection. On the other hand, when the personalization scopes of the two firms overlap significantly, only one firm protects in equilibrium. The major driver of this result is the incentive to avoid the potential of localized competition for the consumers in both firms' personalization targets simultaneously and to exploit the competition-mitigation effect of asymmetric protection choices. Next, when the investment cost is intermediate, only one firm adopts privacy protection. Given that one firm chooses privacy protection, the other firm cannot maximize its profit through privacy protection, because incremental profit from protection cannot offset the substantial investment cost, resulting in asymmetric choices. The rationale for this differentiated strategic choice is the same as previously given. Finally, when the investment cost is very high, neither firm protects because the investment cost cannot be justified at all.

This result may help explain why sufficient protection of privacy is not common practice. From the normative perspective, this result identifies the optimal privacy protection strategies of personalizing firms under competition. We further find that as there are either more fundamentalists or fewer unconcerned consumers, it is more likely that both firms adopt privacy protection.

Third, our analysis provides insights for the impact of privacy protection on welfare and the efficiency of government regulations that enforce FIPs. We show that autonomous choices of privacy protection by personalizing firms may improve social welfare at the expense of consumer welfare. The main reason for the welfare gain is that with privacy protection, more consumers share information and thus are offered personalized products that fit with their preferences, which in turn eliminates the disutility the consumers would incur from the standard products that do not fit with their preferences. However, the ability to personalize prices enables firms to squeeze profits from consumers, and therefore from more consumers under privacy protection. Consequently, consumer welfare decreases when privacy protection is adopted.

Moreover, we find that privacy regulation enforcing the implementation of FIPs can be socially desirable when only one firm would choose to protect in equilibrium without regulation. Regulation induces all pragmatists to share information and be offered personalization. The underlying logic of welfare gain by the consumers is similar to that in the preceding paragraph. Specifically, we find that when the proportion of pragmatists is high, regulation can improve social welfare because, in this case, regulation creates substantial welfare gain by incurring an intermediate level of protection cost to the firm that would not have offered protection without regulation. However, we find that social welfare always decreases with regulation when neither firm would choose to protect without regulation. Overall, our analysis suggests that the efficiency of privacy regulation for personalizing firms is contingent on circumstances.

The rest of this paper is organized as follows. Related literature is reviewed in the following section. We then present the

[9]For example, if one online apparel retailer offers skirts with lengths ranging from "above the knee" to "mid-calf" while the other retailer's offering is from "at the knee" to "floor length," then both ranges amount to the respective retailers' personalization scopes. The scopes overlap each other between "at the knee" and "mid-calf." Personalization scope will be formally defined in the "Model" section of this paper.

basic model and discuss its characteristics. In subsequent sections, we first examine the pricing strategy of each firm given the privacy protection choices of the firms, and then we analyze the equilibrium privacy protection choices of the firms. Afterward, we explore the welfare impact of privacy protection and privacy regulation. Several variations of the basic model are also examined. Finally, we conclude with a discussion about our findings and suggestions for future research.

Related Literature

This study builds on and contributes to three streams of research. The first stream examines the behavioral characteristics of consumer privacy concerns and information disclosure. In general, it has been found that privacy concerns negatively influence consumers' willingness to disclose personal information in transactions (Culnan and Armstrong 1999; Dinev and Hart 2006; Malhotra et al. 2004; Stewart and Segars 2002).[10] Extensive examinations of consumers' attitudes toward their privacy have shown that consumers are heterogeneous in terms of desired levels of privacy (Harris Interactive 2002; Harris Louis & Associates and Westin 1991). A widely used classification based on the level of privacy concerns includes three groups of consumers: privacy unconcerned, privacy pragmatists, and privacy fundamentalists, in ascending order. The notion of the privacy calculus suggests that individual decision processes prior to the disclosure of personal information involve a comprehensive assessment of the costs and benefits related to information disclosure (Culnan and Armstrong 1999; Dinev and Hart 2006; Laufer and Wolfe 1977). Consequently, under proper privacy protection measures, such as FIPs, privacy-concerned people tend to willingly disclose their information (Awad and Krishnan 2006; Culnan and Armstrong 1999; Hui et al. 2007).

An implicit assumption of these studies is that firms can improve performance by addressing and reducing consumers' privacy concerns and thereby inducing them to share personal information. Whereas the studies are well-focused on the consumer-side privacy calculus, they are usually missing the firm-side privacy calculus (an assessment of the costs and benefits related to privacy protection). Our paper contributes to this research stream by incorporating the firm's calculus, in the context of personalization. Further, we consider the calculus in a competitive setting, whereas the above studies mainly focus on the relationship between a single firm and its customers. With this setup, we generate a normative insight on how to *effectively manage* the privacy concerns in personalization instead of suggesting *reducing* the concerns, as is frequently claimed in the cited literature.

Second, this study is also related to the research stream on personalization and customization. In this literature, firms tailor only prices (e.g., Chen and Iyer 2002; Chen et al. 2001; Choudhary et al. 2005; Shaffer and Zhang 1995, 2002, Thisse and Vives 1988) or both products and prices (e.g., Dewan et al. 2000, 2003; Ghose and Huang 2009; Syam and Kumar 2006). One major finding from the literature's early studies is that when symmetric firms adopt personalization or customization, a prisoner's dilemma generally results in which all firms become worse-off with the adoption (Chen et al. 2001; Choudhary et al. 2005; Dewan et al. 2000; Shaffer and Zhang 1995; Thisse and Vives 1988). This is mainly because pricing flexibility enables firms to address each consumer with a personalized offering and, as a result of competition, the firms try to acquire each consumer by lowering the prices for the consumer competitively.

However, recent studies have identified several mechanisms that enable firms to avoid the prisoner's dilemma. For example, asymmetry between firms can produce such mechanisms. Shaffer and Zhang (2002) find that when competing firms differ in size of loyal consumers, the larger firm may benefit from personalized pricing that increases its market share. Dewan et al. (2003) show that when competing firms adopt customization sequentially, the early adopter enjoys an advantage and may deter the entry of potential competitors by strategically investing in customization. Another mechanism involves expansion of market coverage. It has been identified that when the market is not fully covered, firms can widen their market coverage and thus increase profits by tailoring products (Syam and Kumar 2006) or personalizing prices (Choudhary et al. 2005). Finally, when targeting accuracy is imperfect, individual marketing can lead to a win–win outcome by lessening price competition, even though the market does not expand (Chen et al. 2001).

While this research stream has generated significant insights on the competitive impact of personalization or customization, it has usually overlooked the consumers' privacy calculus and assumed that consumer information is exogenously given to firms or readily available by incurring some costs. By contrast, our model considers consumer privacy concerns and its heterogeneity across consumers, consistent with the previous empirical findings. Such a setup leads us to complement the research stream by identifying another competition-mitigating mechanism in personalization: the strategic choice of privacy protection. Further, we find that the composition of hetero-

[10]For a summary of empirical studies on information privacy, refer to Awad and Krishnan (2006).

geneous consumer segments can affect pricing strategies, firm performance, and equilibrium protection choices.

Third, this study is related to the literature on the economics of privacy and privacy regulation. The early literature on privacy argues that the use of personal information leads to socially efficient outcomes, and therefore there is no need for privacy regulation (Posner 1981; Stigler 1980). However, this literature ignores the cost of information collection (Hui and Png 2006).

Given the expansion of privacy intrusions and the advance of technologies for privacy protection, a growing body of literature has examined the welfare implications of privacy policies in various settings: a single-seller setting in a single market (e.g., Acquisti and Varian 2005; Chellappa and Shivendu 2008), a single seller in a multi-market setting (e.g., Taylor 2004) and a setting with multiple sellers (e.g., Bouckaert and Degryse 2006; Tang et al. 2008). The results from these studies generally indicate that welfare impact of privacy regulation is not consistent across different settings.

For example, Bouckaert and Degryse (2006) find that when firms can set different prices based on personal information, social welfare increases unambiguously with the degree of privacy protection enforced when there are a small number of sellers, but the welfare is non-monotone in the degree of privacy protection in a free-entry setting where firms can freely enter the market. Tang et al. (2008) compare social welfare under different privacy protection regimes. In their two-seller model, firms offer standard (non-personalized) products with uniform pricing to both privacy-insensitive consumers and privacy-sensitive consumers, who incur a utility loss when their privacy is not protected. They demonstrate that social welfare under government regulation cannot be higher than that under autonomous choices when consumers are sure that firms adopting protection will indeed fulfill protection. Acquisti and Varian (2005) show that in a single-seller setting, privacy regulation that makes customer tracking infeasible can raise or lower social welfare depending on the characteristics of consumer segments.

Overall, whether privacy regulation increases social welfare is contingent on the specific circumstances, suggesting that regulation should be tailored to the circumstances (Hui and Png 2006). This result calls for the analyses of various settings involving privacy regulation. Our study contributes to the literature by investigating the welfare impact of privacy regulation when competing firms offer product and price personalization to consumers with different privacy concern levels, a setting that to our knowledge has not been covered in the literature. Our result illustrates that privacy regulation can be desirable from the social perspective by limiting the competition-mitigation incentives of firms when there is a sufficient size of privacy pragmatists.

Model

In this section, we develop a basic model to address the research questions. The model incorporates essential features of privacy protection in a personalization setting such as product and price personalization, consumer privacy concerns, and the investment by firms in privacy protection. The basic model presented here is further extended in the "Model Extension" section.

Composition of Consumer Segments

Consider a market with two competing firms, A and B. The market has a unit mass of consumers. Each consumer buys at most one unit of the product from A or B. Consumers in our model are assumed to be different in terms of two dimensions: preference and privacy concern level.

First, consumers have different preferences or tastes for the product. For example, of the consumers for a sweater from myShape.com or zafu.com, some may prefer a petite sweater while others may prefer a larger one. This difference is a prerequisite for personalization because if there were no difference in preference, personalization would not be necessary. To capture the difference, we assume that consumer preferences are uniformly distributed on the line [0, 1].[11] Each consumer is identified by a point or location in the line that represents her ideal preference for the product. Thus, the distance between the locations of two consumers is proportional to the difference between their preferences. Each consumer has a reservation value, or willingness to pay, of R for a product that fits with her preference perfectly. We assume that R is sufficiently high to ensure that all of the consumers buy the product from one of the firms. A consumer incurs loss of value, or in other words, disutility, tx from consuming a product that does not fit perfectly with her preference, where t measures the intensity of preference and x represents the distance between the location of the consumer's ideal pre-

[11] In general, preferences can be classified into two types (Choudhary et al. 2005; Syam et al. 2005). One is preference over quality attributes—attributes that exhibit a "more is better" property for every consumer (e.g., duration of the money-back guarantee or speed of a service). The other is preference over those attributes for which consumers have different tastes or desired levels (e.g., the length or color of a skirt). In this study, we consider the second type of preference.

Table 1. Notations of the Model

Notation	Description
R	Consumer reservation value
t	Consumers' preference intensity parameter
x	Consumer location in terms of the preference
u	Proportion of the unconcerned
v	Proportion of pragmatists
w	Proportion of fundamentalists (= $1 - u - v$)
s	Personalization scope parameter
p_i	Price of standard product of firm i, where i = A, B
$q_i(x)$	Price of personalized product of firm i offered to consumers at location x
K_P	Fixed cost that a firm incurs to protect privacy by implementing FIPs
K_I^u	Cost that a firm incurs to gather information on the unconcerned
K_I^{u+v}	Cost that a firm incurs to gather information on the unconcerned and pragmatists
K	Investment cost of privacy protection (= $K_P + K_I^{u+v} - K_I^u$)
π_{ki}	Profit of firm i in Case k, where i = A, B and k = 1, 2, 3

ference and the location of the product in the line. Thus, the net value to a consumer of a product with a distance of x is $R - tx$. The notations of the model are summarized in Table 1.

Second, in addition to their preferences, consumers in our model are heterogeneous in terms of their attitude toward information privacy. Following the widely used classification suggested by Westin (Harris Interactive 2002; Harris Louis & Associates and Westin 1991), we segment consumers into three groups based on the levels of privacy concerns: *privacy fundamentalist*, *privacy unconcerned*, and *privacy pragmatists*.

Fundamentalists feel very strongly about privacy matters. They are usually distrustful of organizations that ask for their personal information and are firmly resistant to any invasion or use of it. Thus, we assume that fundamentalists do not share their personal information with any firm (see Figure 1). At the other extreme are the unconcerned, who have no real concerns about privacy. They are generally trusting of organizations that collect their personal information and the use of it by those organizations. Therefore, the unconcerned are assumed to be always willing to share their personal information with firms they interact with, for example, through web site registrations, surveys, browsing of sites, and transactions. Those in the middle are called pragmatists; they have strong opinions about privacy and are concerned about protecting themselves from the misuse or abuse of their personal information. However, when they believe proper care will be taken to prevent the misuse of their personal information, they generally do allow firms to access and use the information. Thus, pragmatists are assumed to share personal information only with firms that protect their privacy, that is, those implementing FIPs. A recent survey of 1,010 adults in the United States by Westin and Harris Interactive found that the percentage of fundamentalists, pragmatists, and the unconcerned are respectively 26 percent, 64 percent, and 10 percent (Taylor 2003).[12]

We denote the sizes of the unconcerned, pragmatist, and fundamentalist segments as u, v, and w (= $1 - u - v$), respectively. Further, we assume that while the sizes of the three segments are commonly known to the firms, a firm cannot discern between the unconcerned and the pragmatists in its customer database.[13]

Offerings of Standard and Personalized Products

Each firm offers a standard product that is differentiated from the product offered by its competitor. We assume that firms'

[12]A more recent poll of 2,337 U.S. adults on the use of personal health information found that those with the highest concern about privacy represented about 21 percent and those with the lowest concern represented about 28 percent of the respondents (Krane 2007). A survey of 2,513 U.S. adults on websites that customize contents shows that 7 percent of respondents were very comfortable with websites tailoring contents, but 25 percent were not at all comfortable (Krane 2008).

[13]We provide the results when firms *can* discern between the unconcerned and pragmatist in the "Model Extension" section.

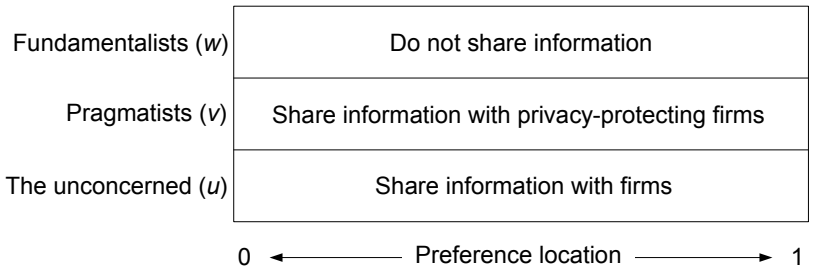


Figure 1. Market Segments

standard products are located at the ends of the line, firm A at 0 and firm B at 1. Each firm produces its standard product at a constant marginal cost, which is assumed to be zero without loss of generality. The standard product is available to all consumers. Each firm charges a single price for its standard product. Let p_i denote the price of firm i's standard product, where i = A or B.

Additionally, firms offer personalized products to those consumers who share their personal information. They are based on the individual consumers' preferences that have been inferred from their personal information (e.g., see the myShape.com, Zafu.com, and Capital One cases in the "Introduction" section).[14] Because fundamentalists do not share their personal information with any firm, both firms offer only standard products to these consumers. On the other hand, firms offer both standard and personalized products to the unconcerned, who willingly share their personal information with the firms. Finally, pragmatists share personal information only with firms that protect their privacy. Thus, a firm that protects privacy offers pragmatists both personalized and standard products, while a firm that does not protect privacy offers only the standard product to them. This implies that by protecting consumer privacy through implementing FIPs, a firm can widen its personalization target, the consumer segment to which it offers personalization, to the pragmatist segment in addition to the unconcerned segment.

With the information on individual consumers' preferences, firms personalize their products and prices at a constant marginal cost, c (≥ 0). Because the main results of the paper remain the same as long as c is not sufficiently large, we assume $c = 0$ for simplicity. This assumption is also consistent with the previous literature (Acquisti and Varian 2005; Dewan et al. 2003; Syam et al. 2005).

We assume that a personalized product tailored to a consumer fits her preference perfectly, which has been widely adopted in the literature (e.g. Chen and Iyer 2002; Choudhary et al. 2005; Ghose and Huang 2009; Shaffer and Zhang 2002). Thus, the consumer incurs no disutility due to unfitness from consuming the product. This assumption implies that the results in this paper should be interpreted as the solution to an important limiting case. Actually, Zafu.com found that 94 percent of the women who went through its personalization process responded that the products "fit them great" (Tedeschi 2006).

The firms in our model also personalize the prices of the personalized products.[15] Both myShape.com and Zafu.com personalize prices in the forms of personalized coupons or personalized member benefits. Capital One also personalizes the prices of the products (credit cards) in terms of annual fees and annual percentage rate. Note that because we are considering personalization, not customization, each consumer who shares personal information with a firm receives a single personalized product and price offering from the firm in accordance with her preference.[16]

Personalization Scope of the Firm

We allow firms to have a limited scope of personalization instead of being able to offer personalization to consumers regardless of their preferences. *Personalization scope* of a firm is defined as the length of the line inside the preference

[14]In this paper, we use the term *share* in a broad sense. We identify information-sharing consumers with consumers who provide (correct) information, allow themselves to be tracked, and accept receipt of personalized offerings.

[15]Specifically, firm i charges $q_i(x)$ for its personalized product tailored to consumers whose preferences are located at x.

[16]In contrast, when a firm offers customization, a consumer can choose any pair from a menu of products and prices.

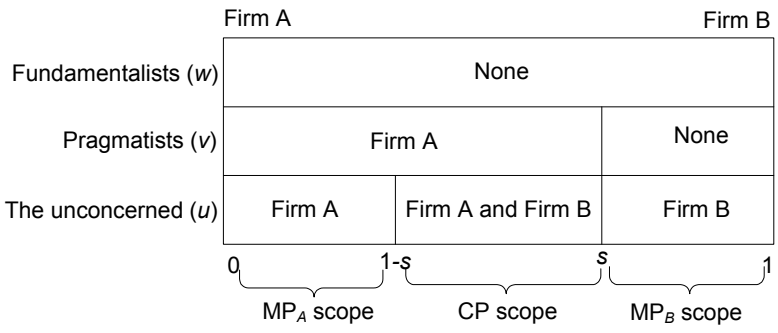


Figure 2. Personalization Offerings When Only Firm A Protects Privacy

line [0, 1] over which the firm produces the personalized products. Specifically, firm A can offer personalization to the consumers whose preferences are located between 0 and s ($\leq$ 1), while firm B can offer personalization to those consumers located between $1 - s$ and 1. Therefore, both firms have the same length of personalization scope that is measured by s. Because competitive interaction between both firms is more salient when their personalization scopes overlap, we assume that s is larger than one-half. The personalization scope s can result from the limitation of customer information available. We can expect that interactions between a firm and a consumer decrease with the distance between them on the preference line. A firm can obtain sufficient information about its own loyal customers and switchers, but obtaining such information for other firms' loyal customers can be prohibitively high (Arora et al. 2008; Chen et al. 2001). Chen and Iyer (2002) also suggest that a firm may have the incentive to enhance their database for the consumers who have higher preferences to its product because they have a higher willingness to pay.

Given a limited personalization scope, only firm A can offer personalization to the information-sharing consumers whose preferences are in the interval $[0, 1 - s]$, termed firm A's *monopoly personalization* (MP_A) *scope*. Similarly, only firm B can offer personalization to the information-sharing consumers in the interval $[s, 1]$, termed firm B's monopoly personalization (MP_B) scope. The remaining information-sharing consumers in the middle, $(1 - s, s)$, can be offered personalization by both firms when they share information with both firms. The interval is termed the *competitive personalization* (CP) *scope*.

Figure 2 illustrates personalization offerings by both firms to each consumer segment when firm A protects privacy but firm B does not. Because all of the unconcerned consumers share personal information, they are offered personalization by either or both firms depending on their preference locations: those in the MP_A scope are offered by only firm A; those in the MP_B scope are offered by only firm B; and those in the CP scope are offered by both firms. On the other hand, only firm A, which protects privacy, can offer personalization to pragmatists. Thus, pragmatists in firm A's personalization scope $[0, s]$ are offered personalization by firm A. However, those pragmatists in $[s, 1]$ are not offered personalization by any firm.

When neither firm protects privacy, pragmatists do not share personal information. As a result, none of the firms offer personalization to them. When both firms protect privacy, pragmatists are offered personalization depending on their preference locations in the same way as the unconcerned.

In this way, our model allows not only the possibility that a firm exclusively addresses a consumer with product and price personalization, but also the possibility that both firms have information about a specific consumer and compete for the consumer with personalization. Further, each firm can change its personalization target through privacy protection, and the resulting personalization offerings to each segment by both firms are determined by the combination of privacy protection choices by the firms.

Costs of Privacy Protection and Customer Information Base Building

FIP implementation incurs a cost because offering notice, choice, access, integrity, and enforcement require managerial and technology investment in personnel and infrastructure (Tang et al. 2008). Thus, we assume that privacy protection incurs a fixed cost, K_P, the same across the firms. The 2004

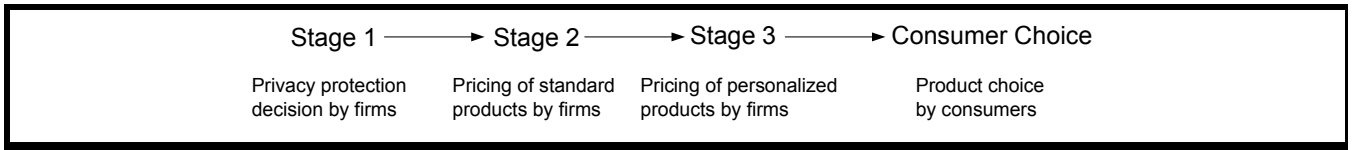


Figure 3. Stages of Decision Making

Cost of Privacy Study conducted by IBM and the Ponemon Institute shows that this cost includes spending on privacy offices and staff, training, IT, policies and procedures, auditing, and enforcement, and it varies considerably across industries from $5 million up to $10 million annually (von Reden 2004). In practice, firms may adopt FIPs partially (i.e., adopt a subset of the principles). As a result, some but not all pragmatists may share their information. Although we do not consider that possibility, we believe that our main results in this paper would not change under such a modification.[17]

Accumulating and processing customer information for personalization also incurs a cost to the firm, termed the *information cost*. The level of this cost would depend on the amount of information to be accumulated and processed in the databases. We denote K_I^u the information cost that a privacy non-protecting firm incurs collecting information on the unconcerned. We also denote K_I^{u+v} the information cost that a privacy-protecting firm incurs collecting information on the unconcerned and pragmatists. Note that the existence of the fixed cost of privacy protection (K_P) guarantees that if a firm protects privacy, it necessarily collects information on pragmatists, because to protect privacy and to not collect information on the pragmatists is always dominated by not protecting privacy at all. The *investment cost of privacy protection*, denoted by K, is the sum of the fixed cost of privacy protection (K_P) and the incremental information cost ($K_I^{u+v} - K_I^u$).[18]

The Sequence of Firms' Decisions in the Game

In our model, firms have three stages of decision, in which each firm's commitment to personalization is assumed.[19] Figure 3 shows the stages. In the first stage, the firms simultaneously decide whether to adopt privacy protection, and then each firm gathers personal information on the unconcerned and pragmatists (if it adopts privacy protection). In the second stage, both firms choose the prices of their standard products, p_A and p_B. Finally, in the third stage, both firms set the prices of their personalized products, $q_A(x)$ and $q_B(x)$, depending on the location x. Finally, each consumer chooses the product that maximizes net benefit (the value of the product minus its price) out of the product offerings available.

We analyze the game by backward induction, where we first consider the last stage of decision making to determine which decision each firm should make in each possible situation to maximize its profit, and then we determine which decision each firm should make at stage 2, and so on.[20] Thus, first we solve for equilibrium pricing of personalized products for each firm to maximize its profits, given their privacy protection choices and standard product prices. Using this result, we then analyze the pricing of standard products by the firms. Finally, we solve for the equilibrium privacy protection choices.

Competition Under Firms' Privacy Protection Choices

We have three distinct combinations of privacy protection choices (Stage 1 in Figure 3): neither firm protects privacy (<No-Prot, No-Prot>); only one firm, say firm A, protects privacy (<Prot, No-Prot>), referred to as *asymmetric privacy protection*; or both firms protect privacy (<Prot, Prot>), refer-

[17]Partial compliance with FIPs could be considered by modeling privacy concerns of pragmatists as continuously distributed.

[18]Because we are not focused on the specific processes of information accumulation, we simplify the analysis by examining a one-period model only, thus abstracting from any prior competition for the customer information. In the "Model Extension" section, we discuss a two-period model in which customer information is accumulated through transactions in the first period.

[19]We examine the decision on the adoption of personalization in the "Model Extension" section.

[20]In game-theoretic terms, we use subgame perfect equilibrium as our solution concept.

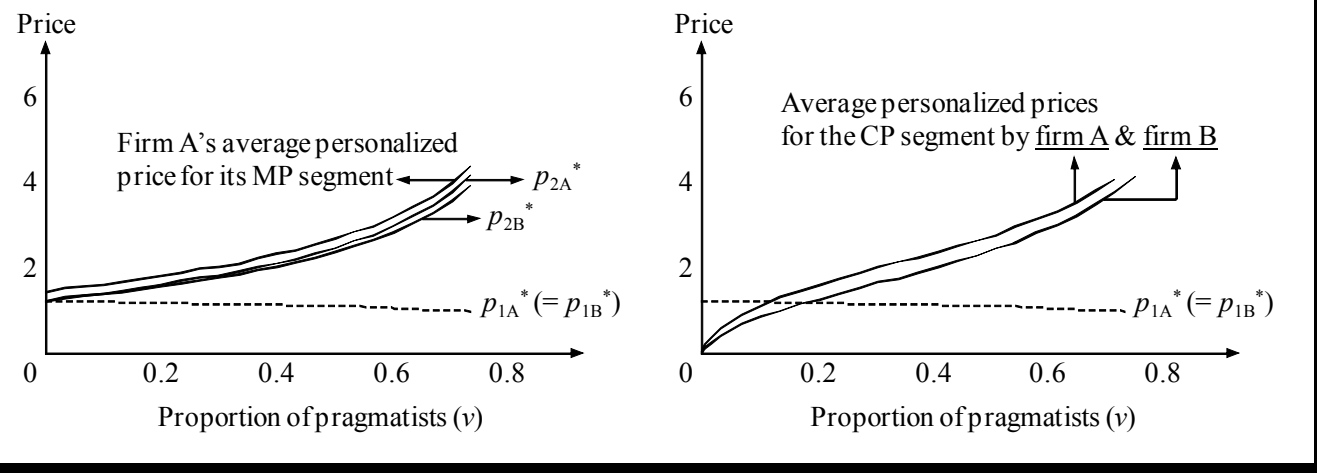


Figure 4. Illustration of Equilibrium Prices (s = 3/4, t = 1,u = (1 – v)/3, w = 2(1 – v)/3)

red to as *symmetric privacy protection*.[21] These three cases are denoted by Cases 1, 2, and 3, respectively. In each case, both firms price standard products (Stage 2) first and then personalized products (Stage 3). Pricing in each of the cases is analyzed in the Appendix.

We can derive the effect of asymmetric privacy protection on the pricing strategies of the firms, by comparing the prices charged by each firm for each consumer segment under asymmetric adoption of privacy protection (Case 2) with the prices under no protection (Case 1). Proposition 1 summarizes the results.

Proposition 1: Asymmetric adoption of privacy protection can mitigate price competition. Specifically, (i) both firms charge higher standard prices than in the absence of protection; (ii) both firms charge personalized prices for their MP segments, and for the unconcerned-CP segment, higher on average than the corresponding prices for the segments in the absence of protection; (iii) when the proportion of pragmatists (v) is not small, firm A charges personalized prices for the pragmatist-CP segment higher on average than its standard price in the absence of protection; (iv) all of the standard prices and the average personalized prices for each segment by both firms are increasing in the proportion of pragmatists.

Proposition 1 states that both firms charge all segments higher prices with the asymmetric adoption of protection, as long as the proportion of the pragmatist segment (v) is not small. Figure 4 illustrates this result. The proposition highlights a critical role of privacy protection in competition between personalizing firms, and suggests that asymmetric privacy protection can mitigate price competition between personalizing firms. Privacy protection leads more consumers to share personal information by mitigating the privacy concerns of pragmatists. Thus, asymmetric privacy protection choices create asymmetric customer information bases between firms, a larger customer information base for the protecting firm and a smaller one for the non-protecting firm. Given the asymmetric information bases, the protecting firm has a strong incentive to extract profit from pragmatists by offering personalization exclusively, and therefore less of an incentive to compete fiercely for the unconcerned-CP segment. As the size of the pragmatist segment increases, the asymmetry in information bases increases and so does the incentive to extract profit from the segment by pricing higher. Hence, the non-protecting firm can also charge higher-on-average personalized prices for the unconcerned-CP segment, generating a higher profit. Therefore, as the right panel in Figure 4 shows, the average prices of both firms for the CP segment increase with v and are larger than the standard prices in Case 1 for a sufficiently large v. Finally, given the potential of higher profits from the CP segment through personalization, both firms have less incentive to compete for the consumers who are offered only standard products of the firms. Accordingly, standard prices also increase, as illustrated in the left panel of Figure 4.

Privacy protection by firm A enables profit extraction not only from the pragmatist-CP segment but also from the pragmatist-MP_A segment. Further, firm B has its own MP segment in which it can maximize profit with the combination

[21]Note that the <No-Prot, Prot> case is symmetric to the <Prot, No-Prot> case. When only one firm protects, we assume that firm A is the protecting firm.

of product and price personalization, without direct competitive pressure from its competitor. Thus, the above result may seem to be the consequence of the presence of MP segments. However, we find that as long as v is large enough, firm A's profit extraction incentive is sufficiently strong that the above proposition holds even in the absence of MP segments ($s = 1$).

In summary, Proposition 1 indicates that under consumer privacy concerns, privacy protection can work as a mechanism to mitigate price competition by generating asymmetry in customer information bases and by enhancing profit-extraction incentives of the firms. By considering the heterogeneity of consumer privacy concerns and the availability of privacy protection by the firms, Proposition 1 suggests another mechanism to lessen price competition in personalization that the previous literature did not identify.

Next, we examine the effect of symmetric privacy protection of the firms (Case 3) on their pricing strategies, by comparing the prices charged in Case 3 with the prices under no protection (Case 1). We find that when both firms choose privacy protection, they set the standard price higher than that under no protection. Because personalized products with perfect fit provide higher value to consumers than standard products, the firms can increase the prices of personalized products for their MP segments corresponding to the increase of standard prices. Thus, personalized prices charged for the MP segments also increase. The price gap between both cases increases with the size of the pragmatist segment (v).

However, note that symmetric privacy protection expands not only each firm's MP segment to pragmatists in its MP scope, but also the CP segment to pragmatists in the CP scope. Because both firms try to acquire each consumer in the CP segment with personalized products that fit with the consumer's preference, they competitively lower the prices for the consumer, generating localized competition and aggregating the profit from the consumer. This result suggests an inherent tradeoff in the symmetric adoption of privacy protection.

Equilibrium Privacy Protection Choices

In this section, we analyze the first stage of the game, in which each firm decides whether to protect consumer privacy by incurring investment cost. Using the equilibrium profits and related protection and information costs in Cases 1 (no protection) to 3 (symmetric protection), we derive the equilibrium choices of the firms. The results are given in Proposition 2 and Table 2. Let π_1^* and π_3^* denote each firm's equilibrium profit in Cases 1 and 3, respectively, and π_{2i}^* denote the equilibrium profit of firm i in Case 2 (asymmetric protection).[22]

Proposition 2: For all K and s, there exists a unique equilibrium. (i) When the investment cost is low ($K \le \pi_3^* - \pi_{2B}^*$), both firms adopt privacy protection in equilibrium if the personalization scope is small ($s \le s'(u, v, w)$); but only one firm adopts privacy protection if the personalization scope is large ($s > s'(u, v, w)$). (ii) When the investment cost is moderate ($\pi_3^* - \pi_{2B}^* < K \le \pi_{2A}^* - \pi_1^*$), only one firm adopts privacy protection. (iii) When the investment cost is high ($K > \pi_{2A}^* - \pi_1^*$), neither firm adopts privacy protection.

Proposition 2 shows that equilibrium protection choices depend on the personalization scope and the investment cost. We first examine the result when the investment cost is low ($K \le \pi_3^* - \pi_{2B}^*$). From Table 2, we can see that even when the investment cost is zero, both firms do not always choose privacy protection. While both firms adopt privacy protection for $s \le s'$, only one firm adopts for $s > s'$. When the personalization scope is small (i.e., each firm's MP scope is large), privacy protection enables substantial profit extraction from the large MP segment, exceeding the low investment cost.

On the other hand, when the personalization scope is large, only one firm chooses privacy protection. The major driver of this result is the competition-mitigation effect of asymmetric protection choices identified in Proposition 1. Given that firm A chooses to protect privacy, firm B cannot maximize its profit by enlarging its personalization target through privacy protection. This is because under the large personalization scope, firm B's incremental profit extraction which the protection would enable is not substantial and is dominated by the enhanced competition effect from the increased CP segment (pragmatists in addition to the unconcerned in the CP scope). Faced with this situation, firm B strategically differentiates its privacy management policy, or it chooses to not protect at all. This leads firm A to enjoy the profit from its MP segment without any increase of the CP segment, reducing firm A's incentive to compete for the consumers in the other segments. Thus, firm B can also enjoy profit without any investment in privacy protection. In fact, we find that firm B's standard price in Case 2 is higher than in the other cases.[23]

[22]Note that these profits do not include protection cost or information cost.

[23]The asymmetric equilibrium choices suggest an analogy with the quality differentiation literature in which firms differentiate equilibrium choices of product quality in order to weaken head-to-head price competition (see Moorthy 1988). However, our model can have symmetric equilibria in addition to the asymmetric one, depending on the conditions as specified in Table 2.

Table 2. Equilibrium Choice of Privacy Protection

Investment Cost \ Personalization Scope	$s \le s'(u, v, w)$	$s > s'(u, v, w)$
$K \le \pi_3^* - \pi_{2B}^*$	<Prot, Prot>	<Prot, No-Prot>
$\pi_3^* - \pi_{2B}^* < K \le \pi_{2A}^* - \pi_1^*$	<Prot, No-Prot>	
$K > \pi_{2A}^* - \pi_1^*$	<No-Prot, No-Prot>	

Next, when the investment cost is intermediate ($\pi_3^* - \pi_{2B}^* < K \le \pi_{2A}^* - \pi_1^*$), only one firm protects privacy even when the personalization scope is small ($s \le s'$). Suppose again that firm A chooses privacy protection. Firm B cannot maximize its profit through privacy protection, because incremental profit extraction cannot justify the substantial investment cost. Instead, firm B differentiates itself by choosing to not protect privacy. The rationale and the effect of this differentiated strategic choice are the same as given above. Since the cost effect dominates the possible profit extraction effect, only one firm chooses privacy protection, regardless of the size of the personalization scope. Finally, when the investment cost is very high ($K > \pi_{2A}^* - \pi_1^*$), it is intuitively expected that firms will not protect privacy, because the investment cost cannot be justified at all.

Next, by examining the properties of $s'(u, v, w)$ in Proposition 2, we identify the relationship between the consumer segment composition and the equilibrium privacy protection choices for the low investment cost case in the following corollary.

Corollary 1: Suppose that the investment cost is low. (i) As the proportion of fundamentalists (w) increases, both firms are more likely to adopt privacy protection in equilibrium. (ii) As the proportion of pragmatists to the unconcerned (v/u) increases, both firms are more likely to adopt privacy protection in equilibrium.

Although privacy protection is not effective regarding fundamentalists, as it in no way changes their information sharing behavior, the first part of the corollary states that as the proportion of fundamentalists increases, the likelihood that <Prot, Prot> emerges as the equilibrium outcome also increases. The economic logic behind this counterintuitive result is simple. Suppose that firm A chooses privacy protection. As the proportion of fundamentalists increases, firm A's profit extraction from pragmatists decreases, and its incentive to compete for fundamentalists increases.[24] With these two effects combined, the competition-mitigation effect that asymmetric privacy protection would generate is reduced. Therefore, firm B is more likely to choose privacy protection instead of capitalizing on the reduced competition-mitigation effect.

Part (ii) of the corollary indicates the effect of the proportion of pragmatists to the unconcerned on the protection choices. As the relative proportion of pragmatists increases, firm B's guaranteed profit extraction from the unconcerned decreases. On the other hand, the potential profit gain from privacy protection is magnified because of the increased pragmatist segment. Thus, firm B more vigorously pursues privacy protection.

The role of the proportion of pragmatists to the unconcerned is similar to that described in Tang et al. (2008), in which a higher proportion of privacy-sensitive consumers (pragmatists, in our terminology) leads to a higher likelihood of symmetric adoption of privacy protection by competing firms. In their model, firms offer standard products only, and by protecting privacy, a firm can eliminate a constant utility loss privacy-sensitive consumers would incur when their privacy is not protected. However, the firm's product itself, and thus the value the consumers derive from the product, remains the same regardless of privacy protection. Therefore, protection choices are fully determined by the relative magnitude of the cost of protection and the utility gain of the sensitive consumers from protection, which is increasing in the proportion of the sensitive consumers. Thus, all firms choose privacy protection when the cost of protection is lower than the utility gain.

To the contrary, the privacy protection choices in our model affect product offerings in the pragmatist segment and the resulting changes in utility are different across the consumers depending on their preference locations. By incorporating personalization in this way, we find that asymmetric choices of protection can emerge even with zero protection cost.

One major implication of Proposition 2 and Corollary 1 is that firms in different markets may adopt different levels of privacy protection, and even in a given market, competing firms may not always offer the same level of protection. This explains, in part, Schwaig et al.'s (2005, 2006) empirical results

[24]It is easily verified that the standard prices of both firms are decreasing in w in the three cases.

showing that compliance by Fortune 500 firms with FIPs varies across markets and even across firms in the same market.[25]

Another implication is that privacy protection is not necessarily used reactively to address consumer privacy concerns; instead, it can be used proactively by profit-maximizing firms to leverage consumer information in the age of the information economy and to mitigate head-to-head competition by generating asymmetric customer information bases between firms.[26] In this sense, the variations reported by Schwaig et al. may be a result of rational behavior by firms rather than indicators of a transient state in the diffusion of privacy protection.

Finally, Corollary 1 implies that as consumers become more concerned about their privacy, resulting in more fundamentalists or fewer unconcerned consumers, it is expected that more firms are likely to adopt privacy protection.

Privacy Protection, Social Welfare, and Privacy Regulation

In the preceding section, we analyzed privacy protection choices by competing firms, and showed that privacy protection can increase their profits. In this section, we analyze the effects of privacy protection on consumer welfare and social welfare.[27] We first investigate the welfare impact of privacy protection choices examined in the previous section and then the welfare impact of privacy regulation by the government that enforces FIP implementation.

Welfare Impact of Autonomous Privacy Protection

First, we analyze the consumer-side impact and social impact of privacy protection by comparing consumer welfare and social welfare *without* privacy protection and *with* protection under the autonomous choices of the privacy protection strategy described in Proposition 2. The analysis may provide an answer to the following question: When competing firms *can* choose to adopt privacy protection, can their choices benefit consumers or an entire society? Specifically, we compare consumer welfare and social welfare in each of the <Prot, No-Prot> and <Prot, Prot> equilibriums with those that would result when the firms do not protect privacy at all. Proposition 3 summarizes the findings.

Proposition 3: (i) Consider the equilibrium in which only one firm adopts privacy protection. Suppose the investment cost is low ($K < [1 - 2(1 - s)^2]t/4$). Then, compared with the case without privacy protection, social welfare increases with protection when the proportion of pragmatists is large ($v > v'$), and decreases with protection otherwise ($v < v'$). Under a high investment cost ($K > [1 - 2(1 - s)^2]t/4$), social welfare decreases. Consumer welfare always decreases with protection. (ii) Consider the equilibrium in which both firms adopt privacy protection. Compared with the case without privacy protection, social welfare always increases with protection. But, consumer welfare always decreases with protection.

The above results tell us that when privacy protection is available to personalizing firms, autonomous protection choices can improve social welfare. With privacy protection, more consumers are offered personalized products that suit their preferences; in turn, this eliminates consumer disutility due to unfitness of standard products and generates a welfare gain. Without privacy protection, only the unconcerned are offered personalized products. Under <Prot, No-Prot> equilibrium, the pragmatists in firm A's personalization scope also buy personalized products. If the proportion of pragmatists is large, the welfare gain in this segment is significant enough to offset the investment cost of the firm when the cost is relatively low ($K < [1 - 2(1 - s)^2]t/4$). Thus, as the left panel in Figure 5 illustrates ("K is low" case), social welfare increases for a large v. On the other hand, when the cost is relatively high ($K > [1 - 2(1 - s)^2]t/4$), the welfare gain cannot compensate for the cost (refer to the "K is high" case in the panel).

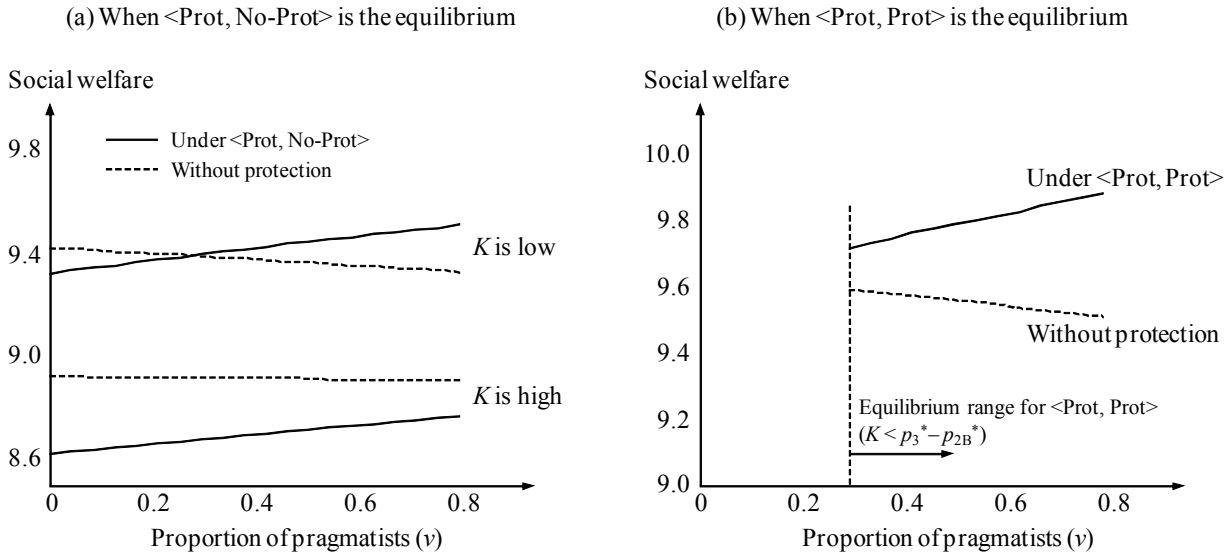
When both firms adopt privacy protection in equilibrium, all of the pragmatists also purchase personalized products. In this case, Proposition 3 states that the welfare gain is so substantial compared with the low investment cost (note the equilibrium condition, $K < \pi_3^* - \pi_{2B}^*$ in Proposition 2) that the social welfare unambiguously increases with the protection. The right panel in Figure 5 provides an illustration for this case.

From the consumer's perspective, however, the proposition indicates that privacy protection always aggravates consumer welfare. On one hand, the ability to personalize prices en-

[25] Although our result is based on the personalization setting, similar industry practices are found in various markets. A study on the privacy practices of key Internet companies (Privacy International 2007) shows that while both eBay and Amazon (in the consumer e-commerce sector) were rated high in their privacy protection, both Google and Yahoo (in the Internet search sector) were given low ratings. In the social network service sector, MySpace was rated highly, whereas Facebook got a low rating.

[26] The equilibrium choices given in Proposition 2 do not involve a prisoner's dilemma outcome.

[27] Formally, *consumer welfare* is the total value consumers receive from a particular product minus the total amount paid. *Social welfare* is the sum of consumer welfare and firm profits.



Note: Parameter values are as follows: $R = 10$, $t = 2$, $u = (1 - v)/3$, and $w = 2(1 - v)/3$; $s = 0.75$, $K_P = 0.1$, $K_I^u = 0.1 + 0.1su$, and $K_I^{u+v} = 0.1 + 0.1s(u + v)$ for "K is small" in the left panel; $s = 0.75$, $K_P = 0.3$, $K_I^u = 0.3 + 0.3su$, and $K_I^{u+v} = 0.3 + 0.3s(u + v)$ for "K is large" in the left panel; $s = 0.55$, $K_P = 0.01$, $K_I^u = 0.01 + 0.01su$, and $K_I^{u+v} = 0.01 + 0.01s(u + v)$ for the right panel.

Figure 5. Illustration of Welfare Impact of Autonomous Privacy Protection

ables firms to squeeze profits from consumers, at least in their MP segments. On the other hand, reduced competition for the fundamentalist segment enables firms to extract more profits from the segment by raising standard prices.[28] With the two forces combined, consumer welfare always decreases when privacy protection is adopted. Thus, privacy protection is beneficial to firms at the expense of consumer welfare. The collection and use of personal information can redistribute benefits among firms and consumers (Hui and Png 2006). Privacy protection, by affecting the ability to collect and use personal information, redistributes benefits in the firm's favor when it offers product and price personalization.

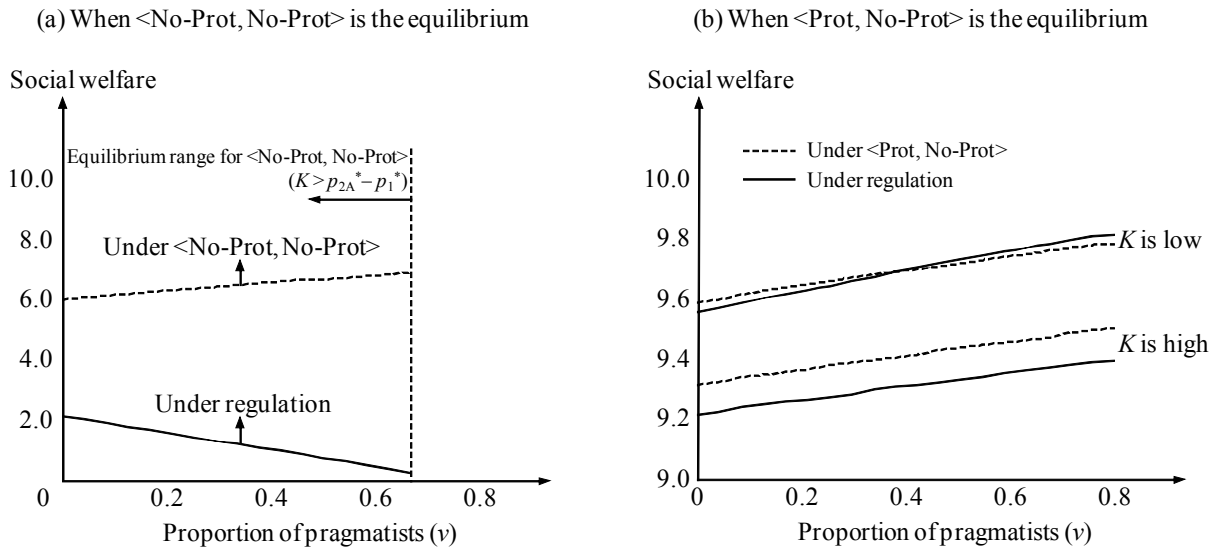
Welfare Impact of Privacy Regulation

Next, we examine the welfare impact of regulation on privacy protection to seek answers to the following questions: Given that all firms do not necessarily choose privacy protection under autonomous protection choices, can privacy regulations improve social welfare compared with the case of autonomous protection choices? If so, when can it do so? Do consumers benefit from such regulation? These questions can be addressed by comparing consumer welfare and social welfare *under the autonomous choices* of the privacy protection strategy in Proposition 2 and those *under the regulation* that enforces FIP implementation. Specifically, we compare consumer welfare and social welfare in each of the <No-Prot, No-Prot> and <Prot, No-Prot> equilibriums with those that would result when the firms are required to protect privacy. The results are summarized in Proposition 4.

Proposition 4: (i) Consider the equilibrium whereby neither firm adopts privacy protection. With regulation on privacy protection, social welfare always decreases. However, consumer welfare increases with regulation when the personalization scope is large ($s > s''$) *and* the proportion of pragmatists is small ($v < v''$), and decreases otherwise. (ii) Consider the equilibrium whereby only one firm adopts privacy protection. Suppose the investment cost is low ($K < (1 - s)^2t/2$). Then, with regulation on privacy protection, social welfare increases when the proportion of pragmatists is large ($v > v^+$), and decreases when the proportion is small ($v < v^+$). Under a high investment cost ($K > (1 - s)^2t/2$), social welfare decreases. Consumer welfare always increases with regulation.

The message of Proposition 4 is that both types of welfare—social and consumer—can increase or decrease with the regulation. When <No-Prot, No-Prot> is the equilibrium protec-

[28]The increased prices can be interpreted as the costs that privacy-concerned consumers pay for their privacy under personalization.



Note: Parameter values are as follows: $R = 10$, $t = 2$, $u = (1 - v)/3$, and $w = 2(1 - v)/3$; $s = 0.8$, $K_P = 2$, $K_I^u = 1 + 3su$, and $K_I^{u+v} = 1 + 3s(u + v)$ for the left panel; $s = 0.75$, $K_P = 0.02$, $K_I^u = 0.02 + 0.02su$, and $K_I^{u+v} = 0.02 + 0.02s(u + v)$ for "K is small" in the right panel; $s = 0.75$, $K_P = 0.1$, $K_I^u = 0.1 + 0.1su$, and $K_I^{u+v} = 0.1 + 0.1s(u + v)$ for "K is large" the right panel.

Figure 6. Illustration of Welfare Impact of Privacy Regulation

tion choice, social welfare always decreases with regulation, because reduction in the pragmatists' disutility due to unfitness of standard products cannot compensate for the high investment cost (note the equilibrium condition, $K > \pi_{2A}^* - \pi_1^*$ in Proposition 2). The left panel in Figure 6 demonstrates the decrease. On the other hand, under <Prot, No-Prot> equilibrium, the regulation can raise the social welfare when the investment cost is relatively low and the proportion of pragmatists is large. Thus, as illustrated in the right panel in Figure 6 (the "K is low" case), the line representing social welfare under regulation crosses that under <Prot, No-Prot> from below as v increases. The underlying economic logic is similar to the explanation for part (i) of Proposition 3.

Our result on the effect of regulation on social welfare contrasts with the result found by Tang et al. (2008), in which firms offer only standard products. In Tang et al., the social welfare under regulation cannot be higher than that under autonomous protection choices by firms, as long as consumers are sure that firms sending signals of privacy protection will indeed fulfill protection.[29] However, when firms offer personalization, we find that privacy regulation can improve social welfare under the condition identified in Proposition 4 (ii).

This inefficiency of autonomous protection choices compared with privacy regulation in our result is related to the competition-mitigation effect of asymmetric protection choices. This can be seen most clearly in the case in which the investment cost is substantially low ($K \rightarrow 0$). Proposition 2 states that because of the competition-mitigation effect, <Prot, No-Prot> emerges as the equilibrium in this case, as long as the personalization scope is large.[30] Then, with regulation, the disutility due to unfitness of standard products incurred by the pragmatist-MP_B segment is eliminated, generating a welfare gain. Since the welfare loss due to additional investment costs by firm B is negligible, social welfare increases. Thus, whereas the competition-mitigation effect can benefit firms in general, it may harm society as a whole.

Consumer welfare is also affected by regulation. Consider the equilibrium <No-Prot, No-Prot>. As the personalization scope increases, the CP scope increases while both firms' MP scopes decrease. Thus, under regulation, the welfare gain of the pragmatist-CP segment increases whereas profit extracted

[29]Examples of the signal include displaying a privacy policy or a seal-of-approval logo such as TRUSTe (Tang et al. 2008). Because we do not consider the role of such signals, our model implicitly assumes that consumers are sure of the firm's fulfillment of protection.

[30]To the contrary, Tang et al. found that all firms adopt privacy protection when the protection cost is negligible.

from the pragmatist-MP segments decreases. Therefore, when the personalization scope is large ($s > s''$), pragmatists' welfare gain is substantial. However, under regulation, standard prices increase, worsening the welfare of fundamentalists (the standard price in Case 3 is higher than that in Case 1; see equations (3) and (5) in the Appendix). Since the standard price in Case 3 is increasing in v, this welfare loss of fundamentalists is not large when the proportion of the pragmatists is small ($v < v''$). As a result, regulation can improve consumer welfare when the two conditions ($s > s''$ and $v < v''$) are satisfied.

Under <Prot, No-Prot> equilibrium, consumer welfare always increases with regulation. Two positive forces under the regulation lead to this result. First, all the unconcerned and pragmatists in the CP scope enjoy a substantial welfare gain because, with symmetric privacy protection enforced by the regulation, both firms competitively lower the prices of the personalized products for the consumers as discussed earlier. Second, standard prices decrease under regulation, improving the welfare of fundamentalists.[31] With these two effects combined, regulation always benefits consumers.

Overall, Proposition 4 indicates that, in some circumstances, privacy regulations can be efficient from the social perspective. They can improve the social welfare by limiting the competition-mitigation incentives of firms, thus lowering firm profits and raising consumer welfare.

Model Extensions

In this section, we provide several variations of our basic model. First, we consider the case in which firms decide whether to adopt personalization before the privacy protection decision. Second, we analyze the scenario where firms can discern between the unconcerned and pragmatists in their databases. Finally, we examine a model in which customer information is obtained through transactions and then personalization is offered based on the information.

When the Decision on Personalization Adoption Is Included

In the preceding sections, we assumed that all competing firms offer personalization. However, in practice, adoption of personalization is a decision variable of the firm. We modify our basic model to include the decision by firms to adopt personalization and to examine whether personalization can be a viable choice in the presence of consumer privacy concerns and privacy protection available to the firms. This can be done by letting firms choose whether to offer personalization or not in the model. The sequence of the extended game is as follows. First, both firms simultaneously decide whether to adopt personalization by incurring a fixed cost (stage 1). This generates three distinct cases: both firms adopt personalization; only one firm adopts personalization; neither firm adopts personalization. Second, privacy protection decisions are made by the firms that have adopted personalization (stage 2). Third, all firms set the prices for their standard products (stage 3). Finally, the firms that have adopted personalization set the prices for their personalized products (stage 4). Note that the first case in stage 1 is the same as our basic model.

Through the analysis of this extended game, we find that given an affordable fixed cost for personalization, *both firms choose to adopt personalization when the personalization scope is not too large, and only one firm adopts personalization otherwise.* When only one firm adopts personalization, the personalizing firm always chooses to protect privacy, as long as the investment cost (K) is not too high.

When Firms Can Discern between the Unconcerned and Pragmatists

We have assumed that firms are unable to discern the unconcerned from pragmatists in their databases. In the <Prot, No-Prot> case, this inability caused firm A's pricing strategy for its personalized products to be the same for both the unconcerned and pragmatists on the same preference location in the CP scope. Thus, its pricing needed to consider the tradeoff between competing for the unconcerned and extracting the profit from pragmatists in the interval. Given this tradeoff, firm B could charge higher personalized prices for the unconcerned in the CP scope than in <No-Prot, No-Prot> case, resulting in a strong competition-mitigation effect.

When firm A can discern between the unconcerned and pragmatists in its database, in the <Prot, No-Prot> case, this ability allows firm A to price personalized products for the CP scope depending not only on the preference locations of individual consumers but also on the degree of their privacy concerns (whether they are pragmatists or the unconcerned).[32] Specifically, the unconcerned segment in the scope is subject to the localized competition as in the <Prot, Prot> case. Thus, both firms' profit from the segment is sharply reduced. How-

[31]From equations (4) and (5) in the Appendix, it can be shown that the standard price in Case 3 is lower than the standard price of each firm in Case 2.

[32]Note that the analysis in the other two cases is not affected by the modification of the model.

ever, firm A can charge pragmatists in this scope the highest possible prices for the personalized products, because it knows that these consumers are not included in firm B's database.[33]

By comparing the profit each firm garnered from the unconcerned and pragmatists in the CP scope with the corresponding profit in the base model, we find that, given the standard prices, while firm A earns the same profit from the consumers, firm B's profit vanishes. This implies that firm B becomes more aggressive in charging its standard price. Thus, *overall, the competition-mitigation effect of asymmetric protection choices decreases when firms can distinguish between the unconcerned and pragmatists*.

The above result implies that *asymmetric choices of protection privacy are less likely, while symmetric adoption by both firms is more likely to be the equilibrium outcome compared with the basic model*. However, we find that the main results of our research remain the same under the modification. We also have an implication regarding the improvement of customer knowledge. When firms have more knowledge about individual consumers and thus can identify each consumer's privacy concern level as well as the consumer's preferences, they can personalize prices along both dimensions of customer knowledge. This enhanced facet of personalization, however, never improves profits. Instead, it can result in a lower profit.

When the Customer Information Base Is Built by Transactions

In our basic model, we assumed away the specific process of accumulating customer information by assuming that firms can collect customer information with a cost K_I. We build a revised model to analyze the case in which customer information is obtained through transactions of products between firms and consumers as follows. The model consists of two periods. In the first period (termed the *information gathering period*), both firms simultaneously decide whether to adopt privacy protection, and then they set the prices of their standard products. Each firm acquires personal information of the unconcerned (and pragmatists as well if the firm protects privacy) who *buy its standard product*. Each firm's personalization scope is determined as a result of the consumers' choices. In the second period (termed the *personalizing period*), each firm offers its standard product to all consumers and personalized products to those consumers who shared personal information with the firm in the first period.

Note that the revised model rules out the possibility of both firms having information on the same consumer, because each consumer buys at most one unit during a single period; that is, there is no CP segment.[34] As one might expect, we arrive at the same qualitative result that we have obtained when the personalization scope approaches one-half in the basic model (refer to Table 2). That is, *both firms protect privacy when the investment cost is low, only one firm protects for an intermediate level of the cost, and neither firm protects when the cost is substantially high*. This result partially supports the validity of our main results in this paper. We also find that *both firms charge lower standard prices in the first period and then set higher standard prices in the second period*. Because customer information works as a competitive weapon in the competition between personalizing firms, both firms have a strong incentive to build a larger customer information base to exploit. This intensifies price competition in the first period. In the second period, however, firms can exploit the customer information with personalized offers, thus alleviating the competition between standard products.

Implications and Conclusion

Information and communication technologies have revolutionized the ability of firms to offer personalization based on information gleaned from consumers. However, the collection and subsequent use of private information have caused widespread concern among consumers regarding privacy intrusion. Such concern, in turn, has become an important issue for corporate managers to address. In this paper, we have taken a game-theoretic approach to trace the motivations of firms to enable or reject privacy protection, along with examining its impact on competition and social welfare in the context of product and price personalization. By considering the privacy calculus from the perspectives of both consumers and corporations, our analysis provides significant insights and implications.

One striking finding from our analysis is that strategic choices of privacy protection can work as a competition-mitigating mechanism in personalization. Specifically, asymmetric privacy protection choices can alleviate competition because the protecting firm can expand the consumer segment to which it offers personalization exclusively, which leads the firm to earn substantial profit from the segment rather than to compete with its rival for the other consumers, and accordingly the non-protecting firm can also enjoy a higher profit from the latter consumers. As the proportion of pragmatists increases, the competition-mitigation effect also

[33]Formally, the highest possible price for the personalized product targeted at the pragmatists is the minimum of the standard price of both firms plus the respective disutility of consumers due to unfitness.

[34]A discussion of a possible extension involving generation of the CP segment is provided in the next section.

increases. This finding adds to our theoretical understanding of economic forces that govern the competition in personalization. Further, it implies that privacy protection is not necessarily a reactive means to address consumer privacy concerns; rather, it can function as a proactive measure to exploit consumer information in the information-intensive economy.

Our analysis also sheds light on how to effectively manage privacy concerns in personalization. A firm's privacy protection strategy under competition should be based on the investment cost of protection and the size of the personalization scope. Even when the investment cost is very low, allowing each firm to easily induce more consumers to disclose personal information, it is not necessarily optimal for the firm to adopt privacy protection. When the personalization scope is small, all firms should adopt protection to maximize the profit extraction from the large MP segments; however, when the personalization scope is large, firms are advised to make asymmetric protection choices to avoid head-to-head competition in the CP segment and to leverage the competition-mitigation effect the asymmetric choices generate. Next, when the investment cost is intermediate, firms should make asymmetric protection choices again, because profit extraction under symmetric protection cannot offset the cost. Finally, when the investment cost is substantially high, neither firm is advised to adopt privacy protection.

Although we assumed that personalization scope is given in the model, in practice a firm can manipulate the scope in several ways to some extent. A lot of effort has been directed at increasing the accuracy of preference inference using previous transaction or clickstream data (e.g. Kim 2007; Moe and Fader 2004; Zhang and Krishnamurthi 2004). This technical improvement could change the personalization scope. A firm may be able to purchase customer information from an outside vendor. Finally, competing firms may strategically share their customer information with rivals (Chen et al. 2001).

Third, our analysis offers an implication for policy regarding the impact of privacy protection on social welfare and the efficiency of government regulations that enforce FIPs. The results indicate that autonomous choices of privacy protection made by personalizing firms may improve social welfare by reducing consumer disutility due to unfitness of standard products through the expansion of the personalization segment. However, this improvement is accompanied by benefit redistribution in which consumers always become worse off. Next, in spite of the growing privacy concerns of consumers, indications are that self-regulation on privacy protection by industry organizations has neither been fully implemented, nor is it effective (Culnan and Bies 2003; Hoofnagle 2005). Given this ineffectiveness, our results show that enforcing the implementation of FIPs through government regulation can be socially desirable by limiting the incentives of firms to exploit the competition-mitigation effect when the proportion of pragmatists is large and the investment cost is not very high.

As a first step, several interesting extensions can be further explored using this study's findings as a base.[35] One such extension would be running empirical tests of the predictions our analysis has suggested. For example, the equilibrium outcome identified in Proposition 2 states that privacy protection choices by firms in a market are affected by the level of investment cost of protection and the size of personalization scope. The privacy protection level of a firm could be measured by applying a content analysis method similar to those referenced in Culnan (1999) and Schwaig et al. (2006). Then, the firm-level data could be aggregated to produce a market-level measure of privacy protection (e.g., mean and variance of the firm-level data in a market). The level of investment cost of protection could be measured based on the expenditure components included in von Reden (2004). A possible way to operationalize the size of the personalization scope would be to use, as a proxy measure, the proportion of the average number of consumers in the firms' customer databases at play in a market to the size of the entire market. Further, Corollary 1 could also be tested empirically by measuring the composition of the unconcerned, pragmatists, and fundamentalists in each market. The composition is expected to vary over markets depending on several factors, such as the nature of the product or service, and the amount and sensitivity of the information required for personalization.

Second, we assumed that the personalization scope is exogenously given and symmetric. It could be possible to endogenize the formation of the personalization scope, for example, by allowing multi-homing in a two-period model; that is, consumers can purchase multiple products in order to reap maximal benefits (Choi 2006). In such a model, consumers whose preferences are located in the middle inside the preference line would purchase from both firms, forming a CP segment. This modification may generate asymmetric MP scopes for the firms when only one firm adopts privacy protection—a larger scope for the protecting firm compared with the non-protecting firm. This can be viewed as a shift of the CP scope to the location of the non-protecting firm. However, we conjecture that this asymmetry would not substantially change the equilibrium outcome of the game. The protecting firm would have a stronger incentive to exploit its MP segment, which could cause the non-protecting firm to increase its standard price rather than to undercut its rival. This potential effect might make non-protecting a viable

[35]We thank the AE and the anonymous reviewers for the suggestions on further research.

strategic choice, as long as the asymmetry is not significant. The analysis of such an extended model, however, would provide additional, interesting insights.

Third, while our analysis addressed a situation where firms in a market make decisions simultaneously, an interesting extension would be a sequential entry game between an incumbent firm (firm A) and a potential entrant (firm B). A sequential entry model can give insights on the strategic aspects of subsequent decisions by firms (Tirole 1988). One possible modeling approach would be that firm A makes a privacy protection decision and builds a customer information base through transactions before firm B's market entry decision. In such a model, firm A may deter entry by strategically choosing to protect privacy, given a substantial cost of privacy protection under which it would not choose to do so without the threat of potential entry. By protecting privacy, firm A's personalization segment covers all the unconcerned and pragmatists in its personalization scope. Then, firm B's obtainable personalization segment would be limited to the consumers other than firm A's personalization segment because the latter segment would not buy firm B's standard product but choose firm A's personalized products. Given the decreased attractiveness of the market, firm B may not enter the market when a substantial, additional entry cost is required. Thus, privacy protection may work as an entry-deterrence instrument.

Fourth, we adopted a dynamic pricing scheme in our model. Due to lower transaction and menu costs on the Internet, firms can apply dynamic pricing mechanisms, which allow sellers to price-discriminate to increase profit (Bakos 1997). However, the scheme can make consumers angry because they might think it is unfair (Hinz et al. 2011; Odlyzko 2003). For example, when Amazon.com's experiments with variable pricing were noticed, people who bought products from the firm were outraged and criticized its pricing policy, finally causing the firm to draw back its dynamic pricing scheme (Streitfeld 2000). Our model does not incorporate subjective attributions that may matter to consumers. An important venue for further research would be to consider other pricing schemes that address psychological factors of consumers. NYOP (name-your-own-price) is an example of such pricing schemes, where a seller defines a secret threshold price indicating the minimum price for which he is willing to sell the product and, subsequently, a buyer is asked to place a bid indicating her willingness-to-pay for the product offered (Hinz et al. 2011). When the bid value is equal or above the seller's threshold price, the transaction is initiated. Not only has the scheme been adopted widely in the e-marketplace (by eBay.com and Priceline.com, for example), but it could alleviate customers' concerns about firm-driven dynamic pricing.

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RESEARCH ARTICLE

MANAGING CONSUMER PRIVACY CONCERNS IN PERSONALIZATION: A STRATEGIC ANALYSIS OF PRIVACY PROTECTION

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Appendix

Equilibrium Pricing and Proofs

Equilibrium Pricing of the Personalized Products

Cases 1, 2, and 3 can be represented and solved using a single general formulation. Let α and β denote the proportion of those consumers who are willing to share personal information with firm A and B, respectively. There are different values for α (β), depending on firm A's (firm B's) protection choice; $\alpha = \beta = u$ in <No-Prot, No-Prot> case (Case 1); $\alpha = u + v$ and $\beta = u$ in <Prot, No-Prot> case (Case 2); $\alpha = \beta = u + v$ in <Prot, Prot> case (Case 3). Note that $\alpha \geq \beta$.

Given both firms' standard prices, p_A and p_B, each firm sets personalized prices. First, we examine personalized pricing for the information-sharing consumers in the MP scopes (the α segment in the MP_A scope and the β segment in the MP_B scope). Consider an information-sharing consumer located at x in the MP_i scope. This consumer is offered personalized products from firm i and standard products from both firms. Because the net utility the consumer could get from the standard product offerings is $\max[R - p_A - tx, R - p_B - t(1-x)]$, she would choose firm i's personalized product only when the net utility from the personalized product is at least $\max[R - p_A - tx, R - p_B - t(1-x)]$. Therefore, the price of the personalized product tailored to the consumer x, $q_i(x)$, should be $r(x)$ ($\equiv \min[p_A + tx, p_B + t(1-x)]$). Under this pricing, the consumer chooses the personalized product, and firm i's profit from the consumer is maximized (in case of a tie in utility between a standard product and a personalized product, we assume that a consumer chooses the latter, because a firm can decrease the price of the personalized product infinitesimally, given the standard price).[1] Thus, the profits from the MP scopes are $\int_0^{1-s} \alpha r(x)dx$ for firm A and $\int_s^1 \beta r(x)dx$ for firm B.

[1] Although we assume the firms' commitment to personalization, it is easy to verify that firm i is always better off by selling the personalized product to consumers in the MP_i scope. Consider the MP_A scope. First, for consumer x such that $p_A + tx > p_B + t(1-x)$, firm A's profit margin from its standard product is zero, because the consumer prefers the competitor's standard product. However, by offering a personalized product with $q_A(x) = p_B + t(1-x)$, firm A can earn a profit of $p_B + t(1-x)$ from the consumer. Second, for consumer x such that $p_A + tx < p_B + t(1-x)$, firm A's profit margin from its standard product is p_A, which is dominated by the profit margin from its personalized product, $p_A + tx$. Thus, firm A always chooses to offer personalization. A similar argument is applied to firm B. Further, we can show that both firms offer personalization to the consumers in the CP scope.

Next, we examine personalized pricing for the consumers who are in the CP scope and share personal information with firm A (the α segment in the scope). Note that the α segment includes the β segment since $\alpha \geq \beta$. In the following, we show that both firms' pricing for the personalized products does not exhibit a pure strategy equilibrium for $\alpha > \beta$, and derive a mixed strategy equilibrium. The solution for the case $\alpha = \beta$ is a degenerate case of the mixed strategy solution.

When $\alpha > \beta$ (i.e., the unconcerned and pragmatists share information with firm A, but only the unconcerned share information with firm B), the unconcerned are offered personalized products by both firms, while pragmatists are offered personalization by firm A only. However, since firm A cannot distinguish between the unconcerned and pragmatists on the same location, its pricing strategy should be the same for all consumers at x in the α segment in the CP scope. Thus, firm A's pricing for the CP scope should consider the tradeoff between two conflicting objectives: (1) charging pragmatists as much as possible to extract the surplus from them and (2) attracting the unconcerned consumers (the β segment) by undercutting firm B's price.

By focusing on the first objective, firm A can guarantee itself a profit of $(\alpha - \beta)r(x)$ from the consumers at x by charging their effective reservation price $r(x)$. In this case, however, firm B can capture the entire β segment at location x with personalized products by undercutting firm A's price. Considering the second objective, firm A can set its price lower to get the β segment at x, as long as the profit is larger than $(\alpha - \beta)r(x)$. However, firm B could react with a strategy of undercutting. This implies that if a firm fixes a price at each location, then its competitor can always undercut the price and capture the entire β segment at the location. Therefore, there is no pure strategy equilibrium. Instead, we will have a mixed price equilibrium at each location inside the CP scope.

The construction of the mixed-strategy equilibrium at each point in the CP scope follows Varian (1980) and Narasimhan (1988). The consumers in the unconcerned-CP segment choose the firm that offers the lower price for the personalized products. Thus, the effect of the segment is similar to the informed and switching segments in Varian and in Narasimhan. The consumers in the pragmatists-CP segment always choose the personalized products offered by firm A. So, the effect of the segment is similar to the uninformed and loyal segments in Varian and in Narasimhan. Thus, from the technical perspective, the equilibrium at each point x in our model is equivalent to the case in Narasimhan in which there are v consumers who are loyal to firm A but not to firm B, there are u consumers who are switchers, and the reservation price is $r(x)$, leading to the following results:[2]

(i) The equilibrium cumulative distribution function of the prices charged by firm i for the personalized products targeted at x in the CP scope, $F_{ix}(q)$ ($\equiv Pr(q_i(x) \geq q)$) is given by

$$F_{Ax}(q) = \begin{cases} 0, & q < \dfrac{\alpha - \beta}{\alpha} r(x), \\ 1 - \dfrac{\alpha - \beta}{\alpha} \dfrac{r(x)}{q}, & \dfrac{\alpha - \beta}{\alpha} r(x) \leq q < r(x), \\ 1, & q \geq r(x), \end{cases} \tag{1}$$

and

$$F_{Bx}(q) = \begin{cases} 0, & q < \dfrac{\alpha - \beta}{\alpha} r(x), \\ 1 - \dfrac{\alpha - \beta}{\beta} \dfrac{r(x) - q}{q}, & \dfrac{\alpha - \beta}{\alpha} r(x) \leq q < r(x), \\ 1, & q \geq r(x). \end{cases} \tag{2}$$

(ii) Firm A's expected profit from its personalized products targeted at x in the CP scope is $(\alpha - \beta)r(x)$, and firm B's expected profit from its corresponding products is $(\beta/\alpha)(\alpha - \beta)r(x)$. ■

[2]Mixed pricing has been interpreted as a form of temporal sales (Narasimhan 1988; Varian 1980) or promotions with different discount level to different consumers (Shaffer and Zhang 2002). myShape.com also frequently offers targeted discount promotions with very short terms of validity (e.g., 24 hours) through e-mail.

Equilibrium Pricing of the Standard Products

There are three distinct cases depending on the location of the fundamentalists who are indifferent in choosing between both firms' standard products. Let y denote the location of the indifferent consumers. Then, $y = 1/2 + (p_B - p_A)/2t$. The first case is $y < 1-s$, the second case is $1-s \le y \le s$, and the third case is $y > s$. We find that only the second case is possible, as an equilibrium of the pricing game.

(i) **$y < 1 - s$ case:** In this case, the profit functions for both firms are

$$\pi_A = \alpha\left[\int_0^y (p_A + tx)dx + \int_y^{1-s} [p_B + t(1-x)]dx\right] + (\alpha-\beta)\int_{1-s}^{s} [p_B + t(1-x)]dx + (1-\alpha)\int_0^y p_A dx,$$

$$\pi_B = \beta\int_s^1 [p_B + t(1-x)]dx + \frac{\beta}{\alpha}(\alpha-\beta)\int_{1-s}^{s} [p_B + t(1-x)]dx + \left[(\alpha-\beta)\int_s^1 p_B dx + (1-\alpha)\int_y^1 p_B dx\right].$$

We obtain the following solution of the first-order conditions:

$$p_A = \frac{[3+(4s-2)\beta]\alpha - (1+2s)\alpha^2 - 2(2s-1)\beta^2}{\alpha(1-\alpha)(3-2\alpha)}t,$$

$$p_B = p_A - \frac{(2s-1)(\alpha^2 - 2\alpha\beta + 2\beta^2)}{\alpha(3-2\alpha)}t.$$

With the above prices, $y = 1 - s + (2s - 1)[3\alpha(1 - \beta) + 2\beta(\alpha - \beta)]/2\alpha(3 - 2\ \alpha) > 1 - s$. Thus, the case condition is not satisfied, and no equilibrium exists for this case.

(ii) **$1 - s \le y \le s$ case**: Similarly to the above case, the profit functions for both firms in this case are

$$\pi_A = \alpha\int_0^{1-s} (p_A + tx)dx + (\alpha-\beta)\left[\int_{1-s}^{y} (p_A + tx)dx + \int_y^s [p_B + t(1-x)]dx\right] + (1-\alpha)\int_0^y p_A dx,$$

$$\pi_B = \beta\int_s^1 [p_B + t(1-x)]dx + \frac{\beta}{\alpha}(\alpha-\beta)\left[\int_{1-s}^{y} (p_A + tx)dx + \int_y^s [p_B + t(1-x)]dx\right]$$
$$+ \left[(\alpha-\beta)\int_s^1 p_B dx + (1-\alpha)\int_y^1 p_B dx\right].$$

From the first-order conditions, we obtain the candidate equilibrium prices

$$p_A = \frac{(1-\beta)\gamma + 2(1-s)[(\alpha-\beta)^2 + \beta\gamma]}{(1-\alpha)[(\alpha-\beta)^2 + \gamma]}t,$$

$$p_B = p_A - \frac{(2s-1)(\alpha-\beta)^2}{(\alpha-\beta)^2 + \gamma}t,$$

where $\gamma = 3\alpha(1 - \alpha) + 2\beta(\alpha - \beta)$.

Then, we have $y = 1 - s + (2s - 1)[3\alpha(1 - \alpha) + 2\beta(\alpha - \beta)]/2[3\alpha(1 - \alpha) + \alpha^2 - \beta^2] = 1/2 - (2s - 1)(\alpha - \beta)^2/2[3\alpha(1 - \alpha) + \alpha^2 - \beta^2]$, which is between $1 - s$ and $1/2$. Thus, the case condition is always satisfied. With the above prices, the profits are

$$\pi_A = \frac{(2s-1)(2-\alpha-\beta)t}{4(1-\alpha)} \times \left[\frac{(2s-1)(1-\alpha)(\alpha-\beta)^4}{[\gamma+(\alpha-\beta)^2]^2} - \frac{2(\alpha-\beta)^2[1+(2s-1)(\alpha-2\beta)]}{\gamma+(\alpha-\beta)^2}\right.$$
$$\left. + \frac{(1-\alpha+4\beta)[2-(1+2s^2)\alpha+(1+4s^2)\beta]+4s[\alpha(2-\alpha+4\beta)-\beta(5+4\beta)]}{(2s-1)(2-\alpha-\beta)}\right],$$

$$\pi_B = \pi_A - \frac{(\alpha-\beta)t}{4\alpha}\times$$
$$\left[\begin{array}{l}\alpha-\beta-2(1-s)^2(\alpha-2\beta)+\dfrac{4(2s-1)(\alpha-\beta)[1-(2s-1)\beta]}{1-\alpha}+\dfrac{(2s-1)^2[2\gamma+3(\alpha-\beta)^2](\alpha-\beta)^3}{[\gamma+(\alpha-\beta)^2]^2} \\ +\dfrac{2(2s-1)(\alpha-\beta)\left[2(2s-1)(\alpha^3+\beta^3)+[5+2\beta-4s(2+\beta)]\alpha^2-3(2s-1)\beta^2-\alpha[1-(2s-1)(8-3\beta)\beta]\right]}{(1-\alpha)[\gamma+(\alpha-\beta)^2]}\end{array}\right],$$

Next, we need to examine each firm's unilateral deviation incentive from the strategies in this candidate equilibrium. There are four possible deviation scenarios. Firm A can deviate by increasing its standard price in such a way that the resulting y is less than $1 - s$ (deviation to $y < 1 - s$ case) or by decreasing the standard price in such a way that the resulting y is larger than s (deviation to $y > s$ case below). Similarly firm B can deviate to $y < 1 - s$ case by decreasing its standard price, or to $y > s$ case by increasing its standard price. It is easily verified that firms do not have deviation incentives for $\alpha = \beta$ (Cases 1 and 3). It is also found that when $\alpha > \beta$ (Case 2), only the second scenario (firm A's deviation to $y > s$ case) can be profitable when s is sufficiently small *and* α is sufficiently high, while firms do not have deviation incentives in the other three scenarios.

The equilibrium prices and profits for Cases 1, 2, and 3 can be obtained by replacing α, $1 - \alpha$, and β with the corresponding values for the cases as follows:

$$p_1^* = p_{1A}^* = p_{1B}^* = t\left[1+\frac{2(1-s)u}{v+w}\right],$$
$$\pi_1^* = \pi_{1A}^* = \pi_{2B}^* = \frac{t}{2}\left[1-(3s-2)su+\frac{4(1-s)^2u}{1-u}\right], \tag{3}$$

$$p_{2A}^* = \frac{(v+w)\gamma_2+2(1-s)(v^2+u\gamma_2)}{w(v^2+\gamma_2)}t \quad \text{and} \quad p_{2B}^* = p_{2A}^* - \frac{(2s-1)v^2}{v^2+\gamma_2}t, \tag{4}$$

where $\gamma_2 = 2uv + 3(u + v)w$,

$$\pi_{2A}^* = \frac{(2s-1)(1-u+w)t}{4w}\times\left[\begin{array}{l}\dfrac{[2-v+2s^2(u-v)](4u+w)-4s[u(4u+3w)-v(1+w)]}{(2s-1)(1-u+w)} \\ -\dfrac{2[1-(2s-1)(u-v)]v^2}{v^2+\gamma_2}+\dfrac{(2s-1)wv^4}{(v^2+\gamma_2)^2}\end{array}\right],$$

$$\pi_{2B}^* = \pi_{2A}^* - \frac{t}{4(u+v)}\times\left[\begin{array}{l}2(1-s)^2(u-v)v+v^2+4(2s-1)[1-(2s-1)u]\dfrac{v^2}{w}+(3v^2+2\gamma_2)\dfrac{(2s-1)^2v^4}{(v^2+\gamma_2)^2} \\ +\left[(1-w)w[(2s-1)(u-v)-1]+[4(1-s)(1-u)-(2s+1)w]v^2-2v^3\right]\dfrac{2(2s-1)v^2}{w(v^2+\gamma_2)}\end{array}\right], \tag{5}$$

$$p_3^* = p_{3A}^* = p_{3B}^* = \left[1+\frac{2(1-s)(u+v)}{w}\right]t,$$

and

$$\pi_3^* = \pi_{3A}^* = \pi_{3B}^* = \frac{t}{2}\left[1-(3s-2)s(u+v)+\frac{4(1-s)^2(u+v)}{1-u-v}\right].$$

(iii) ***y > s* case:** In this case, both firms' profit functions are

$$\pi_A = \int_0^{1-s} \alpha r(x)\,dx + \int_{1-s}^{s} (\alpha-\beta) r(x)dx + \int_s^y (\alpha-\beta) p_A dx + \int_0^y (1-\alpha) p_A dx,$$

$$\pi_B = \int_s^1 \beta r(x)dx + \int_{1-s}^{s} \frac{\beta}{\alpha}(\alpha-\beta) r(x)dx + \left[\int_y^1 (\alpha-\beta) p_B dx + \int_y^1 (1-\alpha) p_B dx\right].$$

After replacing $r(x)$ and then solving the first-order conditions simultaneously, we have

$$p_A = \frac{3-4s\beta+(2s-1)\beta^2}{(1-\beta)(3-2\beta)}t,$$

$$p_B = p_A + \frac{(2s-1)\beta}{(3-2\beta)}t.$$

With the above prices, $y = s - 3(2s-1)(1-\beta)/(6-4\beta) < s$. Thus, the case condition is not satisfied, and no equilibrium exists for this case. ■

Proof of Proposition 1

Part (i): Since $p_{2A}^* > p_{2B}^*$ from equation (4), it is sufficient to show that $p_{2B}^* > p_1^*$.

$$p_{2B}^* - p_1^* = \frac{(v+w)(2uv+3uw+vw)+2(1-s)[v^2+u\gamma+2vw(v+w)]}{w(v+w)(v^2+\gamma)} vt > 0$$

Thus, $p_{2B}^* > p_1^*$. So, the consumers in the fundamentalist segment and the pragmatists in the MP_B scope, who buy the standard products, are charged higher standard prices by both firms in Case 2 compared with those in Case 1.

Further, it is trivial to verify that p_{2A}^* and p_{2B}^* are increasing in v.

Parts (ii) and (iii): Consider the unconcerned and pragmatists located at x in firm A's MP scope. They are charged $p_{2A}^* + tx$ and buy the firm's personalized product in Case 2. Since $p_{2A}^* + tx > p_1^* + tx \geq p_1^*$, the consumers are charged higher prices than in Case 1. Similarly, the unconcerned in firm B's MP scope are also charged higher prices for the firm's personalized products than in Case 1, since $p_{2B}^* + tx > p_1^* + tx$.

Next, consider the unconcerned in the CP scope, who buy personalized products in both cases. Let APP_{2i}^{CP} denote the average personalized price charged by firm i for the CP segment in Case k. Then, from (1) and (2), it is easy to see that $APP_{2i}^{CP} > APP_1^{CP} = 0$. Thus, both firms charge higher on average for the personalized products for the segment in Case 2 than in Case 1.

Finally, consider the pragmatists in the CP scope, who buy standard products in Case 1 but buy firm A's personalized products in Case 2. Let $f_{Ax}(q)$ denote the probability density function of $q_A(x)$. From (1), we have $f_{Ax}(q) = vr(x)/(u+v)q^2$ and $F_{Ax}(q)$ has a probability mass point at $r(x)$ equal to $v/(u+v)$. Thus, the average value of $q_A(x)$, $E[q_A(x)]$, is calculated as follows:

$$E[q_A(x)] = \int_{vr(x)/(u+v)}^{r(x)} q f_{Ax}(q)dq + \frac{vr(x)}{u+v} = \frac{vr(x)}{u+v}\left[1+\log(\frac{u+v}{v})\right].$$

Then $APP_{2A}^{CP} = \frac{1}{1-2s}\int_{1-s}^{s} E[q_A(x)]dx$.

From Equation (3), it is easily verified that p_1^* is decreasing in v and approaches t as v approaches 1. Since both p_{2A}^* and p_{2B}^* increasing in v, $E[q_A(x)]$ and thus APP_{2A}^{CP} increases with v. $E[q_A(x)]$ and APP_{2A}^{CP} approaches 0 as v approaches 0. Further, $E[q_A(x)]$ and APP_{2A}^{CP} approaches $r(x)$ as v approaches 1. Therefore, $APP_{2A}^{CP} - p_1^*$ is negative when v approaches 0, increases as v increases, and is positive when v approaches 1.

Part (iv): This part of the proof is included in the previous parts.

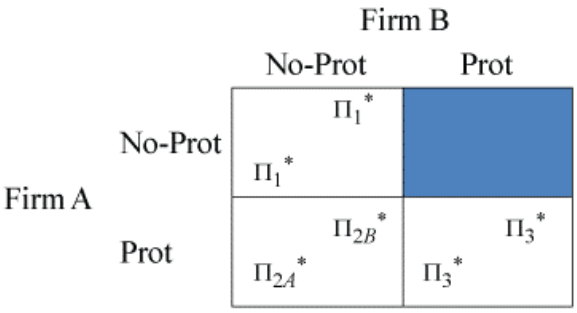

Figure A1. The First Stage of the Game

Proof of Proposition 2

Let Π_{ki}^* denote the equilibrium net profit of firm i in Case k. Then, $\Pi_1^* = \Pi_{1A}^* = \Pi_{1B}^* = \pi_1^* - K_I^u$, $\Pi_{2A}^* = \pi_{2A}^* - K_P - K_1^{u+v}$, $\Pi_{2B}^* = \pi_{2B}^* - K_I^u$, and $\Pi_3^* = \Pi_{3A}^* = \Pi_{3B}^* = \pi_3^* - K_P - K_1^{u+v}$. Figure A1 shows the payoff matrix for the first stage of the game.

<No-Prot, No-Prot> is the equilibrium if and only if neither firm can deviate profitably by adopting privacy protection. This condition is equivalent to $\Pi_1^* > \Pi_{3A}^*$, which is reduced to $K > \pi_{2A}^* - \pi_1^*$.

<Prot, Prot> is the equilibrium if and only if neither firm has an incentive of unilateral deviation by not adopting privacy protection. This condition is equivalent to $\Pi_3^* > \Pi_{2B}^*$, which is reduced to $K < \pi_3^* - \pi_{2B}^*$. It can be shown that $\pi_3^* - \pi_{2B}^*$ is a quadratic and convex function of s. Further, it can be shown that $\pi_3^* - \pi_{2B}^* > 0$ at $s = 1/2$ and $\pi_3^* - \pi_{2B}^* < 0$ at $s = 1$. Thus, $\pi_3^* - \pi_{2B}^* > 0$ for $s < s'(u, v, w)$ and $\pi_3^* - \pi_{2B}^* < 0$ for $s > s'(u, v, w)$, where $s'(u, v, w)$ is the smaller solution of the equation $\pi_3^* - \pi_{2B}^* = 0$. Therefore, <Prot, Prot> is the equilibrium for $s < s'(u, v, w)$ and $K < \pi_3^* - \pi_{2B}^*$. On the other hand, <Prot, Prot> cannot be an equilibrium for $s > s'(u, v, w)$.

Finally, <Prot, No-Prot> is the equilibrium if and only if $\Pi_1^* < \Pi_{3A}^*$ and $\Pi_3^* < \Pi_{2B}^*$. From the above results, these two conditions are equivalent to $s > s'(u, v, w)$ and $K < \pi_3^* - \pi_{2B}^*$, or $\pi_3^* - \pi_{2B}^* < K < \pi_{2A}^* = \pi_1^*$. ■

Proof of Corollary 1

Part (i) of the proposition is equivalent to $\partial s'(u, v, w)/\partial w > 0$. Because of the complex nature of the formula, we need to rely on numerical procedures on a dense grid of u, v, and w to check the sign of $\partial s'(u, v, w)/\partial w$. Specifically, we let u, v, and w vary from 0.01 to 0.99 by 0.01 and ensure that the constraint $u + v + w = 1$. We find that the sign is invariably positive.

Part (ii) of the proposition can be verified by showing that for any given value of w, $s'(u, v, w)$ increases with v/u. Again we apply numerical analysis. First, we vary w from 0.01 to 0.99 by 0.01. Then, for each value of w, we vary v from 0.01 to $0.99 - w$ by 0.01 and set $u = 1 - v - w$, which ensures v/u increases for the given w. We find that $s'(u, v, w)$ invariably increases with v/u for any given value of w. ■

Proof of Proposition 3

The social welfare when <No-Prot, No-Prot> is the equilibrium (SW_1) is

$$SW_1 = uR + (v+w)\left[\int_0^{1/2}(R - tx)dx + \int_{1/2}^{1}[R - t(1-x)]dx\right] - 2K_I^u$$

$$= R - \frac{(v+w)t}{4} - 2K_I^u.$$

The social welfare when <Prot, No-Prot> is the equilibrium (SW_2) is

$$SW_2 = uR + v\left[sR + \int_s^1 [R - t(1-x)]dx\right] + w\left[\int_0^y (R - tx)dx + \int_y^1 [R - t(1-x)]dx\right] - (K_P + K_I^{u+v} + K_I^{u})$$
$$= R - \frac{wt}{4} - \frac{(1-s)^2 vt}{2} - \frac{(2s-1)^2 v^4 wt}{4[3u(1-u) + v(3-2v) - 4uv]^2} - (K_P + K_I^{u+v} + K_I^{u}).$$

Then social welfare when <Prot, Prot> is the equilibrium (SW_3) is

$$SW_3 = (u+v)R + w\left[\int_0^{1/2} (R - tx)dx + \int_{1/2}^1 [R - t(1-x)]dx\right] - 2(K_P + K_I^{u})$$
$$= R - \frac{wt}{4} - 2(K_P + K_I^{u}).$$

Part (i): $SW_2 - SW_1$ is calculated as follows:

$$SW_2 - SW_1 = \frac{[1 - 2(1-s)^2]vt}{4} - \frac{(2s-1)^2 v^4 wt}{4[3u(1-u) + v(3-2v) - 4uv]^2} - K \equiv L - K.$$

Thus, $SW_2 - SW_1 > 0$ for $K < L$. Note from Proposition 2 that a necessary condition for <Prot, No-Prot> being the equilibrium is $K < \pi_{2A}^* - \pi_1^*$. By algebraic manipulations, we find that $L < \pi_{2A}^* - \pi_1^*$. So, the parameter set that satisfies $K < L$ is a subset of the parameter set that satisfies $K < \pi_{2A}^* - \pi_1^*$.

It can be verified that $L = 0$ at $v = 0$, $L = [1 - 2(1-s)^2]t/4$ at $v = 1$, and L is monotonically increasing in v. Thus, when $K < [1 - 2(1-s)^2]t/4$, social welfare increases with the protection for $v > v'$, and decreases for $v < v'$, where v solves the equation $K = L$. When $K > [1 - 2(1-s)^2]t/4$, social welfare always decreases with protection.

Next, let's consider the consumer welfare (CW). $CW_2 - CW_1 = (SW_2 - \Pi_{2A}^* - \Pi_{2B}^*) - (SW_1 - 2\,\Pi_1^*)$ can be shown to be a quadratic function of s and negative both at $s = 1/2$ and at $s = 1$. Thus, when $CW_2 - CW_1$ is convex in s, it is always negative. When $CW_2 - CW_1$ is concave in s, it can be shown that $CW_2 - CW_1$ is always increasing in s for $1/2 < s < 1$. Thus, consumer welfare always decreases with protection.

Part (ii): $SW_3 - SW_1 = vt/4 - 2K$. Thus, $SW_3 - SW_1 > 0$ for $K < vt/8$. From Proposition 2, <Prot, Prot> can be the equilibrium choice only if $K < \pi_3^* - \pi_{2B}^*$. We find that $vt/8 > \pi_3^* - \pi_{2B}^*$ as follows. First, $vt/8 - (\pi_3^* - \pi_{2B}^*)$ is quadratic and concave in s. Next, it is found that $vt/8 - (\pi_3^* - \pi_{2B}^*) = 0$ at $s = 1/2$, and $vt/8 - (\pi_3^* - \pi_{2B}^*) > 0$ at $s = 1$. Thus, we always have $vt/8 - (\pi_3^* - \pi_{2B}^*) > 0$. So, whenever <Prot, Prot> is the equilibrium choice, $K < vt/8$ is always satisfied. Thus, social welfare always increases with protection.

Next, $CW_3 - CW_1 = (SW_3 - SW_1) - 2(\Pi_3^* - \Pi_1^*)$ is calculated as follows:

$$CW_3 - CW_1 = \frac{(1 - 8s + 12s^2)vt}{4} - \frac{4(1-s)^2 vt}{(1-u)(1-u-v)}.$$

By solving $CW_3 - CW_1 > 0$, we have

$$s > \frac{3 + 2u - u^2}{1 + 6u - 3u^2} - \frac{1}{6}\sqrt{1 + \frac{4(47 - 102u + 51u^2)}{(1 + 6u - 3u^2)^2}} \equiv s'' \text{ and } v < 1 - u - \frac{16(1-s)^2}{(1-u)(1 - 8s + 12s^2)} \equiv v''.$$

However, it can be shown that $s'' > s'$. Since <Prot, Prot> can be the equilibrium choice only if $s < s'$, the condition $s > s''$ cannot be satisfied. Thus, consumer welfare always decreases with protection. ■

Proof of Proposition 4: **Part (i)**: From the proof of Part (ii) of Proposition 3, $SW_3 - SW_1 > 0$ for $K < vt/8$. From Proposition 2, <No-Prot, No-Prot> is the equilibrium choice if and only if $K > \pi_{2A}^* - \pi_1^*$. However, we find that $vt/8 < \pi_{2A}^* - \pi_1^*$, and thus $K < vt/8$ cannot be satisfied under the <No-Prot, No-Prot> equilibrium choice, as follows. First, $(\pi_{2A}^* - \pi_1^*) - vt/8$ is found to be quadratic in s, and positive both at $s = 1/2$ and $s = 1$. Second, when $(\pi_{2A}^* - \pi_1^*) - vt/8$ is convex, it can be shown that $(\pi_{2A}^* - \pi_1^*) - vt/8$ is always decreasing in s between 1/2 and 1. So, we always have $vt/8 < \pi_{2A}^* - \pi_1^*$. Thus, social welfare always decreases with regulation.

Next, from the proof of Part (ii) of Proposition 3, $CW_3 - CW_1 > 0$ for $s > s$" and $v < v$".

Part (ii): $SW_3 - SW_2$ is calculated as follows:

$$SW_3 - SW_2 = \frac{(1-s)^2 vt}{2} + \frac{(2s-1)^2 v^4 wt}{4[3u(1-u)+v(3-2v)-4uv]^2} - K \equiv M - K.$$

Thus, $SW_3 - SW_2 > 0$ for $K < M$. Note from Proposition 2 that a necessary condition for <Prot, No-Prot> being the equilibrium choice is $K < \pi_{2A}^* - \pi_1^*$. By algebraic manipulations, we find that $M < \pi_{2A}^* - \pi_1^*$. So, the parameter set that satisfies $K < M$ is a subset of the parameter set that satisfies $K < \pi_{2A}^* - \pi_1^*$.

It can be verified that $M = 0$ at $v = 0$, $M = (1-s)^2 t/2$ at $v = 1$, and M is monotonically increasing in v. Thus, when $K < (1-s)^2 t/2$, social welfare increases with the regulation for $v > v^+$, and decreases for $v < v^+$, where v^+ solves the equation $K = M$. When $K > (1-s)^2 t/2$, social welfare always decreases with regulation.

Next, $CW_3 - CW_2 = (SW_3 - 2\Pi_3^*) - (SW_2 - \Pi_{2A}^* - \Pi_{2B}^*)$ can be shown to be quadratic and concave in s. Further, it can be verified that $CW_3 - CW_2 = 0$ at $s = 1/2$ and $CW_3 - CW_2 > 0$ at $s = 1$. Thus, $CW_2 - CW_1$ is always positive for $1/2 < s < 1$; that is, consumer welfare increases with regulation. ■

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