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博士論文

Studies on Rent System of Retailers in Shopping Center

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Chapter 1 Introduction

In a shopping center (SC), there are a developer and retailers. A developer attracts retailers to an SC, while retailers make a tenant contract with a developer. Since an SC has a key feature as a commercial agglomeration that retail tenants are placed side by side, there is competition among the retailers to attract customers. Thus, it is important to consider the degree of competition in an SC. Moreover, the profits of developers may be affected depending on whether similar retailers sell similar products or differentiated products in the SC. In reality, exactly the same retailers never exist in one SC and hence, by considering the situation where an SC has various retail tenants selling differentiated products, we can make our model closer to reality. Therefore, it is important to consider the degree of competition among retailers. Furthermore, for the tenant contracts of retail companies in SCs, the rent system plays an important role in the overall optimization strategy of the SC. In other words, the rent system in SCs is an important problem for the developer because the developer gains a great profit by charging rent to the retailers. That is, a rent system can have a significant effect on the profit of the developer.

Although the sizes of retailers vary across companies, for simplicity, we categorize companies into two types: large retailers (e.g., UNIQLO, ZARA, H&M etc.) and small retailers. In particular, we investigate whether a developer gives preferential treatment to either large or small retailers by assigning a higher percentage of the royalty rent or fixed fee rent to large or small retailers. Previous studies have also analyzed this problem and discussed the rent system of SCs (Benjamin et al. 1990, 1992; Brueckner 1993; Chun et al. 2001, 2003; Colwell and Munneke 1998; Gatzlaff et al. 1994; Gerbich 1998; Gould et al. 2005; Pashigian and Gould 1998; Wheaton 2000) and two-part tariff consisting of the royalty and fixed fee (Faulí-Oller and Sandonís 2002; Gallini and Winter 1985; Griva and Vettas 2015; Kamien and Tauman 2002; Katz and Shapiro 1985; Kitagawa et al. 2014; Mukherjee and Balasubramanian 2001; Niu 2013; Saggi and Vettas 2002; Martín and Saracho 2010, 2015, 2016; Wang 1998, 2000; Wang and Yang 1999).

In the rent system of *ad valorem* royalties (revenue sharing royalties), the rent depends on the sales of retailers. Meanwhile, in the rent system of per unit royalties, the rent depends on the volume of sales. An example of the latter agreement is a percentage rent. In fact, *ad valorem* royalties and fixed fee rents are relatively commonly used in rent contracts in SCs. In Japan, according to the Annual Report of AEON Mall in 2016, the basic operating revenue of AEON Mall as a developer comes from real estate rents consisting of the fixed fee rent and royalty rent. Moreover, the revenue structure of AEON Mall in fiscal year 2015 was that 53.2% of the revenue came from the fixed fee rent, while the commission revenue of the royalty rent was 46.8%. The annual report mentioned that the royalty rent is decided by the sales of retail tenants. The revenue of AEON Mall as the developer would increase as the sales of retail tenants in SCs rise. Therefore, in the research field of SCs, it is important to consider not only one type of rent contract but also the rent types combined with the fixed fee rent and royalty rent to consider the revenue sharing royalty rent according to sales of the retail tenants in SCs.

Nonetheless, in supply chain management (SCM) research, researchers have not necessarily used *ad valorem* royalty rents, fixed fee rents, and two-part tariffs (*ad valorem* royalties plus fixed fee rents), rather preferring a rent system comprising per unit royalties, fixed fee rents, and two-part tariffs (per unit royalties plus fixed fee rents). In other words, in previous studies, despite its importance, the *ad valorem* royalty with two-part tariffs has received less attention, especially compared with the rent system of the per unit royalty (e.g., Heywood et al. 2014; Martín and Saracho 2016). Therefore, we conducted research to bridge this gap between reality and the research field. By using a model of the optimal two-part tariff licensing between a developer and two asymmetric retailers as the base model, we focus on the effect of the demand uncertainty situation as the extended model.

We explain the assumption of the extended model. In reality, many retailers selling many kinds of products in SCs have a plenty of information about customers. Specifically, we assume that the retailers in SCs accumulate a lot of knowledge and information about customers, such as the number of customers to come into the retail

store, the general number of products they can sell by month, and what kinds of needs customers in SCs have. In practice, this means that retailers know customer demand. That is, at the stage of selling products, we assume that large and small retailers know customer demand in a retail store and compete on quantity. On the contrary, since the developer does not have information about the customer demand of each retailer at the stage of making a contract, it is faced with the situation of knowing customer demand probabilistically. In this paper, we build the extended model by considering the situation that customer demand in SCs is uncertain.

In this paper, we focus on comparing royalty licensing with fixed fee licensing, which is one of the themes dealt with in previous studies. Many papers have examined the impact of licensing on innovation (Gallini and Winter 1985; Grossman and Shapiro 1987; Kamien and Tauman 1986; Katz and Shapiro 1985). Combinations of the fixed fee rent and ad valorem royalty rent are most often observed in practice. In our model, we develop a theoretical model by applying the accumulation of these previous studies to the method of collecting the tenant rents of retailers in SCs. Some classic studies are only concerned with one form of licensing, either fixed fees or royalties (Gallini and Winter 1985; Grossman and Shapiro 1987; Katz and Shapiro 1985). Specifically, Gallini and Winter (1985) considered only a royalty contract. On the contrary, Katz and Shapiro (1985) considered only a fixed fee contract. While licensing by means of a royalty is more prevalent than licensing by means of a fixed fee, Kamien and Tauman (1986) showed that a fixed fee is superior to a royalty for both inventors and consumers. In this way, a major finding of the classic literature is that licensing by means of a fixed fee is superior to licensing by means of a royalty. However, this analysis considered a license to companies that are not competitors. In the case of a license to companies that are competitors, past research shows a greater profit for licensing by means of a royalty than licensing by means of a fixed fee. In this way, previous studies have focused on the conditions under which the relationship among profit, consumer surplus, producer surplus, and social welfare in the equilibrium is reversed by comparing royalties with fixed fees and judging which system works better for the revenue of the licensing company.

In this paper, we adopt a model of the two-part tariff based on the ad valorem royalty for this problem. Such a treatment by the optimal two-part tariff licensing is also used in Martín and Saracho (2016). Moreover, we analyze and examine changes in the equilibrium when market competition gradually becomes intense and approaches the competition of homogeneous products using the degree of product substitutability. In the model of horizontal product differentiation, since we can examine to what extent the degree of competition may change under certain parameters, we can also discuss changes in the conditions in the equilibrium by the comparative statics using this parameter. Research on product differentiation has been carried out in both the economics and marketing fields (Lancaster 1990; Ratchford 1990). Research in economics and marketing has insisted on the importance of horizontal product differentiation with competition among firms (Brown 1989; d'Aspremont et al. 1979; Ebina et al. 2015; Lancaster 1990).

This paper considers a vertical relationship in SCs with a developer and two different types of retailers: a large retailer and small retailer. First, a developer decides the royalty and fixed fee rent for each retailer. Then, each retailer decides the sales volume in SCs. There are two types of rent payments: one type is a fixed fee rent for a certain period of time and the other type is a rent determined by the sales of the retailer. In our model, a developer determines which rent payments will be assigned. When there are both large retailers and small retailers in one SC, the developer may attempt to make the competitive advantage of the small retailer stronger by improving the quantity of products and intensifying the competition between large and small retailers in the SC. However, in our model, the developer gives preferential treatment to large retailers rather than intensifying competition among retailers by strengthening the competitive advantage of the small retailer at the equilibrium. In other words, we find that the developer chooses an action to make the large retailer even stronger and increase the sales volume of the large retailer by decreasing the royalty of the rent of the large retailer to increase the profits of the developer. Then, the developer collects the rents with a greater ratio of the fixed fee rent from the large retailer and the rents with a greater ratio of the ad valorem royalty rent from the small retailer in SCs.

Therefore, we explain the observed relationship in real-world SCs by using our theoretical model.

Furthermore, in our extended model, we reveal the surprising phenomenon that this conclusion would be reversed in the situation with demand uncertainty. Specifically, although we find that the proportion of the fixed fee rent is higher for large retailers than small retailers in our benchmark model, the extended model shows that the proportion of the fixed fee rent becomes greater for small retailers. Moreover, regarding important factors such as the relation of the fixed fee rent between large and small retailers, we find that one region is reversed. In this way, we find that the benchmarks and results change with a simple comparison. Moreover, in our model, when the degree of demand uncertainty is the same in each retailer, we find that the result is consistent with the benchmark model. In other words, we find that the fixed fee rent increases only if a factor widens the difference in the degree of demand uncertainty between the large retailer and the small retailer.

In addition, under demand uncertainty, we find that when the demand uncertainty in the whole SC increases and market competition gradually becomes intense and approaches the competition of homogeneous products using the degree of product substitutability, the developer would increase the proportion of the fixed fee rent for both large and small retailers. Our analysis in the benchmark model confirms that large and small retailers have a contrasting movement with respect to the proportion of the rent at the equilibrium. However, in the situation where the extent of the demand uncertainty of both retailers increases, we find that both large and small retailers take the same action in terms of the fixed fee rent of retailers at the equilibrium.

Furthermore, by using the comparative static analysis, we analyze what would happen when differentiated products become homogeneous products and the competition between retailers becomes more intense in SCs. Then, if the retailers in SCs become even more competitive, it could decrease the profit of the developer. This is confirmed by using a benchmark model that the profit of the developer would decline as previously when approaching homogeneous products, it reduces the profit of the developer at the equilibrium. This is a general result. However, in our extended model,

we discover a counterintuitive result that the profit of the developer would increase under uncertainty in SCs. In other words, when the degree of product substitutability increases and similar retail tenants carry similar products in an SC, there is an increase in the profit of the developer. Then, amazingly, when the degree of demand uncertainty in the whole SC increases, the profit of the developer increases more at the equilibrium. Furthermore, we obtain similar results for social welfare under uncertainty at the equilibrium. This is one of the most interesting results in our extended model. In other words, we find that increasing demand uncertainty for the whole SC is desirable for the developer in our model.

The contribution of this research is that we clarify the relationship among the variables that can be observed in reality in an SC by using the theoretical model. In addition, we obtain theoretical evidence that demonstrates the findings from previous empirical studies. In previous studies, the developer gives preferential treatment to large retailers (Benjamin et al. 1992; Brueckner 1993; Eppli and Shilling 1996; Gould et al. 2005; Miceli et al. 1998; Pashigian and Gould 1998; Wheaton 2000). Much of this previous literature has focused on the rent system of the per unit royalty and hence studies of the ad valorem royalty with two-part tariffs have received relatively less attention. The result of our paper is novel for building a theoretical model using revenue sharing, called the ad valorem royalty rent system, which is commonly used in practice in SCs.

Furthermore, in the context of SCs, prior research has paid insufficient attention to the theoretical relationship between the proportion of the two rent systems (ad valorem royalty and fixed fee rent) for large and small retailers and the profits of developers. In addition, insufficient discussion has been carried out on the changes in the proportion of the fixed fee rent and ad valorem royalty rent between large and small retailers and in the profits of developers by considering the degree of product substitutability and demand uncertainty in the context of SCs. Additionally, no argument has been made on the degree of the difference in uncertainty between two types of retailers at the same time. Therefore, this paper can explain the observed relationship in reality by using factors not used in previous studies. This paper

contributes by pointing out the importance of considering competitive relations due to the change in the degree of product substitutability between large and small retailers and of considering the uncertainty of customer demand faced in SCs in the real world.

Interestingly, our analysis shows that when demand uncertainty is expanded in SCs, that is, when a developer attracts a retailer with a high degree of demand uncertainty such as opening a new tenant or rolling out new products, selling a new product for new customers in SCs, it would be better for the developer to increase the proportion of the fixed fee rent. Moreover, from a managerial perspective, we find that a developer should attract a retailer with the demand uncertainty in the whole SC and similar retail tenants such as those that sell similar quality products to the SC. Furthermore, this paper makes a major contribution to the better management of SCs by indicating that when a developer opens an SC in areas where demand uncertainty is relatively high, it may be profitable for developers to attract retailers producing a similar product to other retailers, having a similar consumer need, and selling a product that has a similar quality or value.

The remainder of this dissertation is organized as follows. In Chapter 2, we show the related literature. In Chapter 3, we investigate the ad valorem royalty plus fixed fee model as the benchmark model. Chapter 4 focuses on the ad valorem royalty plus fixed fee model with demand uncertainty as the extended model. Chapter 5 shows the key findings and concludes the paper by providing directions for further research.

Chapter 2 Related literature

2.1. Literature on SCs

Over previous decades, SCs have been studied from a variety of perspectives. Several studies have discussed the determinants of rent in an SC (Benjamin et al. 1990, 1992; Des Rosiers et al. 2002; Gatzlaff et al. 1994; Hardin et al. 2002; Mejia and Benjamin 2002). The literature on SCs has mainly evolved around the concepts of agglomeration economies and externalities derived from the presence of a large retailer (Eppli and Benjamin 1994; Mejia and Benjamin 2002; Pashigian and Gould 1998), whose bargaining power results in it negotiating a lower rent with the developer in an SC. Hence, few studies have addressed the problem comprehensively and focused on how the relationships among the degree of product substitutability and differences in the rent system of large and small retailers affect the profit of the developer in an SC. We also analyze the rent system of retailers from the point of uncertainty in the model. Therefore, we clarify the causal relationship among these various variables, which has not been considered in previous studies. Meanwhile, since the terms used in previous studies vary, we unify the terms used herein.

First, we provide an overview of the rent problem in an SC. Some previous research presents the problem in relation to the rent of an SC (Benjamin et al. 1990, 1992; Brueckner 1993; Chun et al. 2001, 2003; Colwell and Munneke 1998; Des Rosiers et al. 2005; Gatzlaff et al. 1994; Gould et al. 2005; Hartzell et al. 1987; Pashigian and Gould 1998; Wheaton 2000). We provide the first full-scale analysis of the rents in an SC. Benjamin et al. (1992) examined rents for retailers in an SC based on homogeneous retail tenant space. They found price discrimination to the extent that the variance in rent for retailers attributable to differences in contractual information can be explained by differences in the characteristics of retail tenants. Therefore, they showed that the characteristics of retail tenants are indeed important for explaining the variance in rent. They also showed that a number of other factors might be important

for determining base rents, which are negatively related to percentage rates and positively related to the sales of retail tenants. In recent studies dealing with the degree to which the characteristics of retailers influence the use of percentage retailer contracts with a developer, Chun et al. (2003) dealt with the problem of risk sharing between a developer and retailers from an accounting perspective. In this way, previous studies have shown that the approach to rent determination in an SC is important.

Second, in theoretical studies, some researchers focus on the tenant placement of SCs (Brueckner 1993; Miceli et al. 1998). We review the retail tenant mix and space allocation in an SC. These papers have acknowledged the important role played by the developer in SCs in determining the tenant placement and competitive success of planned SCs. In recent years, how SCs should be built and survive has become a topic of academic research. For example, the choice of retail tenant mix by the developer in SCs was analyzed by Brown (1992). The theoretical foundation is based on previous models of space allocation in an SC (Brueckner 1993; Eppli and Benjamin 1994). Eppli and Benjamin (1994) developed a stylized model with a large retailer and a small retailer. Brueckner (1993) analyzed the problem of the optimal space allocation in an SC in the presence of externalities among retailers. In this model, the sales of retail tenants depend on their own space as well as on the space allocated to other retail tenants in an SC. The sales of retail tenants rise as other retail tenants expand since the SC becomes more attractive to customers. They also developed a model of space allocation between a large retailer and a small retailer for SCs with externalities among retailers. Taking this externality into account, a developer allocates space to various retail tenants to maximize the profit of SCs. The solution to this problem has been analyzed under a number of behavioral assumptions.

Brueckner (1993) explained why large retailers that have higher externality generating ability have a larger space in SCs than other retail tenants. Miceli et al. (1998) explained theoretically why a profit-maximizing developer might include multiple and competing retail tenants in an SC and also explained the implications for tenant mix. They also provided a theoretical analysis of this problem in SCs and concluded by explicitly relating the analysis to the model of Brueckner (1993) of

optimal space allocation in an SC. They insisted on the role played by demand externalities when the developer determines the space size that types of retailers should be allocated in SCs. However, their analysis did not show where a store should be located in the presence of demand externalities. Vitorino (2012) provided a strategic model of entry that allows for positive and negative spillovers among retailers and showed the factors that influence the profitability of the retail tenant in an SC by using a dataset containing information about the retail tenants of SCs in the United States. Although SCs have been an important field in real estate in recent years, they have been largely overlooked in the marketing literature. While there have been some descriptive studies of SCs in the real estate literature, there has been little attempt to explain structurally the observed distribution of retail tenant brands in an SC (Vitorino 2012). They also showed that these factors can be separated into direct effects such as observable demand characteristics and strategic effects, which occur because of the influence of other firms in the market.

On the contrary, a large retailer creates attention for the SC as a key tenant and a small retailer benefits by being located near the large retailer. A large retailer is affected only by the size of the tenant space it leases and not by the tenant space allocated to small retailers. A developer must choose each retailer's optimal space allocation to maximize the total rent of the SC. The space allocation in an SC is based on the volume of sales per square meter of retail space (Gerbach 1998). They provided empirical evidence of the influence of the retail tenant type on base rents and found that a retailer's costs are a negative determinant of the base rent, which generally supports the space allocation results of Brueckner (1993). In connection with the space allocation of retailers, the image of SCs may also affect the sales promotion level in retail stores based on the size and configuration of SCs as well as the quality of the goods and services offered (Brown 1992; Kirkup and Rafiq 1994). In this respect, such an image accords with a realistic trend in SCs (Grewal et al. 1998; Mazursky and Jacoby 1986). In this way, the image of tenant mix in an SC affects the retail tenants in their negotiation over the optimal location (Mejia et al. 2001). Furthermore, Mejia and Benjamin (2002) showed that factors such as retail image and the tenant mix of small

retailers are the most relevant determinants of sales volume and rent for retailers.

Third, we discuss the retail demand externalities in an SC. According to the analyses of previous studies, the proponents of the demand externalities of retailers are considered to be those in large SCs, while small retailers receive demand externalities from the additional traffic generated by large retailers (Brueckner 1993; Eppli and Shilling 1996; Gould et al. 2005; Pashigian and Gould 1998). Previous studies show that the sales of small retailers increase when large retailers that have demand externalities are present in an SC. According to Ingene and Ghosh (1990), demand externalities flow only in one direction, namely from the retail tenant of a large retailer to the retail tenant of a small retailer. They explained that different from the accumulative benefits of homogeneous retailers, where similar retailers benefit from the two-way flow of customers, retail demand externalities flow from large retailers to small retailers. Hence, a large retailer, as a major key tenant, can negotiate a lower rent with the developer of an SC, as its exit may cause rental income to drop (Gatzlaff et al. 1994). This means that its bargaining power is enhanced.

On the contrary, Pashigian and Gould (1998) insist that what has not been established is the quantitative importance of free-rider problems within SCs. According to Pashigian and Gould (1998), the quantitative importance of free-rider problems within SCs is unclear for two reasons. First, the theory of store location in central places has stressed the benefits of attracting more consumers because of retail tenants' agglomeration against the negative effects of increased competition among closely situated retail tenants in SCs and largely ignores the externality question altogether. Second, their search of the literature found empirical studies that convincingly demonstrated the importance of externalities. Therefore, they presented estimates of the size of the demand externalities in SCs and identified the types of retail tenants that create or benefit from demand externalities. Pashigian and Gould (1998) also found that consumers are attracted to SCs because of the presence of well-known large retailers with recognized brand names. Large retailers thus generate SC traffic that indirectly increases the sales of lesser-known retail tenants such as small retailers in SCs. Then, lesser-known small retailers can free ride on the reputations of better-known

large retailers. The developer internalizes these externalities by offering rent subsidies to large retailers and by charging rent premiums to the other tenants in SCs. Arentze et al. (2005) insisted that most previous studies were non-spatial and based on the concept externalities of retail stores in SCs. They showed that the location of particular retail tenants, which is necessarily based on the agglomeration economics of the spatial properties, within the spatial arrangement of the whole SC is a possible extension of previous studies. They also found that studies of SCs have paid little attention to the detailed spatial aspects of a retail tenant's location and rent within the SC. According to Eppli and Shilling (1996), similar retail tenants lead to an increase in their total sales volume for the whole SC, thereby contributing to the success of SCs.

Moreover, consumers attracted by the brand name of a large retailer are likely to visit the SC, and thus the sales and profits of nearby retail tenants are increased by the presence of the large retailer (Konishi and Sandfort 2003). Large retailers, which tend to be found in most SCs, are valued by developers for their ability to attract consumers more than small retailers (Gould et al. 2005; Konishi and Sandfort 2003; Shanmugam 2013). Shanmugam (2013) developed and empirically tested a theoretical model of the competition between large and small retailers in an SC and extended the literature on retail co-location to account for the effects on the quality levels of a large retailer as well as explain the observed pattern of the choices of the quality levels of a large retailer made by developers. They also addressed the fundamental problem of which quality level should be selected as an effective factor of a large retailer when a developer is profit-maximizing. In addition, in recent research, Gao (2017) studied when and how the developer of an SC should subsidize and charge customers. Each retailer provides a different product, decides its price, and shares its profit with the developer according to its bargaining power. Gao (2017) showed that the greater the bargaining power of the developer relative than any retailers, the less elastic is the demand for any retailer, or a large cross-price elasticity of demand for the developer favors a subsidy. They also showed the condition under which the developer charges a fee at all times.

Although many previous empirical studies discuss the relationships among two or three variables, there is a paucity of theoretical models on the many features and

variables of SCs that reflect reality. In our model, we provide a theoretical explanation of the effects on the outcomes of variables and the yet-to-be-defined mechanism of the relationships among the degree of product substitutability, the differences in the proportion of the rent system for large and small retailers (ad valorem royalty or fixed fee rent), the profit of the developer, the differences in the degree of demand uncertainty for each retailer, the degree of demand uncertainty for the whole SC, and the competition between retailers within an SC. Furthermore, in the context of SCs, prior research has not paid attention to the theoretical relationship between the proportion of the two rent systems between large and small retailers or the profits of developers. In addition, insufficient discussion has been carried out on the changes in the proportion of the fixed fee rent and ad valorem royalty rent between large and small retailers and in the profits of developers by considering the degree of product substitutability and demand uncertainty in the context of SCs. Additionally, no argument has been made on the degree of the difference in uncertainty between these two types of retailers at the same time. Then, the profit of a developer in an SC is determined according to the rent system of each retailer and competitive advantage relationship among retailers in SCs as well as the various determinants associated with attracting retailers and the circumstances of the whole SC. In particular, we discuss how a developer determines the rent system for retailers. Thus, we show how the developer optimizes the difference in the proportion of the rent system between large and small retailers to increase its profit. Hence, we clarify the relationship among variables that can be observed in reality by using a theoretical model.

2.2. Two-part tariff model

Over time, the literature on the two-part tariff model has developed from differing points of view. Many previous studies of the two-part tariff model are from research fields on licensing contracts. First, Arrow (1962) started the theoretical literature on the patent licensing contract by examining the performance of fixed fees and royalties as instruments for the licensing of innovations.

Some classic studies are only concerned with one form of contract, either fixed fees or royalties (Gallini and Winter 1985; Grossman and Shapiro 1987; Katz and Shapiro 1985). Specifically, Gallini and Winter (1985) analyzed licensing in R&D and considered only the licensing of royalties. On the contrary, Katz and Shapiro (1985) studied an asymmetric duopoly game of R&D rivalry and considered only licensing contracts with a fixed fee. Research extended these studies by including other elements in the model from an alternative perspective. For example, some researchers considered the oligopoly market model and showed the prerogative of the per unit royalty in the model from the position of the licensor. They considered the case of homogeneous products by means of a fixed fee or a per unit royalty under Cournot competition and Bertrand competition (Kamien and Tauman 1986; Katz and Shapiro 1985). The above analysis focused on the impact of licensing contracts on innovation activities. Licensing contracts can adopt different contract systems such as involving fixed fees and royalties. The fact that licensing contracts by means of a royalty dominate those by means of a fixed fee is a general result in the licensing contract model. However, Kamien and Tauman (1986) found that a licensing contract by means of a fixed fee is superior to a licensing contract by means of a royalty for both the inventor and consumers. In this way, the early literature showed that a licensing contract by means of a fixed fee is superior to a licensing contract by means of a royalty.

Despite the contribution of the early literature, these studies considered a license to companies that are not competitors. At that time, when a company licenses to a company that is not a competitor, licensing by means of using royalties results in an increase in the marginal cost of the licensed company. As a result, the production

activity of the company is reduced by the license. In this way, when one company licenses to another company that is not a competitor, licensing by means of a fixed fee is superior to licensing by means of a royalty. On the contrary, when a company licenses a company that is a competitor, licensing by means of a royalty is superior to licensing by means of a fixed fee. Previous studies have focused on the condition under which this relationship is reversed as the situation demands.

Following on from this research in the field of licensing contracts, some researchers have found that the licensor may desire contracts by means of a royalty rather than contracts by means of a fixed fee under both types of competition (Wang 1998; Wang and Yang 1999). For example, Wang (1998) compared a licensing contract by means of a fixed fee with a contract by means of a royalty in a homogeneous goods duopoly. The author found that royalty licensing can be superior to a contract with a fixed fee for the licensor, as the licensor has a cost advantage over the licensee under contract licensing by means of a royalty, whereas the two firms compete similarly by using a contract with a fixed fee. On the contrary, Wang and Yang (1999) considered licensing by an innovating firm to its competitor in a differentiated duopoly with Bertrand competition. In this paper, they showed that a contract by means of a royalty may be superior to a contract by means of a fixed fee. In addition, Wang (2002) extended the homogeneous product model considered by Wang (1998) to differentiated products in a duopoly model. The author examined the incentive to license for the licensor as well as how alternative licensing methods compare for different degrees of differentiation between two products. The interesting finding here is generalizing the results in the homogeneous product model. Moreover, the licensor may even license a drastic innovation; when that occurs, a royalty is again the preferred choice (Wang 2002). However, according to these studies, the possibility of licensing is measured by two points: royalty licensing or fixed fee licensing. Therefore, they only obtained the result that either type of rent system is preferable at the equilibrium.

Moreover, Kamien and Tauman (2002) compared the most profitable modes of licensing a cost-reducing invention by an inventor. They found that an industry incumbent favors licensing by means of a royalty per unit of output. On the contrary,

an outsider prefers to auction a contract by means of a fixed fee. Previous studies show that the optimal contract for the licensor always includes a positive per unit royalty in horizontally differentiated Cournot and Bertrand duopolies with substitute products (Mukherjee and Balasubramanian 2001; Faulí-Oller and Sandonís 2002). Mukherjee and Balasubramanian (2001) considered a model in the Cournot duopoly market with horizontally differentiated products. In their model, the contract consists of the fixed fee and the per unit royalty for products. Then, when the goods are close substitutes, they showed that the per unit royalty is the only optimal solution. However, whether the incentive for imitation increases with product differentiation is ambiguous. They showed the implications of multiple contracts such as dealing with our model. On the contrary, Faulí-Oller and Sandonís (2002) considered the situations where the licensing contract with a rival firm reduces social welfare, using two-part tariff contracts, which is a fixed fee plus a linear per unit royalty. They showed that if the firms compete on prices, the goods are sufficiently close substitutes, and innovation is sufficiently large but not drastic, the above situation occurs.

Moreover, Saggi and Vettas (2002) examined vertical oligopoly markets with both intrabrand and interbrand competition. They characterized the equilibrium contracts as a royalty or wholesale price and fixed fee when each manufacturer makes a contract with multiple retailers. Specifically, when choosing the royalty, the manufacturer has to adjust two opposing incentives (Saggi and Vettas 2002). On the contrary, they showed that retailers prefer to be more passive (i.e., the royalties control the competition between retailers and their rivals). In addition, they found that the number of retailers is more than relative to that of rival retailers and that the higher the degree of product differentiation, the higher the royalty at the equilibrium. In their model, when the number of retailers is endogenous, each manufacturer chooses only one retailer. Moreover, they found the profit for competitors when the number of independent retailers is large under only a fixed fee in their model.

On the basis of prior studies of the per unit royalty and/or fixed fee, there is a growing literature on two-part tariffs. We review the progress of this research on the two-part tariff model. Griva and Vettas (2015) analyzed aspects of two-part tariff

competition between duopoly firms with homogeneous service when consumers differ in how much they use the product. They showed that competition with only one price may allow both firms to earn positive profits if the other price is sufficiently different between firms. Kitagawa et al. (2014) examined two-part tariff contracts consisting of a fixed fee plus a linear per unit royalty and identified the optimal two-part tariff contract for a patent holder depending on the cost of innovation by the rival, market parameter, and substitutability of goods. They focused attention on the cost of the innovation. However, in their study, ad valorem royalties were not included.

Martín and Saracho (2016) showed that a licensor may be interested in licensing by means of ad valorem royalties even in the context of the product innovation analyzed by Kitagawa et al. (2014). Kitagawa et al. (2014) showed that two-part tariff contracts consist of a fixed fee plus a linear royalty per unit; however, they did not consider the ad valorem royalty. Therefore, Martín and Saracho (2016) extended the analysis to consider this type of royalty. They found that the licensor may prefer to use ad valorem royalties in the contract rather than per unit royalties. In particular, they showed that ad valorem royalties are desirable when the goods are similar to others or the cost for developing the new product is high. The analysis and conclusions were similar to those in Martín and Saracho (2015). The difference in these works is the different ways in which the competitor of the licensor determines the value of the optimal royalty. Martín and Saracho (2015) studied the optimal two-part tariff contract that has a patent on a process innovation in a model of the differentiated Cournot duopoly market. They analyzed how the use of ad valorem royalties or per unit royalties in licensing contracts may differ depending on both the variety of goods and the degree of the product differentiation of goods.

As a preliminary, Martín and Saracho (2010) stated that most licensing contracts observed empirically include either per unit or ad valorem royalties. The previous literature generally focused on per unit royalties. They provided a simple justification for the presence of ad valorem royalties in contracts and compared ad valorem royalties with per unit royalties. They found that including ad valorem royalties in the contract allows the licensor to strategically commit to be less aggressive, as the revenues from

licensing increase in the price. Therefore, they provided a simple justification for the presence of ad valorem royalties in licensing contracts. In addition, licensing may have a negative effect on consumers (Martín and Saracho 2010). Interestingly, the empirical evidence on licensing contracts has also shown the use of ad valorem royalties, that is, payments corresponding to a share of the sales revenues of the licensee (Martín and Saracho 2015).

In reality and in empirical research on SCs, the developer uses the royalties of revenue sharing, called ad valorem royalties. Not only Martín and Saracho (2010, 2016) but also other studies have included this type of payment in the theoretical analysis and some interesting aspects have emerged for the literature on patent licensing. For instance, Heywood et al. (2014) showed that the licensor can choose any two-part tariff contract with either per unit or ad valorem royalties. In their model, they did not use the fixed fee contract and the presence of asymmetric information uniquely drives the per unit royalties. Thus, they served to emphasize the importance of royalties even with asymmetric information and with the possibility of two-part tariffs. In addition, they showed that per unit royalties always generate higher social welfare than ad valorem royalties. Moreover, Niu (2013) proved that profit sharing licensing and per unit royalty licensing are equivalent to each other regarding both profitability and welfare in a duopoly with symmetric product differentiations. In addition, Niu (2013) confirmed the conclusion of the model proposed by Martín and Saracho (2010) in a more general demand setting and further explored the consequence of relaxing the symmetry assumption on demand.

In this way, the literature has focused on the rent system of per unit royalties. In fact, ad valorem royalties and fixed rents are relatively commonly used in the rent contracts of SCs. Nonetheless, researchers have not necessarily used ad valorem royalties, fixed fee rents, and two-part tariffs (ad valorem royalties plus fixed fees), instead using a rent system comprising per unit royalties, fixed fee rents, and two-part tariffs (per unit royalties plus fixed fees). In other words, in previous studies, despite its importance, the ad valorem royalty with two-part tariffs has received less attention, especially compared with the rent system of the per unit royalty. Therefore, we

conducted research to bridge this gap between reality and the research field. The contribution of this research is that we clarify the relationship among variables that can be observed in reality by using a theoretical model. Furthermore, in the context of SCs, prior research has not paid attention to the theoretical relationship between the proportion of the two rent systems (ad valorem royalty and fixed fee rent) for retailers and the profits of developers. Further, insufficient discussion has been carried out on the changes in the proportion of the fixed fee rent and ad valorem royalty rent between large and small retailers and in the profits of developers by considering the degree of product substitutability and demand uncertainty in the context of SCs. Additionally, no argument has been made on the degree of the difference in uncertainty between these two types of retailers at the same time. By using a model of the optimal two-part tariff licensing between a developer and retailers as a base model, we focus on the effect of the demand uncertainty situation as the extended model. The result of our paper is novel for building a theoretical model using revenue sharing, called the ad valorem rent system, which is commonly used in practice.

In sum, contrary to the literature that focuses on competition given the per unit royalty under the impact of the possibility of licensing on innovation activities, the unique theoretical contribution of our work lies in showing the equilibrium structure of the percentage of the ad valorem royalty rent and fixed fee rent in the rent system for the retailer by the developer in a vertical market with demand uncertainty in SCs. To the best of our knowledge, our model is the first to show the interesting point that the equilibrium structure changes by changing the degree of product substitutability and demand uncertainty in the context of SCs and we provide the example of the market for SCs such as those of outlet malls and SCs that matches this theoretical result.

Chapter 3 SC Model

Ad valorem royalty plus fixed fee model

3.1. Introduction

In an SC, there are a developer and retailers. A developer attracts retailers to an SC, while retailers make a tenant contract with a developer. Since an SC has a key feature that retail tenants are placed side by side, it is important to consider the degree of competition among retailers in an SC. Then, the profits of the developer may be affected depending on the variety of retail tenants in the SC (i.e., whether similar retailers sell similar products or differentiated products). Given that asymmetric retailers (i.e., large and small retailers) sell products differentiated by different brands in the SC, we can analyze and capture the situation of retail tenants that is closer to a real SC. Then, the rent system in SCs is an important problem for the developer because it gains a great profit from the rent charged to large and small retailers. In fact, revenue sharing royalties, which depend on the sales of retail tenants and fixed fee rents, are relatively commonly used in rent contracts in SCs. Therefore, in the research field of SCs, it is important to consider not only one type of rent contract but also rent types combined with the fixed fee rent and royalty rent to consider the revenue sharing royalty rent according to the sales of the retail tenants in SCs. However, in previous studies, despite its importance, the ad valorem royalty with two-part tariffs has received less attention, especially compared with the rent system of the per unit royalty. The same holds in the field of SC research. In this paper, we adopt a two-part tariff model based on ad valorem royalties for this problem. Such a treatment by the optimal two-part tariff licensing is also used in Martín and Saracho (2016). Therefore, we expand their model and guarantee novelty as a theoretical model because they presented an applicable ad valorem royalty model. In this way, we bridge this gap between reality and the research field.

When there are both large retailers and small retailers in one SC, the developer may attempt to make the competitive advantage of small retailers stronger by decreasing the royalty for the small retailer and improving the quantity of products for them, thereby intensifying the competition between large and small retailers in the whole SC. However, in our model, the developer gives preferential treatment to large retailers rather than intensifying the competition between large and small retailers by strengthening small retailers' competitive advantage at the equilibrium. In other words, we found that the developer chooses an action to make the large retailers even stronger and increase the sales volume of the large retailers by decreasing their royalty to increase the profit of the developer. As a result, we found that the developer collects rents with a greater ratio of the fixed fee from large retailers and the rents with a greater ratio of the ad valorem royalty from small retailers.

3.2. Model

First, we consider the ad valorem royalty plus fixed fee model without demand uncertainty. We expand the model developed by Martín and Saracho (2016). In our paper, we adopt the method of two-part tariffs with ad valorem royalties used in Martín and Saracho (2016). We assume an SC where a developer determines the royalty of the rent to the two types of retailers. To sell products, each retailer must sign lease contracts with the developer. Consider the developer (D) that uses a two-part tariff licensing mechanism to contract with each retailer. We call the retailer of the large efficient company the large retailer (L) and the other of the small inefficient company the small retailer (S). Then, each retailer sells sales volume q_i ($i = L, S$). The retailers get the product from manufacturers except the developer. Then, we assume a cost-competitive setting such as that in the apparel industry. Each retailer's rent depends on its sales of tenant $p_i q_i$. For simplicity, we assume that $r_i p_i q_i$ is the rent according to royalty r_i and the sales of tenant $p_i q_i$ that retailer i attains. Then, f_i denotes the fixed fee rent of each retailer. For simplicity, the marginal cost is given by c and we assume that c is a sufficiently small positive value. Specifically, we explain what kind of situation this assumes. We consider the situation that the willingness to pay of consumers changes depending on the differences in retail brands and brand image for consumer. In this case, it is a natural setting to assume little difference in the goods among the retailers. Then, we identify that it has no effect on the result. To keep positive outcomes, we assume that $a - c > \gamma(1 - c)$.

The utility maximization problem is

$$\max_{q_L, q_S, m} U(q_L, q_S, m) = q_L + a q_S - \frac{1}{2}(q_L^2 + q_S^2) - \gamma q_L q_S + m, \quad (3-1)$$

$$s. t. p_L q_L + p_S q_S + m \leq I,$$

where $0 < a < 1$ and $0 < \gamma < 1$, and the degree of product substitutability is measured by γ . When $\gamma \rightarrow 1$, the goods are perfect substitutes and for $\gamma \rightarrow 0$, the goods are unrelated, that is, we use γ (the degree of product substitutability) as a measure of the competition of the retail market. If γ is large, the products are homogenized and the competition of the retail market becomes intense. Otherwise, if

γ is small, the products are differentiated and the competition of the retail market becomes moderate.

Considering the above assumption in our model, we obtain the condition of the parameter that satisfies a negative definite. As noted above, we assume a sufficiently small positive value c . We assume that the profit function consequently is concave. By solving the determinant of the Hessian matrix, we obtain the condition of the parameter that satisfies the second-order condition. Then, combined with the condition to keep positive outcomes, we obtain the following condition: $a - c > \gamma(1 - c)$. When m is the amount of the numeraire good, p_i is the price of the retailer's product, and I is the income for the consumer. We employ the utility function form represented by Equation (3-1) for the following reason. If the product quality supplied by a retailer is zero, a consumer has no incentive to buy the product. Hence, our utility function is consistent with consumer behavior.

This product differentiation, as assumed in the paper, may be due to each retailer of different brand names. From the first-order conditions of the utility maximization problem, the inverse demand functions that the two retailers face are given by

$$p_L = 1 - q_L - \gamma q_S, \quad (3-2)$$

$$p_S = a - q_S - \gamma q_L. \quad (3-3)$$

The profit function of the developer is given as

$$\pi_D = r_L p_L q_L + f_L + r_S p_S q_S + f_S. \quad (3-4)$$

The profit function of retailer i is given as

$$\pi_L = p_L q_L - r_L p_L q_L - c q_L - f_L, \quad \pi_S = p_S q_S - r_S p_S q_S - c q_S - f_S. \quad (3-5), (3-6)$$

Consumer surplus $CS = (q_L^2 + 2\gamma q_L q_S + q_S^2)/2$ and social welfare $SW = CS + \pi_D + \pi_L + \pi_S$. We next delineate the timeline of a series of decisions made by the players comprising the supply chain. The setting of the assumption and timing of the game are described as follows. We consider a two-stage game. In stage one, the developer chooses the royalty and fixed fee of each retailer, r_i and f_i . In stage two, each retailer independently and simultaneously chooses its sales, q_i . We solve for the

equilibrium by backward induction.

In the model, we assume that the retailer needs to pay the fixed fee f_i regardless of the sales volume q_i . Regarding this point, when contracting with the developer in stage one, retailers have a contract that they have to pay a fixed fee rent to the developer when they open a store in the SC. In other words, the fixed fee can be said to be the cost for participation in the SC. Since the fixed fee rent of retailer f_i has already been determined when each retailer decides q_i , retailers must pay the fixed fee rent f_i without depending on any sales volume q_i . Specifically, since we assume that we do not think of a situation where retailers do not have to pay the fixed fee f_i when they do not sell in SCs, retailers have to pay the fixed fee f_i even in any financial condition. In other words, retailers have already paid the fixed fee rent f_i as a sunk cost to a developer on a contract basis.

From a game procedure point of view, the retailer decides whether to contract or reject at the stage of concluding the contract. In stage one, the developer decides the fixed fee rent f_i and royalty r_i and presents a contract to retailers. Then, the retailers receive a contract agreement from the developer, calculate the fixed fee rent f_i , and sign a contract. At that time, because retailers have already paid the fixed fee rent f_i to the developer, in the second stage the retailer decides the sales volume in the situation that the fixed fee f_i is a sunk cost. Figure 1 illustrates the timeline of events. The model is solved with the use of backward induction along the timeline to derive the subgame perfect equilibrium in this dynamic game.

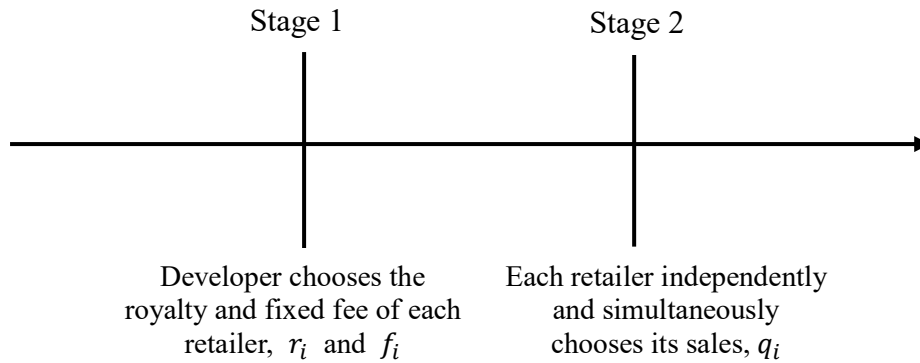


Figure 1. Timeline of events.

Table 1. Nomenclature.

q_L	sales quantity of the large retailer
q_S	sales quantity of the small retailer
p_L	price of the large retailer
p_S	price of the small retailer
r_L	royalty of the large retailer
r_S	royalty of the small retailer
f_L	fixed fee rent of the large retailer
f_S	fixed fee rent of the small retailer
π_D	profit of the developer
π_L	profit of the large retailer
π_S	profit of the small retailer
CS	consumer surplus
SW	social welfare
a	intercept of the inverse demand function
c	marginal cost of retailers
γ	degree of the product substitutability
*	superscript for equilibrium of the old model

3.3. Calculating the equilibrium

In this section, we identify the subgame perfect equilibrium. We consider the following two-stage game. In the second stage, each retailer chooses its sales quantity.

The maximization problem for the large retailer is

$$\max_{q_L} [p_L q_L - r_L p_L q_L - c q_L - f_L]. \quad (3-7)$$

The maximization problem for the small retailer is stated as

$$\max_{q_S} [p_S q_S - r_S p_S q_S - c q_S - f_S]. \quad (3-8)$$

Note that retailers have already paid the fixed fee rent f_i as a sunk cost to the developer.

The first-order conditions ($\partial \pi_L / \partial q_L = 0$ and $\partial \pi_S / \partial q_S = 0$) are derived as

$$\begin{aligned} q_L &= \frac{2(1 - r_S)[(1 - r_L) - c] - \gamma(1 - r_L)[a(1 - r_S) - c]}{(4 - \gamma^2)(1 - r_L)(1 - r_S)}, \\ q_S &= \frac{2(1 - r_L)[a(1 - r_S) - c] - \gamma(1 - r_S)[(1 - r_L) - c]}{(4 - \gamma^2)(1 - r_L)(1 - r_S)}. \end{aligned} \quad (3-9), (3-10)$$

By substituting this outcome into the profit of the developer, we have the maximization problem of the developer as follows:

$$\begin{aligned} \max_{r_L, r_S, f_L, f_S} & [r_L p_L q_L + f_L + r_S p_S q_S + f_S]. \\ \text{s. t. } & p_L q_L - r_L p_L q_L - c q_L - f_L \geq 0, \\ & p_S q_S - r_S p_S q_S - c q_S - f_S \geq 0. \end{aligned} \quad (3-11)$$

As the objective function is an increasing function of f_i and the developer takes the value of the largest fixed fee f_i within the range that satisfies the participation constraints, it is the optimal strategy for the developer to determine the value of the fixed fee f_i . Then, since the value of the fixed fee f_i should be determined to bind with the participation constraints, the value of the fixed fee f_i is as follows:

$$\begin{cases} f_L = p_L q_L - r_L p_L q_L - c q_L, \\ f_S = p_S q_S - r_S p_S q_S - c q_S. \end{cases} \quad (3-12), (3-13)$$

By substituting (3-12) and (3-13) into (3-11), we can write the expected profit maximization in the form that also includes the participation constraints. In other words, we can rewrite the developer's expectation profit maximization problem as follows:

$$\max_{r_L, r_S} [p_L q_L - c q_L + p_S q_S - c q_S]. \quad (3-14)$$

The first-order condition ($\partial \pi_D / \partial r_L = 0$ and $\partial \pi_D / \partial r_S = 0$) in this stage yields

$$r_L^* = \frac{\gamma[a - \gamma - c(1 - \gamma)]}{\gamma(a - \gamma) + c(2 - \gamma)(1 + \gamma)},$$

$$r_S^* = \frac{\gamma[(1 - a\gamma) - c(1 - \gamma)]}{\gamma(1 - a\gamma) + c(2 - \gamma)(1 + \gamma)},$$

(3-15), (3-16)

where the variables with superscript * represent the equilibrium values. By solving the above equation, we obtain the equilibrium outcomes and provide the results in Table 2.

Table 2. Equilibrium outcomes

	Equilibrium
π_D^*	$\frac{a(a - 2[\gamma + c(1 - \gamma)]) + 2c(1 - \gamma)(1 - c) + 1}{4(1 - \gamma^2)}$
q_L^*	$\frac{(1 - a\gamma) - c(1 - \gamma)}{2(1 - \gamma^2)}$
q_S^*	$\frac{a - \gamma - c(1 - \gamma)}{2(1 - \gamma^2)}$
r_L^*	$\frac{\gamma[a - \gamma - c(1 - \gamma)]}{\gamma(a - \gamma) + c(2 - \gamma)(1 + \gamma)}$
r_S^*	$\frac{\gamma[(1 - a\gamma) - c(1 - \gamma)]}{\gamma(1 - a\gamma) + c(2 - \gamma)(1 + \gamma)}$
f_L^*	$\frac{c[(1 - a\gamma) - c(1 - \gamma)]^2}{2(1 - \gamma^2)[\gamma(a - \gamma) + c(2 - \gamma)(1 + \gamma)]}$
f_S^*	$\frac{c[a - \gamma - c(1 - \gamma)]^2}{2(1 - \gamma^2)[\gamma(1 - a\gamma) + c(2 - \gamma)(1 + \gamma)]}$
CS^*	$\frac{a(a - 2[\gamma + c(1 - \gamma)]) + 2c(1 - \gamma)(1 - c) + 1}{8(1 - \gamma^2)}$
SW^*	$\frac{3a[(a - 2[\gamma + c(1 - \gamma)]) + 2c(1 - \gamma)(1 - c) + 1]}{8(1 - \gamma^2)}$

The superscript * denotes the equilibrium for the benchmark model. CS is consumer surplus and SW is social welfare.

3.4. Equilibrium and comparative statics

This paper compares the contract of the rent system by means of the proportion of a fixed fee rent with the contract of the rent system by means of the proportion of the ad valorem royalties in a simple Cournot duopoly model. We compare the difference in the ad valorem royalty of the large and small retailers, r_L^*, r_S^* , as well as the difference in the fixed fee rent of the large and small retailers, f_S^*, f_L^* .

Proposition 1 (Royalty and fixed fee of large and small retailers)

By solving the inequalities of the equilibrium, we draw the conclusions of the relationship that $r_L^ < r_S^*$, $f_S^* < f_L^*$.*

Proof. As we calculate the difference between the two equilibria of the ad valorem royalties of the large and small retailers, r_L^* and r_S^* , as well as the difference between the fixed fee rents of the large and small retailers, f_L^* and f_S^* , we draw the following conclusions. Given the assumption $a - c > \gamma(1 - c)$, the inequalities are satisfied:

$$r_L^* - r_S^* = \frac{2(1-a)c(1-\gamma)\gamma(1+\gamma)^2}{[\gamma(a-\gamma) + c(2-\gamma)(1+\gamma)][\gamma(1-a\gamma) + c(2-\gamma)(1+\gamma)]} < 0,$$

$$f_L^* - f_S^* = \frac{\left(\frac{c[(1-a\gamma) - c(1-\gamma)]^2}{\gamma(a-\gamma) + c(2-\gamma)(1+\gamma)} - \frac{c[a-\gamma - c(1-\gamma)]^2}{\gamma(1-a\gamma) + c(2-\gamma)(1+\gamma)} \right)}{2(1-\gamma^2)} > 0.$$

(3-17), (3-18). $\square$

The intuition is as follows. This result suggests that the developer has incentives to increase the sales volume q_L of the large retailer. Moreover, in this paper, since the movement of the sales volume of the large retailer q_L and the sales volume of the small retailer q_S is symmetric in our model, the developer actively acts to discount the ad valorem royalty of the large retailer r_L . In other words, the developer should decrease the ad valorem royalty of the large retailer r_L , and think that it is better to increase the sales volume of the large retailer q_L . The reason is that in the market in our model, the more valuable product is q_L , which is the product that the large retailer

sells. Furthermore, given the impact on the final profit, we consider that this intuition makes sense since the impact on the profits of large retailers should be greater than the impact on the profits of small retailers.

Let us consider the reaction function in the second stage. At that time, if the developer would like to increase the volume of the sales of either retailer, it would obviously like to increase the sales volume of the large retailer q_L . As explained above, if the developer would like to increase the sales volume of the large retailer q_L , it acts to lower r_L in the equilibrium to increase the incentive to lower the royalty of the large retailer r_L . The proposition is a simple mechanism. As a result of the analysis of the model in this paper, we found in the equilibrium that the best policy of the rent system by developers is that the developer gives preferential treatment to large retailers by decreasing the royalty of the large retailer, r_L .

By differentiating these equilibrium outcomes with respect to the degree of product substitutability γ , we obtain the following proposition.

Proposition 2 (Effect of the degree of product substitutability)

The results of the comparative statics for the degree of product substitutability are as follows. As the degree of product substitutability γ increases, the sales volume of the small retailer q_S^ and the fixed fee rent of the small retailer f_S^* decrease and the royalty of the large retailer r_L^* increases at the equilibrium. Then, the profit of the developer π_D^* decreases at the equilibrium:*

$$\begin{aligned}\frac{\partial r_L^*}{\partial \gamma} &= \frac{2c[a(1 + \gamma^2) - c(1 - \gamma)^2 - 2\gamma]}{[\gamma(a - \gamma) + c(2 - \gamma)(1 + \gamma)]^2}, \\ \frac{\partial r_S^*}{\partial \gamma} &= \frac{2c[(1 + \gamma^2) - c(1 - \gamma)^2 - 2a\gamma]}{[\gamma(1 - a\gamma) + c(2 - \gamma)(1 + \gamma)]^2} > 0, \\ \frac{\partial f_L^*}{\partial \gamma} &= \frac{c[a(1 + \gamma^2) - c(1 - \gamma)^2 - 2\gamma][a\gamma + c(1 - \gamma) - 1]}{2(1 - \gamma^2)^2[\gamma(a - \gamma) + c(2 - \gamma)(1 + \gamma)]^2}, \\ \frac{\partial f_S^*}{\partial \gamma} &= -\frac{c[(1 + \gamma^2) - c(1 - \gamma)^2 - 2a\gamma][a - c(1 - \gamma) - \gamma]}{2(1 - \gamma^2)^2[\gamma(1 - a\gamma) + c(2 - \gamma)(1 + \gamma)]^2} < 0,\end{aligned}$$

$$\frac{\partial q_L^*}{\partial \gamma} = \frac{c(1-\gamma)^2 - a(1+\gamma^2) + 2\gamma}{2(1-\gamma^2)^2}, \quad \frac{\partial q_S^*}{\partial \gamma} = -\frac{1-\gamma(2a-\gamma) - c(1-\gamma)^2}{2(1-\gamma^2)^2} < 0,$$

$$\frac{\partial CS^*}{\partial \gamma} = -\frac{[a-\gamma-c(1-\gamma)][(1-a\gamma)-c(1-\gamma)]}{4(1-\gamma^2)^2} < 0,$$

$$\frac{\partial SW^*}{\partial \gamma} = -\frac{3[a-\gamma-c(1-\gamma)][(1-a\gamma)-c(1-\gamma)]}{4(1-\gamma^2)^2} < 0,$$

$$\frac{\partial \pi_D^*}{\partial \gamma} = -\frac{[a-\gamma-c(1-\gamma)][(1-a\gamma)-c(1-\gamma)]}{2(1-\gamma^2)^2} < 0.$$

$$(3-19), (3-20), (3-21), (3-22), (3-23), (3-24), (3-25), (3-26), (3-27)$$

Next, we analyze the effect of an increase in the degree of product substitutability and tougher competition (an increase in γ) on some of the outcomes in the following propositions. First, we mention some important properties of the change in the degree of product substitutability when we consider what can be claimed by the comparative static science. When γ rises and the product of each retailer is approaching homogeneous goods, the developer takes actions that emphasize large retailers, where $\gamma = 1$ means homogeneous goods. We consider the situations where the values of the intercepts are different for large and small retailers as the asymmetric downstream companies when the products of each retailer are homogeneous. In view of the above, it is mathematically meant that small retailers are inefficient companies compared with large retailers. Therefore, when we consider the question of which of the large and small retailers should take action in a situation where retailers sell similar goods, naturally, the developer gives preferential treatment to the large, more efficient retailer. Although this is an extreme case, this effect becomes more pronounced as γ approaches 1, that is, as the goods of each retailer become closer to the homogeneous goods.

In addition, when the degree of product substitutability γ becomes large, we consider two effects. One is the effect of the products of each retailer approaching homogeneous goods and the other is the effect of market shrinkage. When $\gamma = 0$, we get two inverse demand functions. On the contrary, when $\gamma = 1$, the inverse demand function effectively becomes one. Therefore, there are two effects on the market when

γ increases; when the market shrinks such as the situations of the latter effects, this property basically has the effect of lowering the sales volume of the retailers. This reduces the variables such as the royalties and fixed fee rents of the retailers in our model, which is commonly called the marginal cost. This is the fundamental property of the effect that the market shrinks when γ increases. Moreover, we consider the effect of approaching homogeneous goods when γ increases. As mentioned earlier, when the product of the retailer approaches homogeneous goods, the problem arises as to which retailer is preferred for the developer. Then, although we omit the explanation here, the effect that the developer takes the measure that prefers the large retailer comes out strongly. Considering these properties, we consider what can be claimed by comparative static science.

By differentiating the royalty of each retailer at the equilibrium with respect to the degree of product substitutability γ , we obtain the following proposition.

Proposition 3 (Effect on the royalty of each retailer)

As the degree of product substitutability and tougher competition (an increase in γ) increase, the royalty of the small retailer r_S^ increases. Then, the conditions under which an increase in the degree of product substitutability and tougher competition (an increase in γ) increases or decreases the royalty of the large retailer r_L^* are as follows:*

$$\begin{cases} \frac{\partial r_L^*}{\partial \gamma} > 0 & \text{if } \frac{c(1-\gamma)^2 + 2\gamma}{1+\gamma^2} < a \\ \frac{\partial r_L^*}{\partial \gamma} < 0 & \text{if } c + \gamma(1-c) < a < \frac{c(1-\gamma)^2 + 2\gamma}{1+\gamma^2} \\ \frac{\partial r_S^*}{\partial \gamma} > 0 \end{cases}$$

(3-28), (3-29), (3-30)

Proof. We explain the condition under which an increase in the degree of product substitutability and tougher competition (an increase in γ) increases or decreases the royalty of the large retailer r_L^* .

By differentiating these equilibria of the royalty of the large retailer r_L^* with respect to the degree of product substitutability γ , we gain the expression $\partial r_L^* / \partial \gamma = [c(1-\gamma)^2 + 2\gamma - a(1+\gamma^2)] / [2(1-\gamma^2)^2]$. Then, we solve $\partial r_L^* / \partial \gamma = 0$ for a and obtain the equality $a = [c(1-\gamma)^2 + 2\gamma] / (1+\gamma^2)$. In our model, when the inequality is satisfied $[c(1-\gamma)^2 + 2\gamma] / (1+\gamma^2) < a$, we obtain the inequality $\partial r_L^* / \partial \gamma > 0$. On the contrary, when the inequality is satisfied $a < [c(1-\gamma)^2 + 2\gamma] / (1+\gamma^2)$, we obtain the inequality $\partial r_L^* / \partial \gamma < 0$. To keep positive outcomes, we assume that the inequalities are satisfied $a - c > \gamma(1-c)$. Therefore, we obtain the proposition. $\square$

From Proposition 3, the intuition is as follows. The royalty of the large retailer decreases in the range of $c + \gamma(1-c) < a < [c(1-\gamma)^2 + 2\gamma] / (1+\gamma^2)$ for the rent contracts. In other words, the range indicates that the large retailer has been given

preferential treatment by the developer by lowering commissions. Therefore, when γ becomes large, the large retailer is presented with the preferential treatment details from the developer.

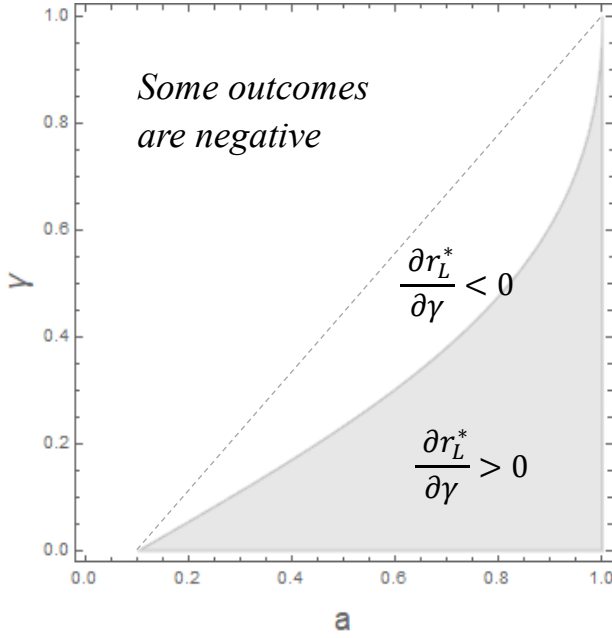


Figure 2. Effect on the royalty of the large retailer

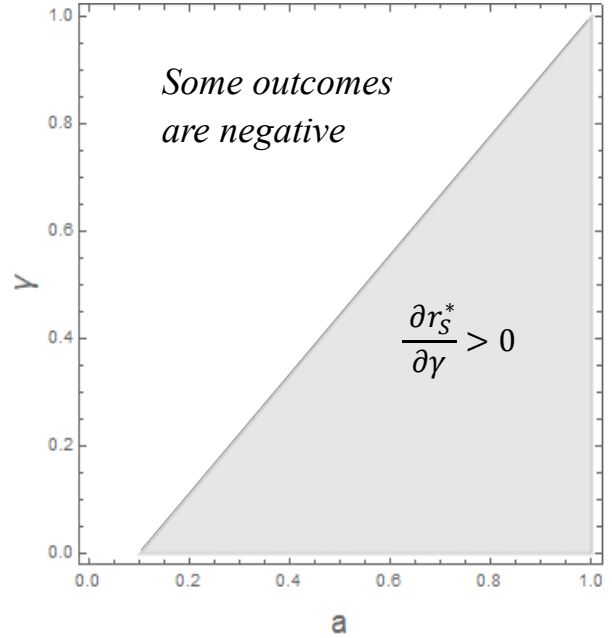


Figure 3. Effect on the royalty of the small retailer

We depict the result of Proposition 3 in Figure 2 and Figure 3. As shown in Figure 2, the gray area is $\partial r_L^* / \partial \gamma > 0$. In the non-shaded area, we find the region in which the royalty of the large retailer r_L^* decreases with the degree of product substitutability and the index of competition γ . On the contrary, as shown in Figure 3, we find the region in which the royalty of the small retailer r_S^* increases with the degree of product substitutability and the index of competition γ .

By differentiating the sales volume of each retailer at the equilibrium with respect to the degree of product substitutability γ , we obtain the following proposition.

Proposition 4 (Effect on the sales volume of each retailer)

As the degree of product substitutability and tougher competition (an increase in γ) increase, the sales volume of the small retailer q_S^ decreases. Then, the conditions under which an increase in the degree of product substitutability and tougher competition (an increase in γ) increases or decreases the sales volume of the large retailer q_L^* are as follows:*

$$\begin{cases} \frac{\partial q_L^*}{\partial \gamma} > 0 & \text{if } c + \gamma(1 - c) < a < \frac{c(1 - \gamma)^2 + 2\gamma}{1 + \gamma^2} \\ \frac{\partial q_L^*}{\partial \gamma} < 0 & \text{if } \frac{c(1 - \gamma)^2 + 2\gamma}{1 + \gamma^2} < a \\ \frac{\partial q_S^*}{\partial \gamma} < 0 \end{cases}$$

(3-31), (3-32), (3-33)

Proof. We now explain the condition under which an increase in the degree of product substitutability and tougher competition (an increase in γ) increases or decreases the sales volume of the large retailer q_L^* .

By differentiating these equilibria of the sales volume of the large retailer q_L^* with respect to the degree of product substitutability γ , we gain the expression $\partial q_L^* / \partial \gamma = [c(1 - \gamma)^2 - a(1 + \gamma^2) + 2\gamma] / [2(1 - \gamma^2)^2]$. Then, we solve $\partial q_L^* / \partial \gamma = 0$ for a and obtain the equality $a = [c(1 - \gamma)^2 + 2\gamma] / (1 + \gamma^2)$. In our model, when the inequality is satisfied $a < [c(1 - \gamma)^2 + 2\gamma] / (1 + \gamma^2)$, we obtain the inequality $\partial q_L^* / \partial \gamma > 0$. On the contrary, when the inequality is satisfied $[c(1 - \gamma)^2 + 2\gamma] / (1 + \gamma^2) < a$, we obtain the inequality $\partial q_L^* / \partial \gamma < 0$. To keep positive outcomes, we assume the inequalities are satisfied $a - c > \gamma(1 - c)$. Therefore, we obtain the proposition. $\square$

From Proposition 4, the intuition is as follows. We consider the effect on the sales volume of each retailer based on the discussion of Proposition 3. We show that the royalty of the large retailer decreases in the range of $c + \gamma(1 - c) < a <$

$[c(1 - \gamma)^2 + 2\gamma]/(1 + \gamma^2)$ for rent contracts (Proposition 3). In other words, the range indicates that the large retailer has been given preferential treatment by the developer by lowering commissions. Therefore, when γ becomes large, the large retailer is presented with the preferential treatment details from the developer. Then, from Proposition 4, we show that the sales volume of a large retailer increases because the large retailer is presented with the preferential treatment details from the developer.

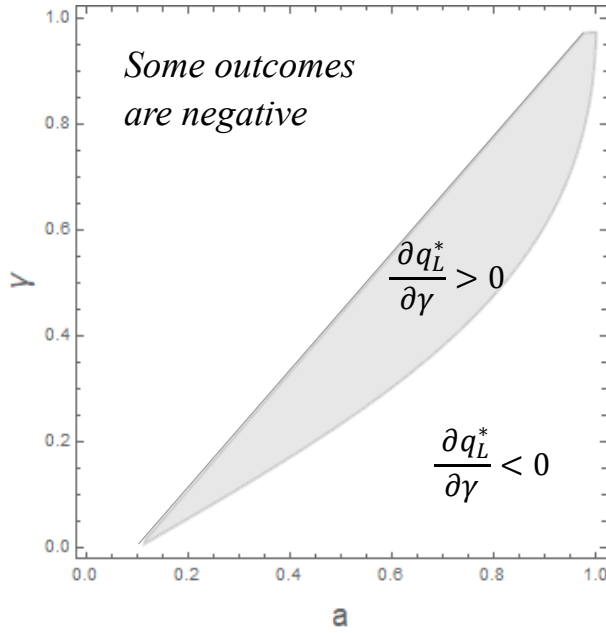


Figure 4. Effect on the sales volume of the large retailer

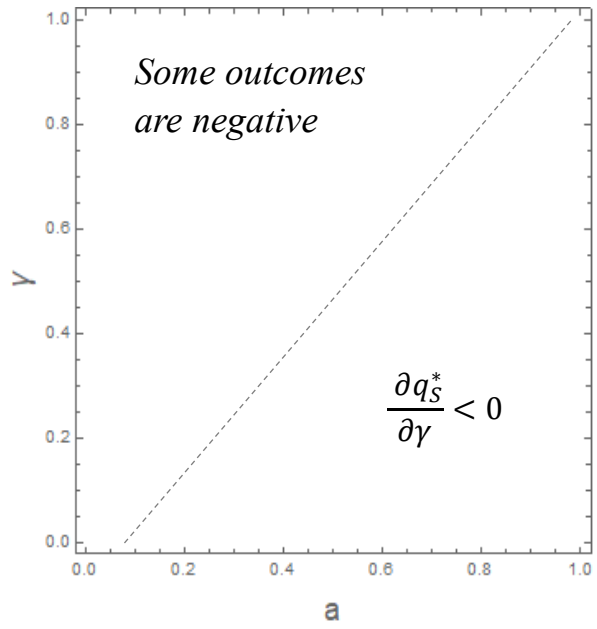


Figure 5. Effect on the sales volume of the small retailer

We depict the result of Proposition 4 in Figure 4 and Figure 5. As shown in Figure 4, we find the region in which the sales volume of the large retailer q_L^* increases or decreases with the degree of product substitutability and the index of competition γ . On the contrary, as shown in Figure 5, we find the region in which the sales volume of the small retailer q_S^* decreases with the degree of product substitutability and the index of competition γ .

By differentiating the fixed fee of each retailer at the equilibrium with respect to the degree of product substitutability γ , we obtain the following proposition.

Proposition 5 (Effect on the fixed fee of each retailer)

As the degree of product substitutability and tougher competition (an increase in γ) increase, the fixed fee rent of the small retailer f_S^ decreases. Then, the conditions under which an increase in the degree of product substitutability and tougher competition (an increase in γ) increases or decreases the fixed fee rent of the large retailer f_L^* are as follows:*

$$\begin{cases} \frac{\partial f_L^*}{\partial \gamma} > 0 & \text{if } c + \gamma(1 - c) < a < \frac{c(1 - \gamma)^2 + 2\gamma}{1 + \gamma^2} \\ \frac{\partial f_L^*}{\partial \gamma} < 0 & \text{if } \frac{c(1 - \gamma)^2 + 2\gamma}{1 + \gamma^2} < a \\ \frac{\partial f_S^*}{\partial \gamma} < 0 \end{cases}$$

(3-34), (3-35), (3-36)

Proof. We explain the condition under which an increase in the degree of product substitutability and tougher competition (an increase in γ) increases or decreases the fixed fee of the large retailer f_L^* .

By differentiating these equilibria of the fixed fee of the large retailer f_L^* with respect to the degree of product substitutability γ , we gain the expression $\partial f_L^* / \partial \gamma = [c(1 - \gamma)^2 + 2\gamma - a(1 + \gamma^2)] / [2(1 - \gamma^2)^2]$. Then, we solve $\partial f_L^* / \partial \gamma = 0$ for a and obtain the equality $a = [c(1 - \gamma)^2 + 2\gamma] / (1 + \gamma^2)$. In our model, when the inequality is satisfied $a < [c(1 - \gamma)^2 + 2\gamma] / (1 + \gamma^2)$, we obtain the inequality $\partial f_L^* / \partial \gamma > 0$. On the contrary, when the inequality is satisfied $[c(1 - \gamma)^2 + 2\gamma] / (1 + \gamma^2) < a$, we obtain the inequality $\partial f_L^* / \partial \gamma < 0$. To keep positive outcomes, we assume the inequalities are satisfied $a - c > \gamma(1 - c)$. Therefore, we obtain the proposition. $\square$

From Proposition 5, the intuition is as follows. We consider the effect on the sales volume of each retailer based on the discussion of the above propositions. We show that the royalty of the large retailer decreases in the range of $c + \gamma(1 - c) < a <$

$[c(1 - \gamma)^2 + 2\gamma]/(1 + \gamma^2)$ for rent contracts (Proposition 3). In other words, the range indicates that the large retailer has been given preferential treatment by the developer by lowering commissions. Therefore, when γ becomes large, the large retailer is presented with the preferential treatment details from the developer. Then, we show that the sales volume of the large retailer increases because it is presented with the preferential treatment details from the developer (Proposition 4).

Then, from Proposition 5, since the large retailer earns considerable revenue, the developer collects a fixed fee rent from the large retailer within the range of $c + \gamma(1 - c) < a < [2\gamma + c(1 - \gamma)^2]/(1 + \gamma^2)$. On the contrary, the small retailer behaves in the opposite direction in the equilibrium. First, as γ increases, the fixed fee rent of the small retailer tends to decline because the market is scaled down. From a different point of view, since the large retailer is given preferential treatment and the profits of the small retailer are reduced, the fixed fee rent of the small retailer is reduced. Therefore, we find that the fixed fee rent of the small retailer always decreases.

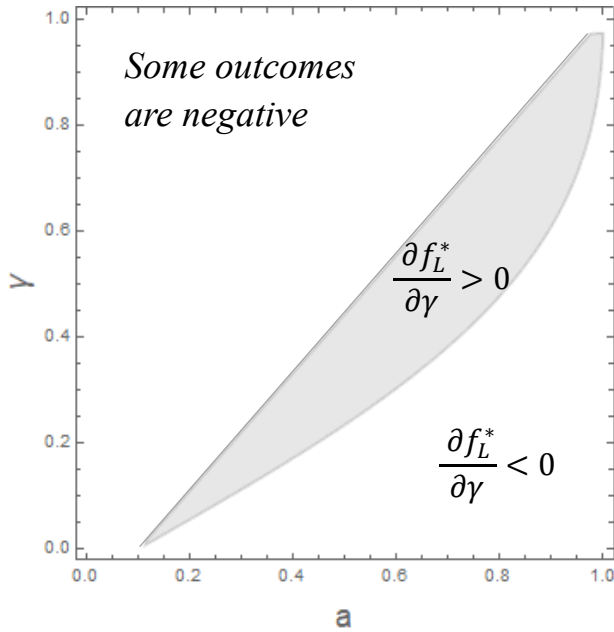


Figure 6. Effect on the fixed fee of the large retailer

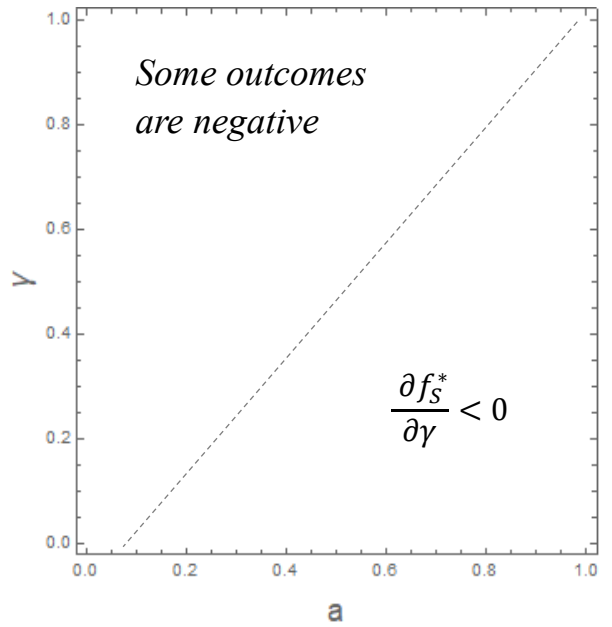


Figure 7. Effect on the fixed fee of the small retailer

We depict the result of Proposition 5 in Figure 6 and Figure 7. As shown in Figure 6, the gray area is $\partial f_L^*/\partial\gamma > 0$. We find the region in which the fixed fee of the large retailer f_L^* increases with the degree of product substitutability and the index of competition γ . On the contrary, as shown in Figure 7, we find the region in which the fixed fee of the small retailer f_S^* decreases with the degree of product substitutability and the index of competition γ .

By differentiating the ratio of the total royalty rent to the fixed fee rent of each retailer $(r_L^*p_L^*q_L^*)/f_L^*$ and $(r_S^*p_S^*q_S^*)/f_S^*$ in the equilibrium outcomes with respect to the degree of product substitutability γ , we obtain the following proposition.

Proposition 6 (The ratio of total royalty to the fixed fee for each retailer)

*As the degree of product substitutability and tougher competition (an increase in γ) increase, the ratio of the total royalty rent of the small retailer to the fixed fee rent of the small retailer $(r_S^*p_S^*q_S^*)/f_S^*$ increases. Then, the conditions under which the region of the ratio of the total royalty rent of the large retailer to the fixed fee rent of the large retailer $(r_L^*p_L^*q_L^*)/f_L^*$ is positive or negative are as follows:*

$$\left\{ \begin{array}{ll} \frac{\partial \frac{r_L^*p_L^*q_L^*}{f_L^*}}{\partial\gamma} > 0 & \text{if } \frac{c(1-\gamma)^2 + 2\gamma}{\gamma^2 + 1} < a \\ \frac{\partial \frac{r_L^*p_L^*q_L^*}{f_L^*}}{\partial\gamma} < 0 & \text{if } c + \gamma(1-c) < a < \frac{c(1-\gamma)^2 + 2\gamma}{\gamma^2 + 1} \end{array} \right.$$

$$\frac{\partial \frac{r_S^*p_S^*q_S^*}{f_S^*}}{\partial\gamma} > 0$$

(3-37), (3-38), (3-39)

Proof. Given the assumption $a - c > \gamma(1 - c)$, the inequalities are satisfied. $\square$

Hence, large and small retailers behave in the opposite direction in the areas of $c + \gamma(1 - c) < a < [2\gamma + c(1 - \gamma)^2]/(1 + \gamma^2)$. However, in the lower right region

$[2\gamma + c(1 - \gamma)^2]/(1 + \gamma^2) < a$, both large and small retailers are positive and disadvantaged. In other words, there is a region where no retailer moves in the opposite direction, that is, both large and small retailers increase their royalties and become positive within $[2\gamma + c(1 - \gamma)^2]/(1 + \gamma^2) < a$.

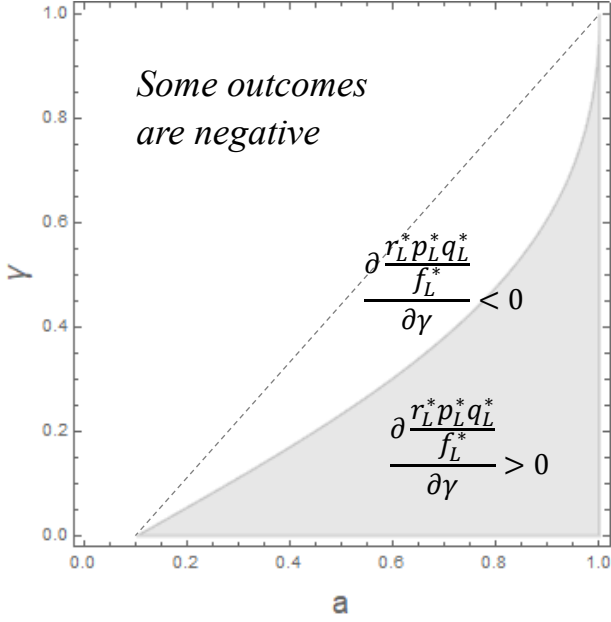


Figure 8. Effect on the ratio of the total royalty rent to the fixed fee rent for the large retailer

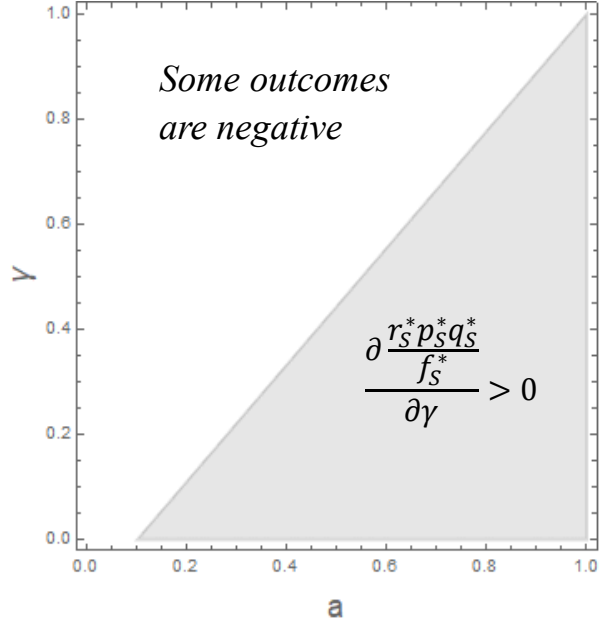


Figure 9. Effect on the ratio of the total royalty rent to the fixed fee rent for the small retailer

Therefore, at this stage, in the bottom right part, it is not clear whether the developer gives preferential treatment to which retailer. To clarify and discuss this issue about favorable treatment, it is impossible to clarify without analyzing the proportion of the difference in the royalty rent of each retailer. Then, we analyze the proportion of the royalty rent of each retailer.

By differentiating the ratio of the royalty rent between the large and small retailers, r_L^*/r_S^* , and the ratio of the fixed fee rent between large and small retailers f_L^*/f_S^* at the equilibrium with respect to the degree of product substitutability γ , we obtain the following proposition.

Proposition 7 (The ratio of each rent between large and small retailers)

As the degree of product substitutability and tougher competition (an increase in γ) increase and the ratio of the fixed fee rent between large and small retailers f_L^*/f_S^* increases. If a is large enough to satisfy $\tilde{a} < a$, then r_L^*/r_S^* is increasing in γ . Otherwise, r_L^*/r_S^* is decreasing in γ . That is,

$$\begin{cases} \frac{\partial \frac{r_L^*}{r_S^*}}{\partial \gamma} > 0 & \text{if } \tilde{a} < a \\ \frac{\partial \frac{r_L^*}{r_S^*}}{\partial \gamma} < 0 & \text{if } c + \gamma(1 - c) < a < \tilde{a} \\ \frac{\partial \frac{f_L^*}{f_S^*}}{\partial \gamma} > 0 \end{cases}$$

where

$$a = \frac{(1 - \gamma) + \gamma^2(5 - \gamma) - c(3 - \gamma)(1 - \gamma^2)}{\sqrt{1 - 2\gamma - 3\gamma^2 + c^2(5\gamma^2 - 2\gamma + 9) - c(3 - \gamma)(1 + \gamma)}} = \tilde{a}. \quad (3-40), (3-41), (3-42), (3-43)$$

Proof. Given the assumption $a - c > \gamma(1 - c)$, the inequalities are satisfied. By differentiating the ratio of the royalty rent between the large and small retailers, r_L^*/r_S^* , in the equilibrium with respect to the degree of product substitutability γ , we gain the expression $\partial(r_L^*/r_S^*)/\partial\gamma$.

$$\frac{\partial \frac{r_L^*}{r_S^*}}{\partial \gamma} = \frac{2c(a - 1)(1 + \gamma) \left(\frac{a^2\gamma[2 - (1 - \gamma)\gamma] - a \left[\frac{(1 - \gamma) + (5 - \gamma)\gamma^2}{-c(3 - \gamma)(1 - \gamma)^2} \right]}{+(1 - \gamma)[2\gamma - \gamma^2 - c(3 - \gamma)(1 - \gamma) - c^2(1 - \gamma)(5 + \gamma)]} \right)}{[(1 - a\gamma) - c(1 - \gamma)]^2[\gamma(a - \gamma) + c(2 - \gamma)(1 + \gamma)]^2}. \quad (3-44)$$

Then, we solve $\partial(r_L^*/r_S^*)/\partial\gamma = 0$ for a and obtain the equality $a = \tilde{a}$. When the inequality is satisfied $\tilde{a} < a$, we obtain the inequality $\partial(r_L^*/r_S^*)/\partial\gamma > 0$. On the contrary, when the inequality is satisfied $c + \gamma(1 - c) < a < \tilde{a}$, we obtain the inequality $\partial(r_L^*/r_S^*)/\partial\gamma < 0$. To keep positive outcomes, we assume the inequalities are satisfied $a - c > \gamma(1 - c)$. Therefore, we obtain the proposition. $\square$

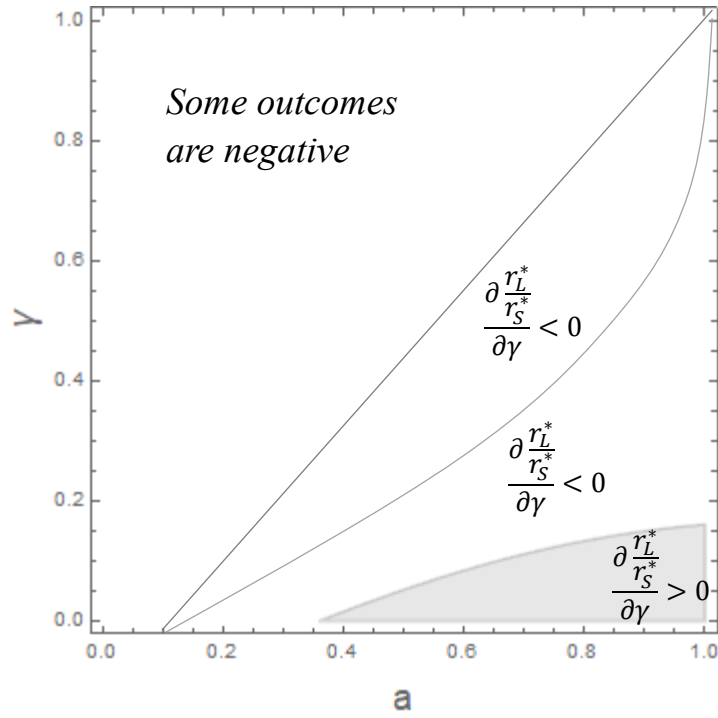


Figure 10. Effect on the ratio of the royalty between the large and small retailers

As shown in Figure 10, the gray area is $\partial(r_L^*/r_S^*)/\partial\gamma > 0$. In the shaded area, we find the region where the large retailer is more disadvantaged than the small retailer. We also find the region where the proportion of the royalty for the large retailer increases when the degree of product substitutability is small in our model.

3.5. Concluding remarks

When there are both large retailers and small retailers in one SC, the developer may attempt to make the competitive advantage of the small retailers stronger by decreasing their royalty and improving their quantity of products, thus intensifying the competition between large and small retailers in the whole SC. However, in our model, the developer gives preferential treatment to large retailers rather than intensifying the competition between large and small retailers by strengthening small retailers' competitive advantage at the equilibrium. In other words, we found that the developer chooses an action to make the large retailers even stronger and increases their sales volume by decreasing their royalty to increase the profits of the developer. As a result, we found that the developer collects the rents with a greater ratio of the fixed fee from the large retailers and the rents with a greater ratio of the ad valorem royalty from the small retailers.

Chapter 4 Extended model

Ad valorem royalties plus fixed fee model with demand uncertainty

4.1. Introduction

By using a model of the optimal two-part tariff licensing between a developer and retailers as the benchmark model, we focus on the effect of demand uncertainty in the extended model. We first explain the assumption of the extended model. In reality, many retailers selling many kinds of products in SCs have considerable information about customers. Specifically, we assume that the retailers of SCs accumulate knowledge and information about customers, such as the number of customers to come into the retail store, the general number of products they can sell by month, and what kinds of needs customers have in SCs. In practice, this means that retailers know customer demand. That is, at the stage of selling the products, we assume that large and small retailers know customer demand in a retail store and compete on quantity in SCs. On the contrary, since the developer does not have information about the customer demand of each retailer at the stage of making a contract, it is faced with only knowing customer demand probabilistically. In this paper, we build our extended model by considering the situation that customer demand in SCs is uncertain.

First, we consider the ad valorem model with demand uncertainty. We expand the model from the one developed by Martín and Saracho (2016). In our paper, we adopt the two-part tariff method with ad valorem royalties used in Martín and Saracho (2016). In addition, we adopt the demand uncertainty method used in Creane and Miyagiwa (2008). In the benchmark model, we showed that the developer gives preferential treatment to large retailers rather than intensifying competition between large and small retailers by strengthening the competitive advantage of small retailers at the equilibrium. We also showed that the developer collects rents with a greater ratio of the

fixed fee rent from the large retailer and rents with a greater ratio of the ad valorem royalty from the small retailer. Moreover, in our extended model, we reveal the surprising phenomenon that this conclusion would be reversed in the situation with demand uncertainty. Specifically, although we found that the proportion of the fixed fee rent is higher for large retailers than for small retailers in our benchmark model, the extended model shows that the proportion of the fixed fee rent becomes greater for small retailers. Moreover, regarding important factors such as the relation of the fixed fee rent between large and small retailers, we consider that a conclusion that some region are reversed is worth discussing. In this way, we obtained the amazing results that the benchmarks and results change with a simple comparison. Moreover, in our model, when the degree of demand uncertainty is the same in each retailer, the result obtained is consistent with the benchmark model. In other words, we find that the fixed fee rent increases only if a factor widens the difference in the degree of demand uncertainty between large and small retailers.

Furthermore, by using the comparative static analysis, we analyze what would happen when differentiated products become homogeneous products and the competition between large and small retailers becomes more intense in SCs. Then, if the retailers in SCs become even more competitive, it could decrease the profit of the developer. It is confirmed by using the benchmark model that the profit of the developer would decline as previously when approaching homogeneous products, it reduces the profit of the developer at the equilibrium. This is a general result. However, in our extended model, we discover a counterintuitive result that the profit of the developer would increase under demand uncertainty in SCs. In other words, when the degree of product substitutability increases and similar retail tenants carry similar products in an SC, there is an increase in the profit of the developer. Then, amazingly, when the degree of demand uncertainty in the whole SC increases, the profit of the developer increases more at the equilibrium. Furthermore, we obtain similar results for social welfare under uncertainty at the equilibrium. This is one of the most interesting results in our extended model. In other words, we find that increasing demand uncertainty for the whole SC is desirable for the developer in our model.

4.2. Model

We assume an SC where a developer determines the royalty of the rent to the two types of retailers. To sell products, each retailer must sign lease contracts with the developer. Consider the developer (D) that uses a two-part tariff licensing mechanism to contract with each retailer. We call the retailer of the large efficient company the large retailer (L) and the other of the small inefficient company the small retailer (S). Then, each retailer sells the sales volume q_i ($i = L, S$). The retailers get the product from manufacturers except the developer. Then, we assume a cost-competitive setting such as that in the apparel industry. Each retailer's rent depends on its sales of tenant $p_i q_i$. For simplicity, we assume that $r_i p_i q_i$ is the rent according to royalty r_i and the sales of tenant $p_i q_i$ that retailer i attains. Then, f_i denotes the fixed fee rent of each retailer. For simplicity, the marginal cost is given by c and we assume that c is a sufficiently small positive value. Specifically, we explain what kind of situation this assumes. We consider the situation that the willingness to pay of consumers changes depending on the differences in retail brands and brand image for consumers. In this case, it is a natural setting to assume little difference in the goods among the retailers. Then, we identify that the cost has no effect on the result in our model.

Begin with demand uncertainty. Assume that the demand intercept A_i is distributed with mean and variance σ_i^2 ; for simplicity, the mean is zero. We assume that σ_i is the degree of the demand uncertainty for each retailer. In our later discussion, we assume that σ is the degree of the demand uncertainty for the whole SC. The distribution is such that outputs are always positive in the equilibrium. To keep positive outcomes, we assume that $a - c > \gamma(1 - c)$.

The utility maximization problem is

$$\begin{aligned} \max_{q_L, q_S, m} U(q_L, q_S, m) &= (A_L + 1)q_L + (A_S + a)q_S - \frac{1}{2}(q_L^2 + q_S^2) - \gamma q_L q_S + m, \\ \text{s. t. } p_L q_L + p_S q_S + m &\leq I, \end{aligned} \tag{4-1}$$

where $0 < a < 1$ and $0 < \gamma < 1$, and the degree of product substitutability is measured by γ . When $\gamma \rightarrow 1$, the goods are perfect substitutes and for $\gamma \rightarrow 0$, the

goods are unrelated, that is, we use γ (the degree of product substitutability) as a measure of the competition of the retail market. If γ is large, the products are homogenized and the competition of the retail market becomes intense. Otherwise, if γ is small, the products are differentiated and the competition of the retail market becomes moderate. Considering the above assumption, we assume that the profit function of the developer consequently is concave. We obtain the condition of the parameter that satisfies the second-order condition. Then, combined with the condition to keep positive outcomes, we obtain the following conditions: $a - c > \gamma(1 - c)$. When m is the amount of the numeraire good, p_i is the price of the retailer's product, and I is the income for the consumer. We employ the utility function form represented by Equation (4-1) for the following reason. If the product quality supplied by a retailer is zero, a consumer has no incentive to buy the product. Hence, our utility function is consistent with consumer behavior.

Assume that there are two asymmetric retailers competing in a market such as Cournot duopolists with horizontally differentiated products. This product differentiation, as assumed in the paper, may be due to each retailer of different brand names. From the first-order conditions of the utility maximization problem, the inverse demand functions that the two retailers face are given by

$$p_L = A_L + 1 - q_L - \gamma q_S, \quad (4-2)$$

$$p_S = A_S + a - q_S - \gamma q_L. \quad (4-3)$$

The profit function of the developer is given as

$$\pi_D = r_L p_L q_L + f_L + r_S p_S q_S + f_S. \quad (4-4)$$

The profit function of retailer i is given as

$$\pi_L = p_L q_L - r_L p_L q_L - c q_L - f_L, \quad \pi_S = p_S q_S - r_S p_S q_S - c q_S - f_S. \quad (4-5), (4-6)$$

Consumer surplus $CS = (q_L^2 + 2\gamma q_L q_S + q_S^2)/2$ and social welfare $SW = CS + \pi_D + \pi_L + \pi_S$. We next delineate the timeline of a series of decisions made by the players comprising the supply chain. The setting of the assumption and timing of the game are described as follows. We consider a two-stage game. In stage one, the developer chooses the ad valorem royalty and fixed fee rent of each retailer, r_i and f_i .

In stage two, each retailer independently and simultaneously chooses its sales, q_i .

In the model, we assume that the retailer needs to pay the fixed fee rent f_i regardless of the sales volume q_i . Regarding this point, when contracting with the developer in stage one, retailers have a contract that they have to pay a fixed fee rent to the developer when they open a store in the SC. In other words, the fixed fee can be said to be the cost for participation in the SC. Since the fixed fee rent of retailer f_i has already been determined when each retailer decides q_i , retailers must pay the fixed fee rent f_i without depending on any sales volume q_i . Specifically, since we assume that we do not think of a situation where retailers do not have to pay the fixed fee f_i when they do not sell in SCs, the retailers have to pay the fixed fee rent f_i even in any financial condition. In other words, retailers have already paid the fixed fee rent f_i as a sunk cost to a developer on a contract basis.

From a game procedure point of view, the retailer decides whether to contract or reject at the stage of concluding the contract. In stage one, the developer decides the fixed fee rent f_i and royalty r_i and presents a contract to retailers. Then, the retailers receive a contract agreement from the developer, calculate the fixed fee rent f_i , and sign a contract. At that time, because retailers have already paid the fixed fee rent f_i to a developer, in the second stage the retailer decides the sales volume in the situations that the fixed fee rent f_i is a sunk cost.

Then, we assume that A_L and A_S appear as random variables and that each of the retailers knows its realization value. As its interpretation, this means that retailers can reliably know information on customers at the point of sale in the retail store. Each of the retailers sees A_L and A_S as random variables in the first stage. Neither large nor small retailers know this specific value, but both know the probability distribution. In other words, the retailers know that the mean of the probability distribution is zero and the variance is σ_i^2 . Figure 11 illustrates the timeline of events. The model is solved with the use of backward induction along the timeline to derive the subgame perfect equilibrium in this dynamic game.

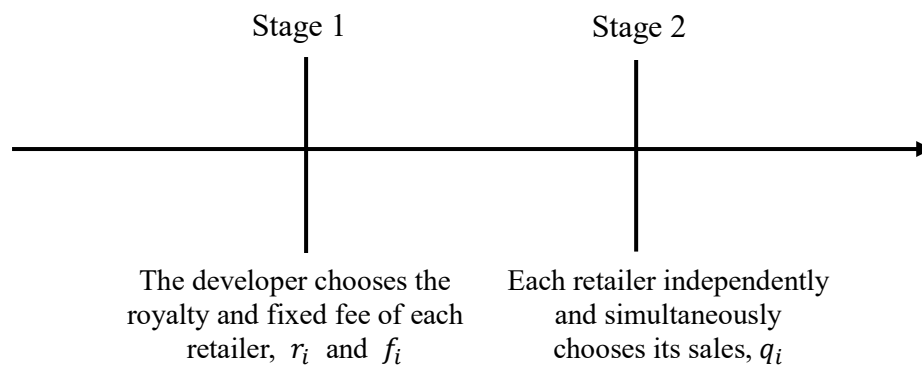


Figure 11. Timeline of events.

Table 3. Nomenclature.

q_L	sales quantity of the large retailer
q_S	sales quantity of the small retailer
p_L	price of the large retailer
p_S	price of the small retailer
r_L	royalty of the large retailer
r_S	royalty of the small retailer
f_L	fixed fee rent of the large retailer
f_S	fixed fee rent of the small retailer
π_D	profit of the developer
π_L	profit of the large retailer
π_S	profit of the small retailer
CS	consumer surplus
SW	social welfare
A_L	random variable of the large retailer
A_S	random variable of the small retailer
σ_L	degree of demand uncertainty for the large retailer
σ_S	degree of demand uncertainty for the small retailer
σ	degree of demand uncertainty for the whole SC
a	intercept of the inverse demand function
c	marginal cost of the retailers
γ	degree of product substitutability
**	superscript for the equilibrium of the new model

4.3. Calculating the equilibrium

In this section, we identify the subgame perfect equilibrium. In the second stage, each retailer knows the value of A_S and A_L and chooses its sales quantity. The maximization problem for the large retailer is

$$\max_{q_L} [p_L q_L - r_L p_L q_L - c q_L - f_L]. \quad (4-7)$$

The maximization problem for the small retailer is stated as

$$\max_{q_S} [p_S q_S - r_S p_S q_S - c q_S - f_S]. \quad (4-8)$$

Note that retailers have already paid the fixed fee rent f_i as a sunk cost to a developer.

The first-order conditions ($\partial \pi_L / \partial q_L = 0$ and $\partial \pi_S / \partial q_S = 0$) are derived as

$$\begin{aligned} q_L &= \frac{2(1 - r_S)[A_L(1 - r_L) - c - r_L + 1] - \gamma(1 - r_L)[(a + A_S)(1 - r_S) - c]}{(4 - \gamma^2)(1 - r_L)(1 - r_S)}, \\ q_S &= \frac{2(1 - r_L)[(a + A_S)(1 - r_S) - c] - \gamma(1 - r_S)[A_L(1 - r_L) - c - r_L + 1]}{(4 - \gamma^2)(1 - r_L)(1 - r_S)}. \end{aligned} \quad (4-9), (4-10)$$

By substituting this outcome into the expected profit of the developer, we have the maximization problem of the expected profit of the developer as follows:

$$\begin{aligned} \max_{r_L, r_S, f_L, f_S} & E [r_L p_L q_L + f_L + r_S p_S q_S + f_S], \\ \text{s. t.} & E [p_L q_L - r_L p_L q_L - c q_L] - f_L \geq 0, \\ & E [p_S q_S - r_S p_S q_S - c q_S] - f_S \geq 0. \end{aligned} \quad (4-11)$$

As the objective function is an increasing function of f_i and the developer takes the value of the largest fixed fee f_i within the range that satisfies the participation constraints, it is the optimal strategy for the developer to determine the value of the fixed fee f_i . Then, since the value of the fixed fee f_i should be determined to bind with the participation constraints, the value of the fixed fee f_i is as follows:

$$\begin{cases} f_L = E [p_L q_L - r_L p_L q_L - c q_L], \\ f_S = E [p_S q_S - r_S p_S q_S - c q_S]. \end{cases} \quad (4-12), (4-13)$$

By substituting (4-12) and (4-13) into (4-11), we can write the expected profit maximization in the form that also includes the participation constraints. In other words, we can rewrite the developer's expectation profit maximization problem as follows:

$$\max_{r_L, r_S} E [p_L q_L - c q_L + p_S q_S - c q_S]. \quad (4-14)$$

Here, the developer cannot present a contract with the fixed fee f_i and royalty r_i depending on the realization value of demand A_i . In other words, since the developer cannot write the contracts as a function of the realized value of demand A_i , we assume that the developer cannot schedule the realization value of demand A_i and its corresponding payment schedule. That is, it is not considered in our model that the fixed fee f_i and royalty r_i vary depending on the realization value of demand A_i .

The first-order condition ($\partial E[\pi_D]/\partial r_L = 0$ and $\partial E[\pi_D]/\partial r_S = 0$) in this stage yields

$$\begin{aligned} r_L^{**} &= \frac{\gamma[a - \gamma - c(1 - \gamma)]}{\gamma(a - \gamma) + c(2 - \gamma)(1 + \gamma)}, \\ r_S^{**} &= \frac{\gamma[(1 - a\gamma) - c(1 - \gamma)]}{\gamma(1 - a\gamma) + c(2 - \gamma)(1 + \gamma)}, \end{aligned} \quad (4-15), (4-16)$$

where the variables with superscript ** represent the equilibrium values. Then, the outcomes of the royalty corresponds to the benchmark model.

By solving the above equation, we obtain the equilibrium outcomes and provide the results in Table 4.

Table 4. Equilibrium outcomes

	Equilibrium
$E[\pi_D^{**}]$	$\frac{a(a - 2[\gamma + c(1 - \gamma)]) + 2c(1 - \gamma)(1 - c) + 1}{4(1 - \gamma^2)} + \frac{(4 + \gamma^2)(\sigma_L^2 + \sigma_S^2)}{(4 - \gamma^2)^2}$
$E[q_L^{**}]$	$\frac{(1 - a\gamma) - c(1 - \gamma)}{2(1 - \gamma^2)}$
q_L^{**}	$\frac{1}{4} \left(\frac{8A_L}{4 - \gamma^2} - \frac{4A_S\gamma}{4 - \gamma^2} + \frac{2[(1 - a\gamma) - c(1 - \gamma)]}{1 - \gamma^2} \right)$
$E[q_S^{**}]$	$\frac{(a - \gamma) - c(1 - \gamma)}{2(1 - \gamma^2)}$
q_S^{**}	$\frac{1}{4} \left(\frac{8A_S}{4 - \gamma^2} - \frac{4A_L\gamma}{4 - \gamma^2} + \frac{2[(a - \gamma) - c(1 - \gamma)]}{1 - \gamma^2} \right)$
r_L^{**}	$\frac{\gamma[(a - \gamma) - c(1 - \gamma)]}{\gamma(a - \gamma) + c(2 - \gamma)(1 + \gamma)}$
r_S^{**}	$\frac{\gamma[(1 - a\gamma) - c(1 - \gamma)]}{\gamma(1 - a\gamma) + c(2 - \gamma)(1 + \gamma)}$
f_L^{**}	$\frac{c[(1 - a\gamma) - c(1 - \gamma)]^2}{2(1 - \gamma^2)[\gamma(a - \gamma) + c(2 - \gamma)(1 + \gamma)]} + \frac{2c(1 - \gamma^2)(4\sigma_L^2 + \gamma^2\sigma_S^2)}{(4 - \gamma^2)^2[\gamma(a - \gamma) + c(2 - \gamma)(1 + \gamma)]}$
f_S^{**}	$\frac{c[(a - \gamma) - c(1 - \gamma)]^2}{2(1 - \gamma^2)[\gamma(1 - a\gamma) + c(2 - \gamma)(1 + \gamma)]} + \frac{2c(1 - \gamma^2)(4\sigma_S^2 + \gamma^2\sigma_L^2)}{(4 - \gamma^2)^2[\gamma(1 - a\gamma) + c(2 - \gamma)(1 + \gamma)]}$
$E[CS^{**}]$	$\frac{a(a - 2[\gamma + c(1 - \gamma)]) + 2c(1 - \gamma)(1 - c) + 1}{8(1 - \gamma^2)} + \frac{(4 - 3\gamma^2)(\sigma_L^2 + \sigma_S^2)}{2(4 - \gamma^2)^2}$
$E[SW^{**}]$	$\frac{3a[(a - 2[\gamma + c(1 - \gamma)]) + 2c(1 - \gamma)(1 - c) + 1]}{8(1 - \gamma^2)} + \frac{(12 - \gamma^2)(\sigma_L^2 + \sigma_S^2)}{2(4 - \gamma^2)^2}$

The superscript ** denotes the equilibrium for the extended model. CS is consumer surplus. SW is social welfare.

4.4. Equilibrium and comparative statics

This paper compares the contract of the rent system by means of the proportion of a fixed fee rent with the contract of the rent system by means of the proportion of the ad valorem royalties in a Cournot duopoly model under demand uncertainty. By differentiating the relationships of the fixed fee rent for each retailer and the fixed fee rent of the small retailer with respect to the degree of demand uncertainty for the small retailer, we obtain the following lemma.

Lemma 1 (Effect of the degree of demand uncertainty for small retailer)

*As the degree of demand uncertainty for the small retailer as variance (an increase in σ_S^2) increase, we show that the relationships of the fixed fee rent of each retailer $f_L^{**} - f_S^{**}$ decreases. In addition, as the degree of demand uncertainty for the small retailer as variance (an increase in σ_S^2) increase, the fixed fee rent of the small retailer f_S^{**} increases:*

$$\begin{aligned} & \frac{\partial(f_L^{**} - f_S^{**})}{\partial\sigma_S^2} \\ &= -\frac{2c(1-\gamma^2)[\gamma[a(4+\gamma^3)-\gamma(4+\gamma)]+c(2-\gamma)(1-\gamma)(2+\gamma)^2]}{(4-\gamma^2)^2[\gamma(a-\gamma)+c(2-\gamma)(1+\gamma)][\gamma(1-a\gamma)+c(2-\gamma)(1+\gamma)]} < 0, \\ & \frac{\partial f_S^{**}}{\partial\sigma_S^2} = \frac{8c(1-\gamma^2)}{(\gamma^2-4)^2[\gamma(1-a\gamma)+c(2-\gamma)(1+\gamma)]} > 0. \end{aligned} \tag{4-17}, (4-18)$$

Proof. Given the assumption $a - c > \gamma(1 - c)$, the inequalities are satisfied. $\square$

From Lemma 1, the intuition is as follows. When the variance of the small retailer σ_S^2 increases, we show that the relationship of the fixed fee rent of each retailer is negative $f_L^{**} - f_S^{**} < 0$ in the equilibrium. In other words, when the variance of the small retailer σ_S^2 decreases per unit, we show that the relationship of the fixed fee rent of each retailer is positive $f_L^{**} - f_S^{**} > 0$ in the equilibrium. As identified above, since the variance of the small retailer σ_S^2 is a decreasing function, we show that the fixed

fee rent of the large retailer f_L^{**} decreases more than the fixed fee of the small retailer f_S^{**} when demand uncertainty increases at the equilibrium.

Next, in order to supplement this discussion, we differentiate these equilibria of the fixed fee rent of the small retailer f_S^{**} with respect to the variance of the small retailer σ_S^2 . Then, we show that the numerator of this equation $\partial f_S^{**} / \partial \sigma_S^2$ is negative and the denominator is also negative in the equilibrium. That is, we obtain the inequality $\partial f_S^{**} / \partial \sigma_S^2 > 0$. Therefore, we find that as the variance of the small retailer σ_S^2 increases, the fixed fee rent of the small retailer f_S^{**} increases in the equilibrium. In other words, from the lemma, we find that the developer tends to collect the fixed fee rent from retailers in SCs with a high degree of demand uncertainty.

By differentiating the fixed fee rent of the small retailer with respect to the intercept of the inverse demand function of the small retailer a , we obtain the following lemma.

Lemma 2 (Effect of intercept of inverse demand function of small retailer)

*As the intercept of the inverse demand function of the small retailer a increases, the fixed fee rent of the small retailer f_S^{**} increases:*

$$\frac{\partial f_S^{**}}{\partial a} > 0. \quad (4-19)$$

Proof. Given the assumption $a - c > \gamma(1 - c)$, the inequalities are satisfied. $\square$

On the basis of the lemma, we take the debate one step further in the next proposition. We explain in the next proposition that we discovered that there is a region reverses the benchmark with respect to the proportion of the rents of SCs of the most important in our paper. In this study, we obtained the results that the benchmarks and results change with a simple comparison. We compare the ad valorem royalty of the large retailer r_L^{**} with the royalty of the small retailer r_S^{**} and the fixed fee rent of the large retailer f_L^{**} with the fixed fee rent of the small retailer f_S^{**} . By solving the inequalities of the equilibrium, we find that $r_L^{**} < r_S^{**}$.

Proposition 8 (The fixed fee and royalty of large and small retailers)

We show that the conditions of the relationship of the fixed fee rent of large and small retailers, f_L^{**}, f_S^{**} , are as follows. If σ_S^2 is large enough to satisfy $\tilde{s} < \sigma_S^2$, then $f_L^{**} - f_S^{**}$ is decreasing. Otherwise, $f_L^{**} - f_S^{**}$ is increasing. That is,

$$\begin{cases} f_L^{**} - f_S^{**} > 0 & \text{if } \tilde{s} > \sigma_S^2 \\ f_L^{**} - f_S^{**} < 0 & \text{if } \tilde{s} < \sigma_S^2 \end{cases}$$

$$r_L^{**} - r_S^{**} < 0$$

where

$$\sigma_S^2 = \frac{c(2-\gamma)[(1-\gamma)(2+\gamma)]^2[(1-a^2)(2-\gamma)^2 + 4(1-\gamma^2)\sigma_L^2] + \gamma[(1-a^3)[1-\gamma(1-\gamma)](4-\gamma^2)^2 + 3a^2\gamma(4-\gamma^2)^2 - a\gamma[3(4-\gamma^2)^2 + 4(1+\gamma)(4+\gamma)(1-\gamma)^2\sigma_L^2]}{4(1-\gamma)^2(1+\gamma)[a\gamma(4+\gamma^3) - \gamma^2(4+\gamma) + c(2-\gamma)(1-\gamma)(2+\gamma)^2]} = \tilde{s}. \quad (4-20), (4-21), (4-22), (4-23)$$

Proof. Given the assumption $a - c > \gamma(1 - c)$, the inequalities are satisfied. As we calculate the difference between the two equilibria of the ad valorem royalties of large and small retailers, r_L^{**} and r_S^{**} , we find $r_L^{**} < r_S^{**}$. On the contrary, as we calculate the difference between the two equilibria of the fixed fee rent of large and small retailers, f_L^{**} and f_S^{**} , we gain the expression $f_L^{**} - f_S^{**}$.

$$\begin{aligned} f_L^{**} - f_S^{**} &= \left(\frac{c[(1-a\gamma) - c(1-\gamma)]^2}{2(1-\gamma^2)[\gamma(a-\gamma) + c(2-\gamma)(1+\gamma)]} + \frac{2c(1-\gamma^2)(4\sigma_L^2 + \gamma^2\sigma_S^2)}{(4-\gamma^2)^2[\gamma(a-\gamma) + c(2-\gamma)(1+\gamma)]} \right) \\ &\quad - \left(\frac{c[a-\gamma - c(1-\gamma)]^2}{2(1-\gamma^2)[\gamma(1-a\gamma) + c(2-\gamma)(1+\gamma)]} + \frac{2c(1-\gamma^2)(4\sigma_S^2 + \gamma^2\sigma_L^2)}{(4-\gamma^2)^2[\gamma(1-a\gamma) + c(2-\gamma)(1+\gamma)]} \right). \end{aligned} \quad (4-24)$$

Then, we solve $f_L^{**} - f_S^{**} = 0$ for σ_S^2 and obtain the equality $\sigma_S^2 = \tilde{s}$. When the inequality is satisfied $\tilde{s} < \sigma_S^2$, we obtain the inequality $f_L^{**} - f_S^{**} < 0$. On the contrary, when the inequality is satisfied $\tilde{s} > \sigma_S^2$, we obtain the inequality $f_L^{**} - f_S^{**} > 0$. To keep positive outcomes, we assume the inequalities are satisfied $a - c > \gamma(1 - c)$. Therefore, we obtain the proposition. $\square$

The intuition is as follows. From this proposition, in the extended model of this paper, we discovered that although demand uncertainty is taken into consideration, the conclusion of the benchmark model on the royalty rent of the large retailer is retained. In other words, we found that the result on the relationship of the royalty of each retailer in the equilibrium is retained. Similar to the benchmark model, we showed that the small retailer has a higher royalty rent than the large retailer in terms of the ad valorem royalty rent in the equilibrium. On the contrary, with respect to the ad valorem royalty rent in the equilibrium, we gained the result that the developer always collects a fixed fee rent from large retailers in the benchmark model.

However, in our extended model, we revealed the surprising phenomenon that this conclusion would be reversed in the situation with demand uncertainty. Specifically, although we found that the proportion of the fixed fee rent is higher for large retailers than for small retailers in our benchmark model, we found that the region where the proportion of the fixed fee rent becomes greater for small retailers in the extended model. Furthermore, under demand uncertainty, we found that when the difference in demand uncertainty between large and small retailers is expanded, the developer would increase the proportion of the fixed fee rent for both large and small retailers.

Next, to simplify the discussion of our model, we gradually expand the difference in the degree of the demand uncertainty of the retailers by means of assigning a definite numerical value to the parameter. That is, we describe concrete values of σ_L and σ_S , which are the degrees of the demand uncertainty for retailers, as shown graphically in Figure 12. Then, we assume that c is fixed to a small value close to zero, which has no effect on the result. We depict the above explanation of Proposition 8 in Figure 12. As shown in the figure, the gray area is $f_L^{**} - f_S^{**} > 0$. In the non-shaded area, we find the region in which the difference between the two equilibria of the fixed fee rent of large and small retailers is negative $f_L^{**} - f_S^{**} < 0$ with the degree of product substitutability and the index of competition γ .

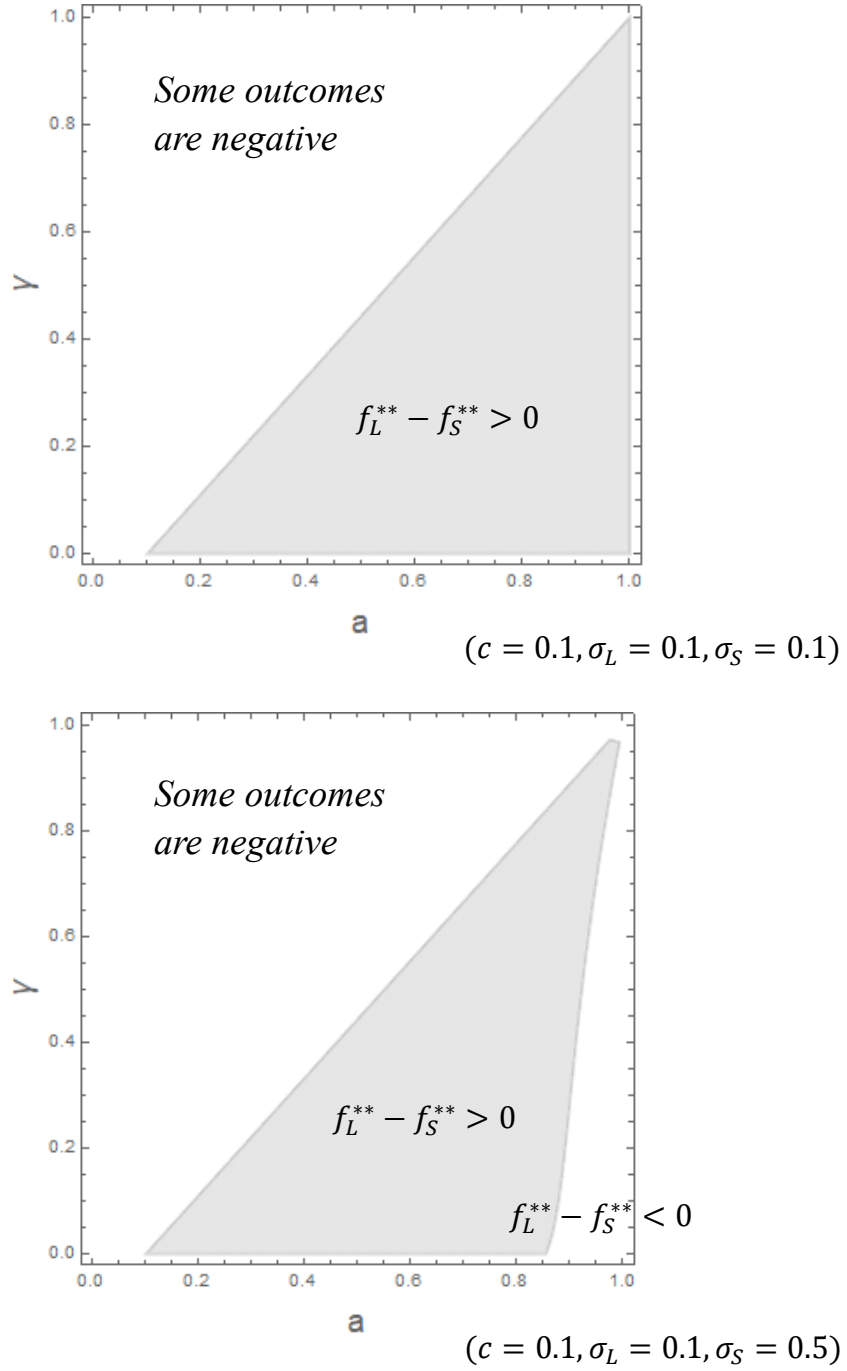


Figure 12. Difference in the fixed fee rent

As shown in this figure, we assume the situations where the values of demand uncertainty between large and small retailers are different. Specifically, when considering the actual SC, the large retailer is more likely to have customer demand

and the degree of demand uncertainty is lower than that for the small retailer in SCs. In other words, we assume a situation where the fixed fee rent of the small retailer f_S^{**} has a greater degree of demand uncertainty. Since the benchmark model is the case when the degree of demand uncertainty is zero, the extended model overlaps the benchmark in a certain area. Then, in our model, the larger the value of a , the larger is the region in which the relation of the fixed fee rent of large and small retailers is reversed. Increasing the value of a means that the competitive advantage of large and small retailers is similar. In other words, it comes closer to a company that has similar competitiveness.

Next, we explore why such a region reverses the benchmark model in this way. From Lemma 1, we found that as the variance of the small retailer σ_S^2 increases, the fixed fee rent of the small retailer f_S^{**} increases in the equilibrium. In addition, we found that the developer tends to collect a fixed fee rent from retailers in SCs with a high degree of demand uncertainty. On the contrary, in our model, when the degree of demand uncertainty is the same in each retailer, we found that the result is consistent with the benchmark model. In other words, the fixed fee rent increases only if a factor widens the difference in the degree of demand uncertainty between the large retailer and small retailer.

Furthermore, from Lemma 2, we further discuss this result. To derive this result, it is important to consider the movement that inverts when the value of a is large. From Lemma 2, by differentiating f_S^{**} with respect to a , we show that the fixed fee rent of a small retailer f_S^{**} is an increasing function of a . In other words, in our model, as the value of a gets larger, the fixed fee rent of the small retailer f_S^{**} tends to be larger. Therefore, for all these reasons, as the value of a and the variance of the small retailer σ_S^2 increase, there is a considerable rise in the fixed fee rent of the small retailer f_S^{**} , which is an increasing function of the value of a and the variance of the small retailer σ_S^2 . As a result, in our model, the fixed fee rent of the small retailer f_S^{**} overtakes the fixed fee rent of the large retailer f_L^{**} in the equilibrium.

As stated above, in this proposition, we discovered a region that reverses the benchmark with respect to the proportion of the rents of SCs. Moreover, regarding

important factors such as the relation of the fixed fee rent between large and small retailers, we found that some regions are reversed. In this way, we found that the benchmarks and results change with a simple comparison. Our analysis shows that when demand uncertainty is expanded in SCs, that is, when a developer attracts a retailer with a high degree of demand uncertainty such as opening a new tenant or rolling out new products, selling a new product for new customers in SCs, it would be better for the developer to increase the proportion of the fixed fee rent.

By differentiating the profit of the developer with respect to the degree of demand uncertainty for the small retailer, we obtain the following lemma.

Lemma 3 (Effect of demand uncertainty on the profit of developer)

*As the degree of demand uncertainty as variance (an increase in σ_S^2) increase, we show that the profit of the developer $E[\pi_D^{**}]$ increases:*

$$\frac{\partial E[\pi_D^{**}]}{\partial \sigma_S^2} = \frac{4 + \gamma^2}{(4 - \gamma^2)^2} > 0. \quad (4-25)$$

Proof. Given the assumption $a - c > \gamma(1 - c)$, the inequalities are satisfied. $\square$

We differentiate the equilibria of the profit of the developer $E[\pi_D^{**}]$ with respect to the variance of the small retailer σ_S^2 . Then, we show that the numerator of this equation $\partial E[\pi_D^{**}]/\partial \sigma_S^2$ is positive and the denominator of this equation $\partial E[\pi_D^{**}]/\partial \sigma_S^2$ is also positive in the equilibrium. That is, we obtain the inequality $\partial E[\pi_D^{**}]/\partial \sigma_S^2 > 0$. Therefore, we find that as the variance of the small retailer σ_S^2 increases, the profit of the developer $E[\pi_D^{**}]$ increases in the equilibrium. In other words, from the lemma, we show that when the degree of demand uncertainty of small retailers increases, the profit of the developer $E[\pi_D^{**}]$ increases more in our model.

By differentiating the profit of the developer with respect to the intercept of the inverse demand function of the small retailer, we obtain the following lemma.

Lemma 4 (Effect of competitiveness on the profit of developer)

*As the intercept of the inverse demand function of the small retailer a increases, we show that the profit of the developer $E[\pi_D^{**}]$ increases:*

$$\frac{\partial E[\pi_D^{**}]}{\partial a} = \frac{a - c - \gamma(1 - c)}{2(1 - \gamma^2)} > 0. \quad (4-26)$$

Proof. Given the assumption $a - c > \gamma(1 - c)$, the inequalities are satisfied. $\square$

We differentiate the equilibria of the profit of the developer $E[\pi_D^{**}]$ with respect to a . Then, we show that the numerator of this equation $\partial E[\pi_D^{**}]/\partial a$ is positive and the denominator of this equation $\partial E[\pi_D^{**}]/\partial a$ is also positive in the equilibrium. That is, we obtain the inequality $\partial E[\pi_D^{**}]/\partial a > 0$. Therefore, we find that as the value of a increases, the profit of the developer $E[\pi_D^{**}]$ increases in the equilibrium.

By differentiating the profit of the developer with respect to the degree of demand uncertainty for the whole SC, we obtain the following lemma.

Lemma 5 (Effect of demand uncertainty for SC on the profit of developer)

*As the degree of demand uncertainty for the whole SC (an increase in σ) increases, we show that the profit of the developer $E[\pi_D^{**}]$ increases:*

$$\frac{\partial E[\pi_D^{**}]}{\partial \sigma} = \frac{4(4 + \gamma^2)\sigma}{(4 - \gamma^2)^2} > 0. \quad (4-27)$$

Proof. Given the assumption $a - c > \gamma(1 - c)$, the inequalities are satisfied. $\square$

For our later discussion, we consider the demand uncertainty for the whole SC. As a simplification, we assume that $\sigma = \sigma_L = \sigma_S$. We differentiate the equilibria of the profit of the developer $E[\pi_D^{**}]$ with respect to the demand uncertainty for the whole SC σ . Then, we obtain the inequality $\partial E[\pi_D^{**}]/\partial \sigma > 0$. Therefore, we find that as the demand uncertainty for the whole SC σ increases, the profit of the developer $E[\pi_D^{**}]$ increases at the equilibrium. In other words, when the demand uncertainty for the whole SC increases, the profit of the developer $E[\pi_D^{**}]$ increases more in our model.

By differentiating the profit of the developer with respect to the degree of product substitutability, we obtain the following proposition. We consider the demand uncertainty for the whole SC, that is, we assume that $\sigma = \sigma_L = \sigma_S$.

Proposition 9 (Effect of tougher competition on the profit of developer)

*The condition under which increasing the degree of product substitutability and tougher competition (an increase in γ) increases or decreases the profit of the developer $E[\pi_D^{**}]$ is as follows. If σ^2 is large enough to satisfy $\tilde{g} < \sigma^2$, then $E[\pi_D^{**}]$ is increasing in γ . Otherwise, $E[\pi_D^{**}]$ is decreasing in γ . That is,*

$$\left\{ \begin{array}{ll} \frac{\partial E[\pi_D^{**}]}{\partial \gamma} > 0 & \text{if } \tilde{g} < \sigma^2 \\ \frac{\partial E[\pi_D^{**}]}{\partial \gamma} < 0 & \text{if } \tilde{g} > \sigma^2 \end{array} \right.$$

where

$$\sigma^2 = \frac{[a - \gamma - c(1 - \gamma)][(1 - a\gamma) - c(1 - \gamma)](4 - \gamma^2)^3}{8\gamma(1 - \gamma^2)^2(12 + \gamma^2)} = \tilde{g}. \quad (4-28), (4-29)$$

Proof. Given the assumption $a - c > \gamma(1 - c)$, the inequalities are satisfied. By differentiating the profit of the developer $E[\pi_D^{**}]$ in the equilibrium with respect to the degree of product substitutability γ , we gain the expression $\partial E[\pi_D^{**}]/\partial \gamma$:

$$\frac{\partial E[\pi_D^{**}]}{\partial \gamma} = -\frac{[a - \gamma - c(1 - \gamma)][(1 - a\gamma) - c(1 - \gamma)]}{2(1 - \gamma^2)^2} + \frac{4\gamma(12 + \gamma^2)\sigma^2}{(4 - \gamma^2)^3}. \quad (4-31)$$

Then, we solve $\partial E[\pi_D^{**}]/\partial \gamma = 0$ for σ^2 and obtain the equality $\sigma^2 = \tilde{g}$. In our model, when the inequality is satisfied $\tilde{g} < \sigma^2$, we obtain the inequality $\partial E[\pi_D^{**}]/\partial \gamma > 0$. On the contrary, when the inequality is satisfied $\tilde{g} > \sigma^2$, we obtain the inequality $\partial E[\pi_D^{**}]/\partial \gamma < 0$. To keep positive outcomes, we assume the inequalities are satisfied $a - c > \gamma(1 - c)$. Therefore, we obtain the proposition. $\square$

From the proposition, the intuition is as follows. First, if the retailers in SCs become even more competitive, it could decrease the profit of the developer. In the benchmark model, we found that when the degree of product substitutability increases,

the profit of the developer decreases. In other words, we discovered that the retailers in SCs become even more competitive, which decreases the profit of the developer. Therefore, the benchmark model confirmed that the profit of the developer would decline as previously when approaching homogeneous products, it reduces the profit of the developer at the equilibrium. This is a general result. However, from this proposition, in our extended model, we revealed the surprising phenomenon that this conclusion would be reversed in the situation with demand uncertainty. In other words, we discovered a counterintuitive result that the profit of the developer would increase under demand uncertainty. Specifically, when the degree of product substitutability increases and similar retail tenants carry similar products in an SC, there is an increase in the profit of the developer. Then, as we discuss later, when the degree of the demand uncertainty of the whole SC increases, the profit of the developer increases more. This is one of the most interesting results in our extended model.

Next, to simplify the discussion of our model, we gradually expand the difference in the degree of the demand uncertainty of the retailers by means of assigning a definite numerical value to the parameter. In this proposition, since we analyze the profit of the developer, we consider the degree of demand uncertainty for the whole SC. We assume that σ is the degree of demand uncertainty for the whole SC. That is, we describe concrete values of σ , which are the degrees of the demand uncertainty for retailers as shown graphically in Figure 13. Then, we assume that c is fixed to a small value close to zero, which has no effect on the result. We depict the result of this proposition in Figure 13. As shown in the figure, the gray area is $\partial E[\pi_D^{**}]/\partial \gamma > 0$. We find the region in which the profit of the developer $E[\pi_D^{**}]$ increases with the degree of product substitutability and the index of competition γ .

As shown in this figure, to give clear and detailed explanations about the effect of demand uncertainty for the whole SC, we assume that $\sigma = \sigma_L = \sigma_S$. Specifically, when considering the actual SC, we consider that the whole SC faces demand uncertainty. In other words, we assume that the degree of the demand uncertainty of the whole SC grows progressively larger. Since the benchmark model is the case when the degree of uncertainty is zero, the extended model overlaps the benchmark in a certain area.

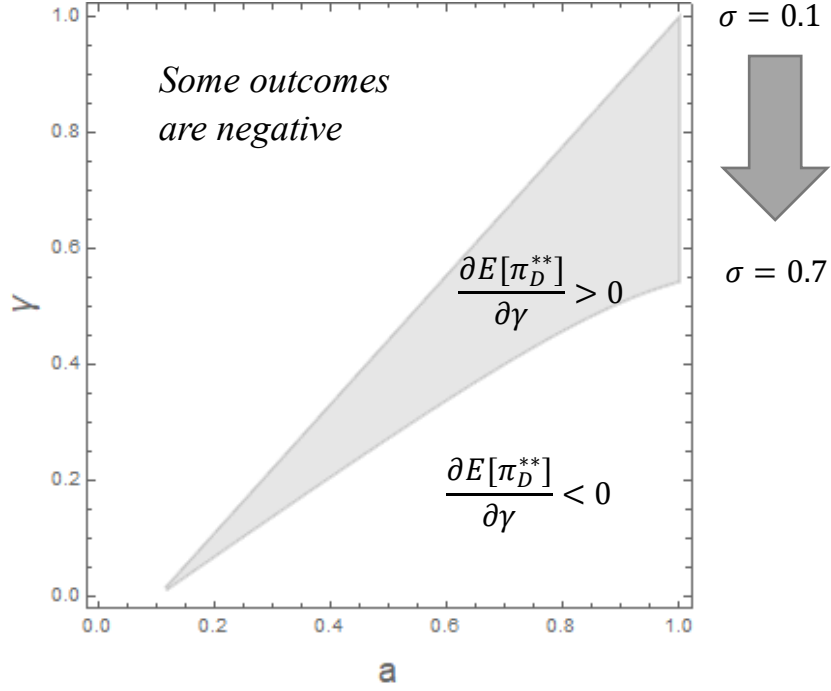


Figure 13. Profit of the developer

However, from this proposition, in our extended model, we revealed the surprising phenomenon that this conclusion would be reversed in the situation with demand uncertainty. That is, in our extended model, we discovered a counterintuitive result that the profit of the developer would increase under demand uncertainty in SCs. In other words, when the degree of product substitutability increases and similar retail tenants carry similar products in an SC, there is an increase in the profit of the developer.

Moreover, from a managerial perspective, we found that the developer should attract the retailer with the demand uncertainty in the whole SC and similar retail tenants (e.g., tenants that sell similar quality products) to the SC. Furthermore, this paper makes a major contribution to the better management of the SC by indicating that when a developer opens an SC in areas where demand uncertainty is relatively high, it may be profitable for developers to attract retailers that produce a similar product to other retailers, have a similar consumer need, or sell a product that has a similar quality or value.

By differentiating these equilibrium outcomes with respect to variance as the degree of demand uncertainty for the whole SC (σ^2) increases, we obtain the following proposition.

Proposition 10 (Effect of tougher competition on the outcomes)

*When the variance as the degree of demand uncertainty for the whole SC (an increase in σ^2) increase, the fixed fee rent of the large retailer f_L^{**} , the fixed fee rent of the small retailer f_S^{**} , consumer surplus $E[CS^{**}]$, social welfare $E[SW^{**}]$, and the profit of the developer $E[\pi_D^{**}]$ increase in the equilibrium:*

$$\begin{aligned}\frac{\partial f_L^{**}}{\partial \sigma^2} &= \frac{2c(1-\gamma)(1+\gamma)(4+\gamma^2)}{(4-\gamma^2)^2[\gamma(a-\gamma) + c(2-\gamma)(1+\gamma)]} > 0, \\ \frac{\partial f_S^{**}}{\partial \sigma^2} &= \frac{2c(1-\gamma)(1+\gamma)(4+\gamma^2)}{(4-\gamma^2)^2[\gamma(1-a\gamma) + c(2-\gamma)(1+\gamma)]} > 0, \\ \frac{\partial E[CS^{**}]}{\partial \sigma^2} &= \frac{4-3\gamma^2}{(4-\gamma^2)^2} > 0, \quad \frac{\partial E[SW^{**}]}{\partial \sigma^2} = \frac{12-\gamma^2}{(4-\gamma^2)^2} > 0, \\ \frac{\partial E[\pi_D^{**}]}{\partial \sigma^2} &= \frac{2(4+\gamma^4)}{(4-\gamma^2)^2} > 0.\end{aligned}$$

(4-32), (4-33), (4-34), (4-35), (4-36)

Proof. Given the assumption $a - c > \gamma(1 - c)$, the inequalities are satisfied. $\square$

In this proposition, we also consider the demand uncertainty for the whole SC. As a simplification, we assume that $\sigma = \sigma_L = \sigma_S$. We differentiate these equilibrium outcomes with respect to the variance of demand uncertainty for the whole SC σ^2 . Then, we find that as the variance of the demand uncertainty for the whole SC σ^2 increases, some of the outcomes increase in the equilibrium. In other words, from the proposition, we show that increasing demand uncertainty for the whole SC is desirable for the developer, consumer, and whole SC in our model. Moreover, our analysis confirms that each retailer has a contrasting movement with respect to the rent at the equilibrium in the benchmark model. However, as the extent of the demand uncertainty of both retailers increases, both take the same action at the equilibrium.

4.5. Concluding remarks

In our extended model, we revealed the surprising phenomenon that this conclusion would be reversed in the situation with demand uncertainty. Specifically, although we found that the proportion of the fixed fee rent is higher for the large retailer than the small retailer in our benchmark model, the extended model found that the proportion of the fixed fee rent becomes greater for the small retailer. Moreover, regarding important factors such as the relation of the fixed fee rent between large and small retailers, we consider that a conclusion that some region are reversed is worth discussing in the paper. In this way, we obtained the amazing results that the benchmarks and results change with a simple comparison. Moreover, in our model, when the degree of demand uncertainty is the same in each retailer, the result obtained is consistent with the benchmark model. In other words, we found that the fixed fee rent increases only if a factor widens the difference in the degree of demand uncertainty between large and small retailers.

Furthermore, by using the comparative static analysis, we analyzed what would happen when differentiated products become homogeneous products and the competition between large and small retailers becomes more intense in SCs. Then, if the retailers in SCs become even more competitive, it could decrease the profit of the developer. The benchmark model confirmed that the profit of the developer would decline as previously when approaching homogeneous products, it reduces the profit of the developer at the equilibrium. This is a general result. However, in our extended model, we discovered a counterintuitive result that the profit of the developer would increase under demand uncertainty in SCs. In other words, when the degree of product substitutability increases and similar retail tenants carry similar products in an SC, there is an increase in the profit of the developer. Then, amazingly, when the degree of demand uncertainty in the whole SC increases, the profit of the developer increases more at the equilibrium. Furthermore, we obtain similar results for social welfare under uncertainty at the equilibrium. This is one of the most interesting results in our extended model. In other words, we found that increasing demand uncertainty for the whole SC is desirable for the developer in our model.

Interestingly, our analysis shows that when uncertainty is expanded in SCs, that is, when a developer attracts a retailer with a high degree of demand uncertainty such as opening a new tenant or rolling out new products, selling a new product for new customers in SCs, it would be better for the developer to increase the proportion of the fixed fee rent. Moreover, from a managerial perspective, we found that the developer should attract the retailer with the demand uncertainty in the whole SC and similar retail tenants (e.g., tenants that sell similar quality products) to the SC. Furthermore, this paper makes a major contribution to the better management of the SC by indicating that when a developer opens an SC in areas where uncertainty is relatively high, it may be profitable for developers to attract retailers that produce a similar product to other retailers, have a similar consumer need, or sell a product that has a similar quality or value.

Chapter 5 Conclusion

This paper considers a vertical relationship in SCs with a developer and two types of retailers: a large retailer and small retailer. First, a developer decides the rent for each retailer. Then, each retailer decides the sales volume. There are two types of rent payments: one type is a fixed rent for a certain period of time and the other type is a rent determined by the sales of the retailer. We provide a game-theoretic model to discuss whether a developer gives preferential treatment to large or small retailers by assigning a higher percentage of the royalty rent or fixed fee rent to them.

The main findings of this research are summarized as follows. First, when there are both large retailers and small retailers in one SC, the developer may attempt to make the competitive advantage of the small retailer stronger by improving the quantity of products, thereby intensifying the competition between the large and small retailers in the SC. However, in our model, the developer gives preferential treatment to large retailers rather than intensifying the competition among retailers by strengthening the competitive advantage of the small retailer at the equilibrium. In other words, we found that the developer chooses to make the large retailer even stronger and increase the sales volume of the large retailer by decreasing the royalty of rent of the large retailer in order to increase the profits of the developer. Then, the developer collects the rents with a greater ratio of the fixed fee rent from the large retailer and the rents with a greater ratio of the ad valorem royalty rent from the small retailer in SCs. Therefore, we explain the observed relationship in real-world SCs by using our theoretical model.

Furthermore, in our extended model, we revealed the surprising phenomenon that this conclusion would be reversed in the situation with demand uncertainty. Specifically, although we found that the proportion of the fixed fee rent is higher for large retailers than for small retailers in our benchmark model, the extended model found that the proportion of the fixed fee rent becomes greater for the small retailer. Moreover, regarding important factors such as the relation of the fixed fee rent between large and small retailers, we consider that a conclusion that one region is reversed is worth discussing in the paper. In this way, we obtained the amazing results that the

benchmarks and results change with a simple comparison. Moreover, in our model, when the degree of demand uncertainty is the same in each retailer, we found that the result is consistent with the benchmark model. In other words, we found that the fixed fee rent increases only if a factor widens the difference in the degree of demand uncertainty between the large retailer and small retailer.

In addition, under uncertainty, we found that when the demand uncertainty in the whole SC increases and market competition gradually becomes intense and approaches the competition of homogeneous products using the degree of product substitutability, the developer would increase the proportion of the fixed fee rent for both large and small retailers. Our analysis in the benchmark model confirmed that large and small retailers have a contrasting movement with respect to the proportion of the rent at the equilibrium. However, in the situation where the extent of the demand uncertainty of both retailers increases, we found that both large and small retailers take the same action in terms of the fixed fee rent of retailers at the equilibrium.

Furthermore, by using the comparative static analysis, we analyzed what would happen when differentiated products become homogeneous products and the competition between retailers becomes more intense in SCs. Then, if the retailers in SCs become even more competitive, it could decrease the profit of the developer. The benchmark model confirmed that the profit of the developer would decline as previously when approaching homogeneous products, it reduces the profit of the developer at the equilibrium. This is a general result. However, in our extended model, we discovered a counterintuitive result that the profit of the developer would increase under uncertainty in SCs. In other words, when the degree of product substitutability increases and similar retail tenants carry similar products in an SC, there is an increase in the profit of the developer. Then, when the degree of demand uncertainty in the whole SC increases, the profit of the developer increases more at the equilibrium. In other words, from the proposition, surprisingly, we found that increasing demand uncertainty for the whole SC is desirable for the developer in our model. Furthermore, we obtained similar results for social welfare under uncertainty at the equilibrium. This is one of the most interesting results in our extended model.

The contribution of this research is that we clarified the relationships among the variables that can be observed in reality in an SC by using the theoretical model. In addition, we obtained theoretical evidence that confirms the findings of previous empirical studies. In previous studies, the developer gives preferential treatment to large retailers (Benjamin et al. 1992; Brueckner 1993; Eppli and Shilling 1996; Gould et al. 2005; Miceli et al. 1998; Pashigian and Gould 1998; Wheaton 2000). Much of this previous literature has focused on the rent system of the per unit royalty, and hence studies of the ad valorem royalty with two-part tariffs have received relatively less attention. The result of our paper is novel for building a theoretical model using revenue sharing, called the ad valorem royalty rent system, which is commonly used in practice in SCs.

Furthermore, in the context of SCs, prior research has paid insufficient attention to the theoretical relationship between the proportion of the two rent systems (ad valorem royalty and fixed fee rent) for large and small retailers and the profits of developers. In addition, insufficient discussion has been carried out on the changes in the proportion of the fixed fee rent and ad valorem royalty rent between large and small retailers and in the profits of developers by considering the degree of product substitutability and demand uncertainty in the context of SCs. Additionally, no argument has been made on the degree of the difference in uncertainty between the two types of retailers at the same time. Therefore, this paper can explain the observed relationship in reality by using factors not used in previous studies. This paper contributes to the literature by pointing out the importance of considering competitive relations due to the change in the degree of product substitutability between large and small retailers and of considering the uncertainty of customer demand in SCs in the real world.

Interestingly, our analysis showed that when uncertainty is expanded in SCs, that is, when a developer attracts a retailer with a high degree of demand uncertainty such as opening a new tenant or rolling out new products, selling a new product for new customers in SCs, it would be better for the developer to increase the proportion of the fixed fee rent. Moreover, from a managerial perspective, we found that the developer

should attract the retailer with the demand uncertainty in the whole SC and similar retail tenants (e.g., tenants that sell similar quality products) to the SC. Furthermore, this paper makes a major contribution to the better management of SCs by indicating that when a developer opens an SC in areas where demand uncertainty is relatively high, it may be profitable for developers to attract retailers that produce a similar product to other retailers, have a similar consumer need, or sell a product that has a similar quality or value.

In this study, since we assume a duopoly market and have not addressed the general number of companies, these extensions—that appear to be possible in the case of maintaining the linear assumption—will be important. In addition, we consider the situation where the marginal costs of retailers are the same in our model. Specifically, we explain what kind of situation this assumes. We consider the situation that the willingness to pay of consumers changes depending on the differences in retail brands and brand image. In that case, it is a natural setting to assume little difference between the goods used by retailers and there is no difference in the marginal cost. We considered the situation where the marginal costs of retailers are the same in our model. However, once we consider the results may change if the marginal cost of each retailer is different. From the model, as the large retailer sells goods with a higher willingness to pay than the small retailer, it can be considered to be sufficient to assume that the large retailer has a higher marginal cost than the small retailer.

For example, when the marginal cost of the large retailer rises, the developer may not increase this marginal cost of the large retailer anymore, so the royalty of the large retailer at the equilibrium may be lowered. Then, as the marginal cost of the large retailer increases, the sales volume of large retailer may decrease, while the sales volume of the small retailer may increase because of the strategic substitution effect. Then, the developer will increase the marginal cost of the small retailer. As a result, considering the relationship of the royalties of both large and small retailers, we can infer that the difference in royalties between these retailers will expand more than in our model. In other words, since the proposition of the relationship of royalties in this model is maintained without dividing the marginal cost, the proposition in our model

is a robust conclusion in that sense. However, as it may be possible to analyze by reversing the assumption of the relation of the marginal cost, we would like to make this a future subject.

Moreover, in our model, we assumed two retailers competing in a market as Cournot duopolists with horizontally differentiated products. First, since Cournot competition was analyzed by Martín and Saracho (2016) and Creane and Miyagiwa (2008), we adopted Cournot competition. As mentioned earlier, in the field of two-part tariffs underlying the theory of our model, it is a novelty that we adopt the ad valorem royalty instead of the per unit royalty. Since quantities are important in the per unit royalty, we analyze Cournot competition in this research to compare it with previous research. However, it is also a future research direction to analyze Bertrand competition. Hence, the model constructed in this study could be developed in future research.

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