The Influence of Consumer Evaluations on the Success of Co-branding

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i	adoption time point where the *i*-th product releases onto the market; $i=1,2,3,\ldots\ldots, I$
R	brand; $R \in \{A,B\}$
G	consumer group; $G \in \{a,b\}$
K	product-related attribute; $K \in \{x,y\}$
$M_{R(i)}$	segment size of brand *R* at time *i*
$M_{R(i)}^{G}$	size of group *G*'s consumers who stay with brand *R* at time *i*
$J_{R(i)}$	the product released by brand *R* at time *i*
$J_{AB(i)}$	the product released by the co-brand *AB* at time *i*
$S_{AB(i)}^{G}$	proportion of group *G*'s consumers who change their preference from brand *A* to *B* after adopting the *i*-th co-branded product
$S_{BA(i)}^{G}$	proportion of group *G*'s consumers who change their preference from brand *B* to *A* after adopting the *i*-th co-branded product
$\Phi_{R(i)}^{G}$	group *G*'s preference score for brand *R* at time *i*
$P_{R(i)}^{K,G}$	group *G*'s belief about attribute *K* of brand *R* at time *i*
$P_{AB(i)}^{K}$	group *G*'s belief about attribute *K* of the co-branded product (i.e., $J_{AB(i)}$) at time *i*
D^{K}	initial (i.e., $i = 1$) attribute-level difference of attribute *K*
$w^{K,G}$	group *G*'s relative weight of importance of attribute *K*
λ_{R}^{K}	relative contributing weight of attribute *K* of brand *R*
$\gamma_{R}^{K,G}$	group *G*'s updating weight of attribute *K* of brand *R*
ε^{G}	group *G*' confusion about the true levels of the co-branded product
ΔM	the amount of required market expansion for the alliance
ΔM_{R}	the amount of required market expansion for brand *R*
δ^{G}	group *G*'s confusion parameter
μ^{G}	group *G*'s ratio of relative weights of attribute importance
θ^{G}	the distribution parameter of group *G*'s confusion

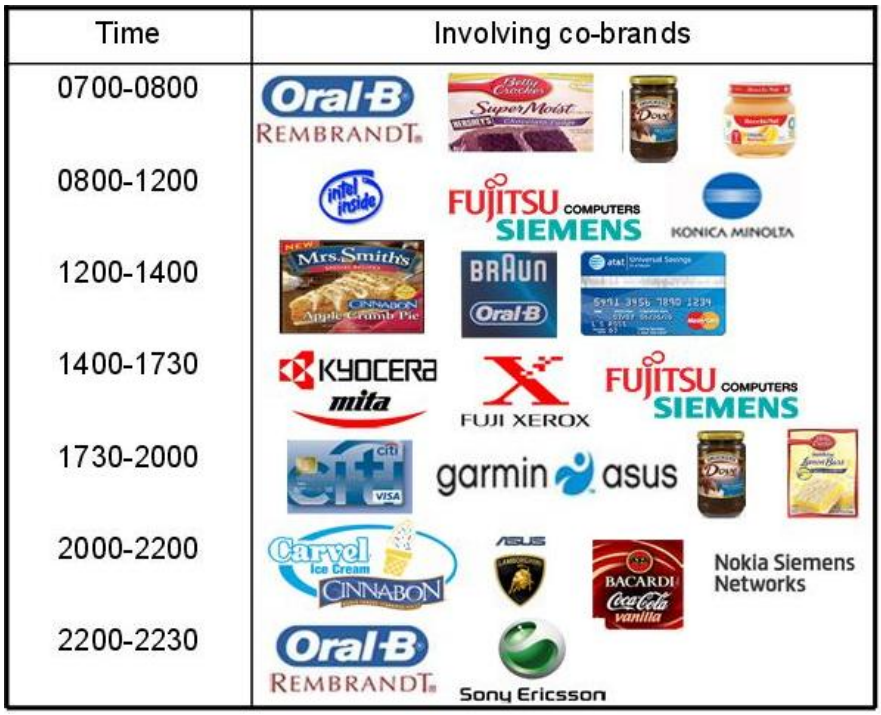
Chapter 1
Introduction

1.1 Motivation

Nowadays, due to fierce competitions, lack of differentiations, and a speedy growth of the service economy, many companies have placed a considerable focus on setting up strategic alliances (e.g., *Intel* and *Nokia* on computing devices, *Yahoo* and *Microsoft* on online search). In particular, marketing managers try to offer new and differentiated products by establishing a specific type of strategic alliance – co-branding. Co-branding has become a commonly accepted one in the marketplace during the last fifteen years (Cooke and Ryan, 2000; Bouten, 2006), and the number of this type of cooperative branding partnership has experienced an annual growth rate of 40% (Spethmann and Benezra, 1994). Hence, the co-branded products[1] appear frequently in our daily life (see Fig. 1.1): we may use an *Oral-B Rembrandt* whitening pen in the early morning, an *IBM* personal computer featuring *Intel*-inside at the office, the *Citi-Visa* credit card for a dinner in the restaurants, and a *Sony-Ericsson* mobile phone to contact family members before a sound sleep.

[1] In this dissertation, we use the "co-branded product" and the "joint product" interchangeably to represent the product released in a co-branding alliance (e.g., the *Sony-Ericsson* mobile).

Figure 1.1: Involving co-brands in daily life



Indeed, the purpose of co-branding can be illustrated by the following sentences:

"*brand names are valuable assets, they maybe combined with other brand names to form a synergistic alliance in which the sum is greater than the parts,*" (p.87, Rao and Ruekert, 1994).

That is to say, a co-branding strategy is expected to integrate the salient attributes of the allying brands[2], to build up a high perceived quality of the new co-branded product, to reach the untapped market segments (Rodrigue and Biswas, 2004), and finally to gain a greater market share. Although successful co-branding alliances can avoid possible failures resulting from over-leveraging the equities of existing brands (Swaminathan et al., 2001; James et al., 2006) and can reduce the cost of introducing new products (Kotler and Keller, 2006),

[2] In this dissertation, we use the "allying brands" and the "partnering brands" interchangeably to represent the two focal brands in a co-branding alliance (e.g., *Sony* and *Ericsson* in the *Sony-Ericsson* alliance).

researchers have inferred that the risks of releasing new products are high – only one out of the ten can survive in the market place (Keller, 1993) –, and that forty percent of these strategic alliances failed over a period of four years (Doorley, 1993). The above findings have motivated our research interests regarding an important question: how do companies predict and measure the outcome of their co-branding alliances? This study aims to provide a normative guideline and an ex-ante measure for measuring the consequence of co-branding from a theoretical point of view.

1.2 Research Scope

To our knowledge, the success of co-branding has been investigated in two different scientific fields, namely the field of strategic alliance and the field of consumer behavior.

A co-branding alliance can be regarded as one type of strategic alliance and can therefore be studied by using the strategic alliance framework (Hadjicharalambous, 2006). Prior work analyzes the success of a strategic alliance by utilizing several theories such as the strategic behavior theory (e.g., Day and Klein, 1987), the transaction cost theory (e.g., Williamson, 1975), the theory of inter-organizational exchange (e.g., Cook, 1977; Pfeffer and Salancik, 1978), and the competitive strategy (e.g., Porter, 1980). These theories are helpful in analyzing the strategic intent (or interests) of each partner to form an alliance. In this field, the term “success of co-branding” is often defined as the “successful formation of an alliance”.

Drawing from the consumer behavior literature, co-branding is thought of as one type of brand leveraging strategy (Aaker, 1996). The purpose of this strategy is to transfer existing brand associations of the allying brands to the co-brand. A number of previous studies in this field have centered on two issues: how consumers form their attitudes toward the joint products (e.g., Park et al., 1996) and how consumers update their attitudes toward and beliefs about each of the

allying brands after experiencing the co-branded products (e.g., Simonin and Ruth, 1998; Geylani et al., 2008). Hence, in this field, the term "success of co-branding" means the "attitudinal favorability of the co-brand and the partnering brands".

In view of the above discussions, this study will focus on the connection between those two fields because we consider that both perspectives are correlated when we investigate the success of co-branding. As an example, according to the theory of inter-organizational exchange, a co-branding alliance can be successfully formed when the focal brands (firms)[3] make value contributions (resource commitments) to the alliance. However, the value of one brand often comes from consumers' favorable evaluation of that brand (Hadjicharalambous, 2006). Thus, we claim that a favorable evaluation of one of the partnering brands not only varies the value of that brand, but also influences the magnitude of that brand (firm)'s contribution to the alliance and, subsequently, affects the effectiveness of a co-branding alliance.

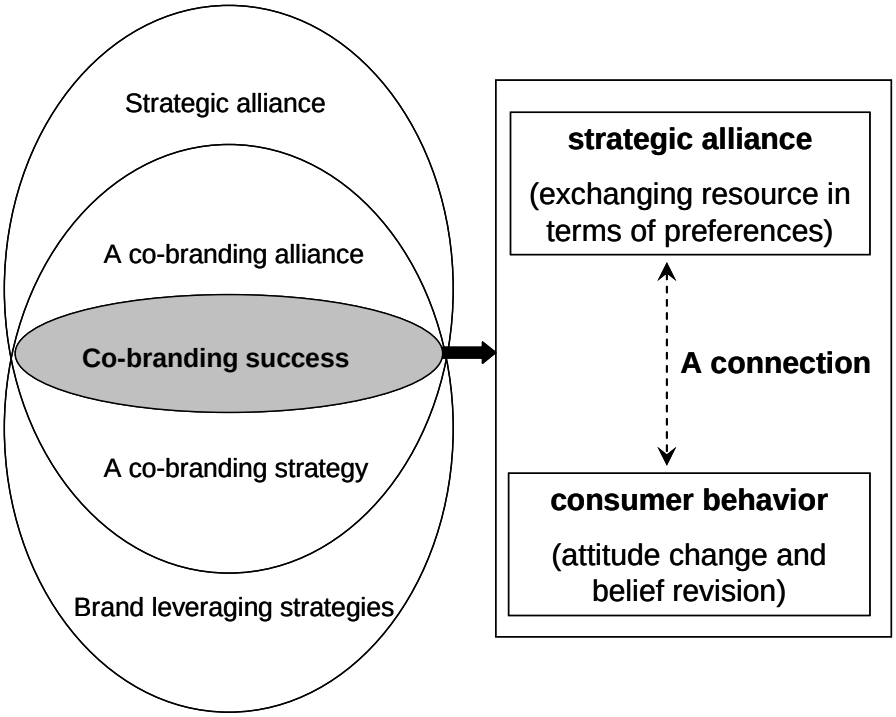
Venkatesh et al. (2000) confirmed our argument. They argued that, on one hand, the emergence of a specific type of "preference change" between the allying brands (i.e., the shift-in preference) is indispensable, because consumer preferences are considered to be the (value) resource owned by each of the brands to exchange for mutual benefits in the alliance. But, on the other hand, the shift-in preference can change each brand's preference share (and revenue) in the alliance, and consequently the alliance may break up. Although their analysis opens a new chapter of discussing co-branding success, the authors totally ignored the behavioral contents behind the shift-in preference.

This dissertation tries to fill this research gap. Starting from Venkatesh et al. (2000), we will try to explain the shift-in preference by relating it to the components of consumer evaluations, namely the attitudes and beliefs, and to

[3] Note that in this dissertation we assume that a co-branding alliance is formed by two firms and each firm owns one of the partnering brands.

add these behavioral elements to the Venkatesh et al. (2000) model to re-examine the necessary condition for a successful co-branding. Fig. 1.2 shows the research scope of this dissertation.

Figure 1.2: The research scope of this dissertation



1.3 Research Questions

As illustrated by the above scope, this dissertation aims to answer the following three questions:

1. What are the distinctions between two different brand leveraging strategies, namely co-branding and brand extension? What are the important factors determining the success of co-branding with regard to the strategic alliance framework on the one hand and the consumer behavior framework on the other?

2. How do consumers evaluate co-branding? How do consumers change their brand attitudes toward and attribute beliefs about the allying brands after experiencing the co-branded product?

3. How do the respective revisions of attitude/belief affect the necessary condition for a successful co-branding? Does an ideal situation - whereby both brands can easily form the alliance - always exist?

1.4 Structure of this Dissertation

As mentioned above, this study will be positioned as an extension to the work of Venkatesh et al. (2000) for connecting the successful formation of a co-branding alliance with the components of consumer evaluations. By following a step-by-step process, this dissertation is structured as follows.

The current chapter highlights the motivation behind this study, the research scope and the research questions.

Chapter 2 reviews the theoretical foundations of co-branding. A classification of co-branding will be presented because there are six confusing terms in the literature to describe the very same cooperative activity. Following this, co-branding will be compared to brand extension and we will introduce a specific type of co-branding that will be analyzed in this study. In addition, we will review the existing literature and summarize the findings with respect to the success of co-branding within two different scientific fields. Finally, we will motivate a need for using the “top-down” approach.

Chapter 3 takes an initial step in the “top-down” approach to systematically analyze the rationale of preference change on the attitude level. Based on the findings of Simonin and Ruth (1998) and Park et al. (1996), we will conclude with a qualitative model to explain how consumers change their attitudes toward the allying brands after co-branding by means of three important effects, namely

the extension effect, the mutual effect, and the reciprocal effect. We will show how the interaction of these effects can be used to systematically expound the rationale behind the preference change in co-branding. Finally, some implications will be deduced from the model and a suggestion for the following analysis in this dissertation will be offered. This chapter originates from a previous paper by Lee and Decker (2009a).

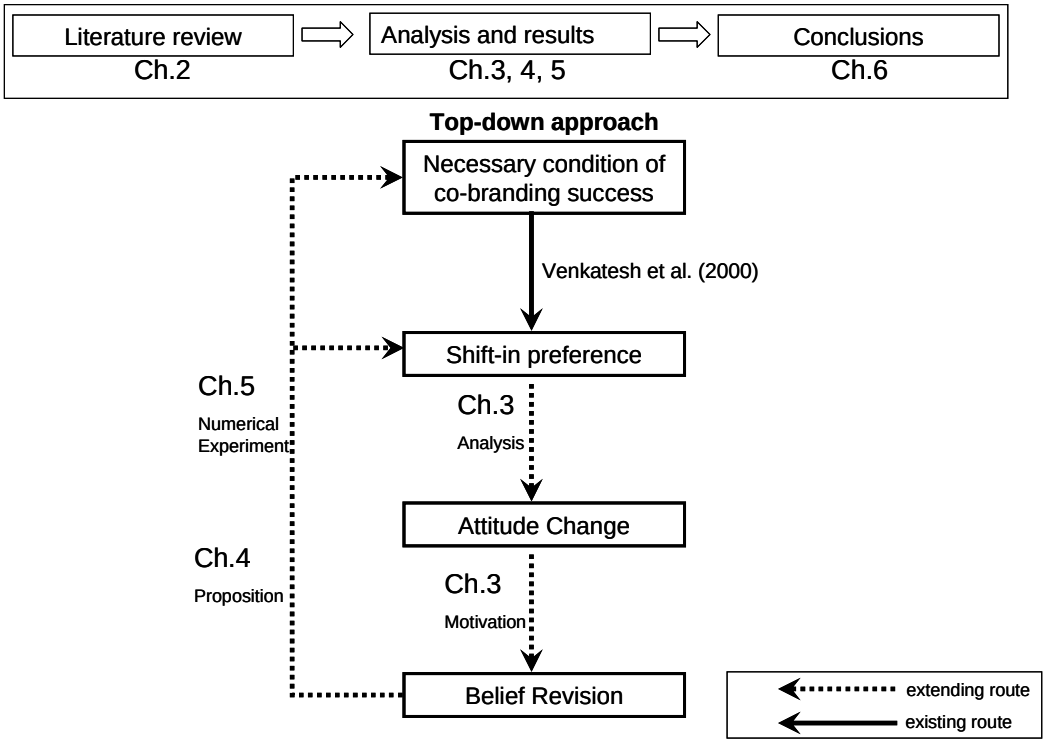
Chapter 4 takes one more step toward the basic unit of consumer evaluations by recognizing that the “attribute belief” is the basic component of consumer preferences. We will regard the allying brands as a combination of two relevant physical attributes and will differentiate the brands by different performance levels. Then, the expectancy-value model (Bass and Talarzyk, 1972; Fishbein and Ajzen, 1975) will be applied to illustrate how consumers merge and transfer their pre-alliance beliefs to co-branding beliefs, and how their post-alliance beliefs are affected by co-branding beliefs. Finally, four propositions will be presented and the decision rules of partner selection will be discussed.

Chapter 5 performs a numerical experiment to complement the mathematical proofs in chapter 4. We will investigate whether an ideal situation can exist in four different scenarios. Note that part of chapter 4 and 5 originates from a previous paper by Lee and Decker (2009b).

Chapter 6 summarizes the answers to the research questions and concludes the success factors of a co-branding alliance (strategy). We also list the limitations and future research directions.

The structure of this dissertation is presented in Fig. 1.3.

Figure 1.3: The structure of this dissertation



1.5 A Brief Summary

As motivated by Venkatesh et al. (2000), this dissertation first defines “a successful co-branding” as “the successful formation of a co-branding alliance” and relates the success to the shift-in preference, the preference change between the allying brands. Then, a top-down approach is applied to analyze the rationale of preference change on the attitude and belief levels. We develop a conceptual model to systematically illustrate attitudinal changes in co-branding, and adapt the Venkatesh et al. (2000) model to examine the influence of belief revision on the necessary condition of a successful co-branding (i.e., a sufficient amount of required expansion for the partnering brands). Finally, we provide a numerical experiment to investigate the existence of an ideal situation that can ensure the success.

We find that consumers' belief revisions of the allying brands may affect the allying brands (partnering firms)' intentions to cooperate with each other. Besides, we claim that - in order to achieve success - it is better for the allying brands to be equivalent in terms of their resource endowments, namely brand reputation, customer loyalty, and customer confusions. The present study has three distinct contributions to the field of co-branding. First, we advance existing knowledge by relating the success of co-branding partnerships to consumer evaluations. Secondly, to our knowledge we are the first to utilize the expectancy-value model to show that the reciprocal effect may exist on the belief level. Finally, we provide a detailed and chronological review on the findings regarding the success factors of co-branding.

Chapter 2
Co-branding and Its Success

Co-branding is one of the brand leveraging strategies (Aaker, 1996) and it is used frequently by brand managers. Co-branding can reinforce the attribute profiles of the allying brands (Park et al., 1996), and differentiate the co-branded product by offering quality assurance to the consumers (Rao and Ruekert, 1994). However, co-branding does not have a commonly agreed-upon definition (Leuthesser et al., 2003) and different researchers have used six terms for the very same marketing tactic. Although these terms are alike to some extent, some differences exist among them. The first part of this chapter will introduce some important notions in branding and make a comparison among these six terms.

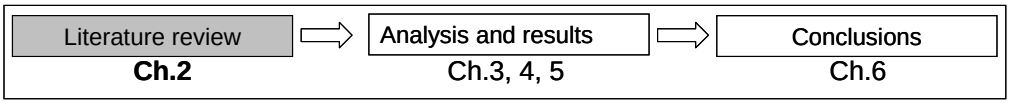
Other than co-branding, another popular brand leveraging strategy is brand extension (Aaker, 1996). Both strategies are used to transfer the equity of existing brand(s) to the new products, but they differ in the number of constituent brands. The second part of this chapter will show a contrast between brand extension and co-branding, and introduce a specific type of co-branding - functional co-branding alliances - that will be analyzed throughout this dissertation.

The extant research on the success of co-branding falls into two major fields. One field of research applies the strategic alliance framework to discover the rationale behind a successful alliance formation (e.g., Bucklin and Sengupta,

1993; Rao and Ruekert, 1994). The other is the analysis on consumer behavior (e.g., Park et al., 1996; Simonin and Ruth, 1998). In the third section, we will summarize the existing findings from these two fields and point out the current limitations. In the fourth section, we will corroborate the need of a new approach for the following analysis in this study and provide a guideline of this dissertation.

The position of this chapter in this study is shown in Fig. 2.1.

Figure 2.1: The position of chapter 2



2.1 Definition

2.1.1 Basic Notions in Branding

This section begins with a review of some important notions in branding. Maybe American Marketing Association (AMA) gives the most rigorous definition of the term “brand”:

> “*a name, term, design, symbol, or any other feature that identifies one seller's good or service as distinct from those of other sellers. The legal term for brand is trademark. A brand may identify one item, a family of items, or all items of that seller*”.

Apart from the AMA’s definition, a brand can be directly referred to a finished product with an identification mark, standardized amount, and appearance and different brands may be differentiated by the quality of the branded products (Meffert, 1998; Begemann, 2008). We can also consider a brand as a set of values which can be further separated into the functional, expressive, and central

values (Blackett and Boad, 1999; Blackett and Harrison, 2001). The functional values are offered by the product-related attributes (e.g., safety) while the expressive values are delivered when the brands help to embody the consumers (e.g., becoming professional). Finally, the central values are created when the brands fulfill a fundamental need (e.g., low risk). Keller and Lehmann (2006) claimed that brands are built on the product itself and that the feelings of one brand originate from consumers' product experience. To sum up, brands are an effective and compelling means to differentiate the products (p.274, Kotler and Keller, 2006) either in the Business-to-Consumer (B2C) or Business-to-Business (B2B) markets (p.44, Kotler et al., 2006).

What is a product? A product is used to satisfy consumers' desires. A product may be a physical good like the *Dr. Oetker* pizza or the *Sony-Ericsson* mobile phone; an intangible service such as the *Citibank* credit card or a series of MBA courses taught at Harvard Business School. Keller (p.3, 2007) argued that the concept of a product can be defined on the five different levels, namely the core benefit level, the generic product level, the expected product level, the augmented product level, and the potential product level. He stated that the battlefield of competitions is located on the augmented product level in many markets because each firm can demonstrate its competence by offering an optimal level of some attributes. In this light, brands can be thought of as products consisting of a number of attributes that deliver different levels of performance (James, 2005).

Brand image is defined as consumers' perceptions about one brand (p.3, Keller, 1993) and thus is formed by brand associations (p.14, James, 2005; p.201, Lowry et al., 2008), where the associations pertain to the information nodes linked to one brand node in memory (Keller, 1993) and are related to the attitudinal favorability of that brand (Aaker, 1990). Hence, these associations can provide a cue to retrieve the information composed of the beliefs - the perceptions of benefits (Mowen and Minor, 1998; Keller, 2007) - such as the

functional performance provided by product-related attributes (Sheinin, 2000; James, 2005). That is to say, the excellent performance of product-related attributes results in positive beliefs about and associations with one brand which strengthen the positioning of that brand, and subsequently lead to the existence of customer-based brand equity (Keller, 1993; p.58, Keller, 2007). In addition, the brand equity can be measured by five dimensions, namely brand loyalty, brand awareness, perceived quality, brand associations, and other proprietary brand assets (p.593, Washburn et al., 2000).

The equity of the existing brand can then be leveraged to develop and release new products on the market. Aaker (1996) has concluded two important brand leveraging strategies, namely co-branding and brand extension[1]. We will review the taxonomy of co-branding in the next section and introduce brand extension in section 2.2.1.

2.1.2 A Comparison of Six Co-branding Terms

There is no universally recognized definition of co-branding. Rao and Ruekert (1994) defined co-branding as a combination of two or more brands for manufacturing a physical product or promoting a symbolical association of brand names. Park et al. (1996) referred co-branding as a composite brand extension where the two brands' names are combined to create a composite brand name for a new product. Keller (2007) claimed that co-branding can be called brand bundling or brand alliances and it pertains to an alliance formed by two or more existing brands for releasing a joint product or executing a marketing communication campaign. Throughout this dissertation the term "co-branding" will be defined as the sharing of manufacturing and marketing expertise by two brands to launch a co-branded product for a short-to-long term cooperation (Park et al., 1996; Leuthesser et al., 2003; Rodrigue and Biswas,

[1] Aaker (1996) identified four different types of brand leveraging strategies, namely co-branding, brand extension, vertical extension, and line extension. Here, we include the latter two strategies into the brand extension strategy.

2004; Kumar, 2005; Helmig et al., 2008). Note that in this dissertation the allying brands are owned by different firms. In other words, we do not discuss the cases whereby the partnering brands are owned by the same company.

In addition to the definitions, in the literature, six terms have been also used interchangeably to describe this kind of cooperative activity, namely co-marketing (Bucklin and Sengupta, 1993; Venkatesh et al., 2000), joint-sales promotion (Varadarajan, 1986; Rodrigue and Biswas, 2004), product bundling (Guiltinan, 1987; Gaeth et al., 1990; Gans and King, 2006), advertising alliance (Grossman, 1997; Samu et al., 1999; Geuens and Pecheux, 2006), dual branding (Levin et al., 1996; Levin and Levin, 2000), and ingredient branding (Norris, 1992; Desai and Keller, 2002). Hence, we feel a need to make a comparison among these terms.

Bucklin and Sengupta (1993) defined “co-marketing” as a form of a short-to-long term working partnership. They claimed that the partnership is developed on the same level in the value-added chain and the purpose of this alliance is to offer a “complementary product”. Furthermore, in this type of partnership, two firms can work together in their marketing campaign, research and development activities, and production. As an example, two singers contribute their expertise to launch several releases of co-branded CDs (Venkatesh et al., 2000) or two pizza makers cooperate to release several co-branded pizzas. In this dissertation, we view “co-marketing” as a “horizontal co-branding” alliance because that kind of partnership is formed at the same stage in the value-added chain (Helmig et al., 2008).

“Joint-sales promotion” represents the cooperation of the promotional resource shared by two or more brands designed to seek an opportunity for sales growth. In this specific type of alliance, each of the brands (products) can be either adopted independently or promoted together for a complementary use. The examples include the *Campbell* soup with the *Nabisco* saltine crackers

(Varadarajan, 1986), the *Bacardi Rum* with *Coca-Cola*, and a menu including a handmade pizza with a *Coca-Cola* (see Fig. 2.2). "Product bundling" is "*a single package consisting of two or more products with one total price*" (p.74, Guiltinan, 1987). The bundle can be either composed of the physical goods like a laptop with its peripherals or the intangible services such as a holiday package including an airline ticket and a city tour guide. The above two terms are excluded from our definition of co-branding because they may involve two or more brands (products) in a short period of time (Leuthesser et al., 2003; Hadjicharalambous, 2006).

Figure 2.2: An example of joint-sales promotion

"Advertising alliance" (or co-advertising, joint-advertising) is characterized by the use of two brands on a promotional campaign delivered by an advertisement (Samu et al., 1999). The joint-advertising of *Axe* anti-sweat spray and *Coca-Cola* zero (see Fig. 2.3) is a typical case. This anti-sweat spray brand signals its functional performance by borrowing the associations of "cool drink" of *Coca-Cola*. Other examples include the *Kellogg* cereals with *Tropicana* fruit juice (Samu et al., 1999) and the *Wasa* bread (knaeckbrot) with *Du darfst* margarine (Huber, 2005). The term "dual branding" concerns an arrangement in which two brands share the same location and consumers, therefore, can purchase their products under the same roof (e.g., *Kentucky Fried Chicken-A&W* restaurants, see Fig. 2.4) (Levin and Levin, 2000). We do not consider the two alliances listed above as the co-branding strategy in this study because of their

usages (i.e., multiple products are offered simultaneously; see Helmig et al., 2008).

Figure 2.3: An example of advertising alliance

Source: http://www.werbeblogger.de/2007/05/09/cola-deo-axe-zero/

Figure 2.4: An example of dual branding

Source: http://farm1.static.flickr.com/22/32397091_4a56ef60f4.jpg?v=0

Pfoertsch and Mueller (2006) have adapted the framework of Baumgarth (2001) to offer a detailed explanation of ingredient branding (see Table 2.1).

They viewed ingredient branding as a combination of either two ingredients (e.g., *Woolmark* plus *Lycra*) or a branded final product with a branded ingredient (e.g., *Opel* with *Blaupunkt* electronic device, see Fig. 2.5). The authors further claimed that implementing an ingredient branding strategy can be effective only on two conditions: (1) if customers perceive a superior performance of the final product induced by the ingredient, and a high complexity of components regarding the final product (e.g., *Intel-inside IBM* laptops), and (2) if the considered market of the final product comprises only a few brands (e.g., laptop) and a limited number of ingredient suppliers (e.g., microprocessor).

Table 2.1: Type of ingredient branding

Components	Examples
Ingredients	*Lycra* and *Wollmark*
Final product with Ingredient	*Beechnut* with *Chiquita* *Coca-Cola* with *NutraSweet* *Dell* with *Intel-inside* *Opel* with *Blaupunkt*

Source: Pfoertsch and Mueller (2006)

Figure 2.5: An example of ingredient branding (1)

Source: Pfoertsch and Mueller (2006)

Figure 2.6: An example of ingredient branding (2)

Source: Pfoertsch and Mueller (2006)

Since we define "ingredient branding" as "a branded ingredient on a branded product introduced or promoted by another brand" (Norris, 1992; Desai and Keller, 2002) in this dissertation, we only consider the latter case in Pfoertsch and Mueller (2006). This type of partnership can be also called "vertical co-branding" in the sense that the firms are producing their products at different steps in the value-added chain (Helmig et al., 2008). Maybe the most famous example is the personal computers featuring "*Intel-inside*". In addition, the "host" brand (e.g., *Dell* laptops) is usually referred to the brand that contains a component manufactured by the "ingredient" brand (e.g., *Intel* chips).

In conclusion, "*ingredient co-branding*" (vertical co-branding) and "*co-marketing*" (horizontal co-branding) will be categorized into our definition of co-branding in this study. Table 2.2 contrasts the differences among these terms.

Table 2.2: The differences among six co-branding terms

<table>
<tr><th>Number of brands</th><th>Number of products</th><th colspan="2">Branding terms</th><th>Time horizon</th><th>Examples</th></tr>
<tr><td rowspan="2">Two or more</td><td rowspan="2">Two or more</td><td colspan="2">joint-sales promotion (Varadarajan, 1986; Rodrigue and Biswas, 2004)</td><td>short term (Walchli, 2007)</td><td>a promotion campaign by Becks beer, Frankfurter sausage, and FC Bayern football-game ticket</td></tr>
<tr><td colspan="2">product bundling (Guiltinan, 1987; Gaeth et al., 1990; Gans and King, 2006)</td><td>short term (Helmig et al., 2008)</td><td>a skin-care package with Nivea crème, Florena face care, and Bebe lip balm</td></tr>
<tr><td rowspan="4">Two</td><td rowspan="2">Two or more</td><td colspan="2">advertising alliance (Grossman, 1997; Samu et al., 1999; Geuens and Pecheux, 2006)</td><td>short term (Walchli, 2007; Helmig et al., 2008)</td><td>Nike sport shoes and Apple i-Pod multimedia player</td></tr>
<tr><td colspan="2">dual branding (Levin et al., 1996; Levin and Levin, 2000)</td><td>mid term (Helmig et al., 2008)</td><td>Deutsche Postbank together with Tchibo retail store</td></tr>
<tr><td rowspan="2">One</td><td rowspan="2">co-branding</td><td>vertical (ingredient co-branding) (Norris, 1992; Pfoertsch and Mueller, 2006)</td><td>short-to-long term</td><td>Coca-Cola with NutraSweet</td></tr>
<tr><td>horizontal (co-marketing) (Bucklin and Sengupta, 1993)</td><td>short-to-long term</td><td>a co-branded CD by Tom Petty and Jimmy Page</td></tr>
</table>

2.2 A Contrast between Co-branding and Brand Extension

2.2.1 A Categorization of Brand Extension

The term “brand extension” refers to the use of an existing brand name to launch a new product (Aaker and Keller, 1990). Kotler and Keller (2006) claimed that there exist two types of brand extension strategies, namely the “line extension” and “category extension”. Line extension incorporates the established brand name into the firm’s existing product category (e.g., *Coca-Cola* introduced the vanilla flavor, see Fig. 2.7). The extended product differs from the original

brand in several minor characteristics such as flavors and sizes (Kapferer, 1998). On the contrary, the "category extension" is the use of current brand name to get access into a totally different product category (e.g., the *Apple* i-Pod).

Figure 2.7: An example of line extension

Source: http://stephen1029.spaces.live.com/

However, Aaker (1996) separated the "vertical extension" from the line extension strategy. He argued that, in the vertical extension, brands can launch several kinds of products with different price and quality levels and each extended product targets a specific group of consumers. The concept is more or less similar to "price discrimination" in the field of economics. The brands in automobile and fashion industries are the illustrating examples (e.g., *Volkswagen*, *BMW*, and *Armani*). For the ease of a contrast between brand extension and co-branding, we consider the "vertical extension" as a sub-case of the line extension throughout this dissertation.

2.2.2 The Relation between Brand Extension and Co-branding

Several researchers (Park et al., 1996; Hadjicharalambous, 2006; Helmig et al., 2008) argued that co-branding and brand extension are similar in their purposes: both of them are utilized to reduce the risk of failures of new products by capitalizing on the existing equities of the parent brand(s) and by transferring the

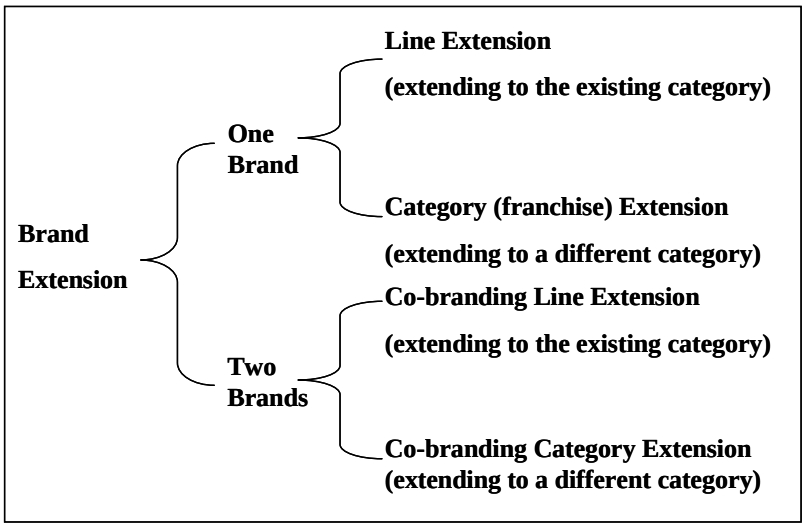
existing brand associations to the new product. However, Leuthesser et al. (2003) claimed that co-branding is sometimes a more effective strategy than brand extension because co-branding has a smaller possibility to dilute the attitudes toward the partnering brands and to damage the allying brands' images. Hadjicharalambous (2006) and Helmig et al. (2008) claimed that the only difference between the two strategies is the number of constituent brands involved: brand extension is characterized by the use of a single brand while co-branding involves a combination of two brands.

Hadjicharalambous (2006) further presented a typology to position co-branding as a sub-case of brand extension. He identified two types of co-branding: the co-branded products releasing in an existing product category is classified as "co-branding line extension" (e.g., the *Lego-Ferrari* brick car, see Fig. 2.8); on the other hand, "co-branding franchise (category) extension" is identified when the joint product is released into a new product category (e.g., hypothetical *IBM-Apple* office furniture). Helmig et al. (2008) confirmed his argument. They stated that, when co-branding is considered to be a brand extension strategy, co-branding can be separated into two different cases by contrasting the extended and existing categories. Fig. 2.9 shows the relation between co-branding and brand extension.

Figure 2.8: An example of co-branding line extension

Source: http://www.automotoportal.com/media/images/vijesti/070323006.2.jpg

Figure 2.9: The relation between brand extension and co-branding



Source: adapted from Hadjicharalambous (2006)

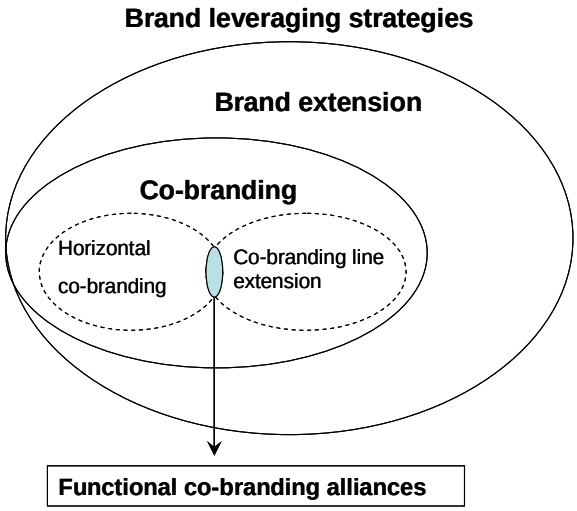
Since the theoretical development and empirical validation on co-branding are relatively limited (Hadjicharalambous, 2006; Helmig et al., 2008), the above classification is beneficial for the researchers to analyze consumer evaluations of co-branding from the rich vein of literature in brand extension (Hadjicharalambous, 2006).

2.2.3 A Specific Type of Co-branding: Functional Co-branding Alliances

A recent study (Helmig et al., 2008) has claimed that a co-branding strategy will be successful when the partnering brands hold the perceived competencies. In order to stress the term "competencies", we introduce a specific type of co-branding: the "functional co-branding alliance" (Cooke and Ryan, 2000), which is established to capitalize on the product competencies associated with the product-related attributes from each brand (e.g. mobile phones of *Sony-Ericsson*). Additionally, both brands originally produce their products at the same step in the value-added chain within the same product category and the products can be differentiated by different performance levels of attributes (e.g., different levels of entertainment or communication quality). In other words,

consumers have different attribute beliefs about the allying brands. Indeed, the nature of this kind of partnership can be presented by the intersection of "horizontal co-branding" (co-marketing) and "co-branding line extension" (see Fig. 2.10).

Figure 2.10: The nature of functional co-branding alliances



We use two dimensions to categorize this type of alliance. The first dimension concerns the intended period of alliances and the number of new product releases. An alliance can be formed for a short-to-medium period of time with one or several new product releases or for a long-term relation (i.e., more than 15 years; see Young and Pelton, 2000). The second dimension deals with the purpose of alliances. Desai and Keller (2002) indicated that the marketing managers can either modify an existing attribute or add a new attribute to improve the competitiveness of their brands when they use the line extension strategy.

As shown in Table 2.3, the particular co-branding partnership to be analyzed in this dissertation is a short-to-mid term partnership with several new product releases for modifying the performance levels of the existing attributes of both

brands (e.g., a hypothetical co-branded pizza mixed "good-taste" and "low-calories"). The co-branded product in this study is defined as a "physical" and "durable" product. Furthermore, each partner forms an "exclusive" alliance with the other and stops selling its own product if the partnership is in effect. However, each player has the right to use its brand for other business activities (e.g., releasing products in other product categories).

Table 2.3: A categorization of functional co-branding alliances

<table>
<tr><td colspan="3"></td><td colspan="2">Line extension</td></tr>
<tr><td colspan="3"></td><td>Modifying existing attributes</td><td>Adding new attributes</td></tr>
<tr><td rowspan="3">Intended period of alliances/Number of new product releases</td><td rowspan="2">Short-to-mid term</td><td>Single release</td><td>an opera CD featuring Paul Plishka and Placido Domingo[2] (mixed "Tenor" with "Bass" of male voice)</td><td>a one-time opera concert featuring Placido Domingo and Whitney Elizabeth Houston (mixed "male" with "female" voice)</td></tr>
<tr><td>Multiple releases</td><td>(1) several releases of co-branded pizzas from Appetite and Bio (mixed "good-taste" with "low-calories")
(2) a series of CDs featuring Placido Domingo and Paul Plishka</td><td>a series of CDs featuring Placido Domingo and Whitney Elizabeth Houston</td></tr>
<tr><td colspan="2">Long term (usually a joint-venture[3])</td><td>Fujitsu-Siemens' PC products</td><td>Sony-Ericsson's W-series music phones (adding Sony's "Walkman" function)</td></tr>
</table>

Note: ■ the particular co-branding partnership to be analyzed in this dissertation

In addition, in this particular partnership the attribute beliefs of the allying brands are influenced with each other (Hillyer and Tikoo, 1995). For example, the second brand (e.g., "*Bio*" in *Appetite-Bio*) may strengthen the attribute beliefs of the primary brand (e.g., *Appetite*) when the primary brand cannot provide an excellent performance in the attribute where the second brand excels

[2] Venkatesh et al. (2000) motivated the use of an individual (e.g., a singer) as the brand.
[3] The joint-venture co-branding refers to the financial cooperation of two companies for releasing a co-branded product (Kotler and Keller, 2006).

(e.g., when *Bio* has a better performance in "*low-calories*"). Conversely, the second brand may not benefit the primary brand and, instead, can hurt the belief of the attribute where the primary brand surpasses (e.g., when *Appetite* has a better performance in "good-taste"). We will introduce this mechanism of belief revision in section 4.2.3.

2.3 The Success of Co-branding

Recently co-branding research has become the key (p.2, Hao, 2008) and the state-of-the-art (Helmig et al., 2008) research area in branding. However, since co-branding is a relatively new phenomenon (Hadjicharalambous, 2006), the explicit findings of the success factors of co-branding remain limited (p.372, Hadjicharalambous, 2006). Therefore in this section we provide a comprehensive review of the existing co-branding research and summarize both the "explicit" and "embedded" findings regarding the success of co-branding in two research frameworks, namely the strategic alliance framework and the consumer behavior framework.

2.3.1 The Analysis with regard to the Strategic Alliance Framework

Due to the abundant literature in analyzing the successful strategic alliances (e.g., Angle and Perry, 1981; Devlin and Bleackley, 1988; Mohr and Spekman, 1994)[4], some marketing researchers have utilized the framework of strategic alliance to examine the success of co-branding. In their studies, the term "alliance success" is often referred to a "successful formation of a co-branding alliance".

Signaling theory (Spence, 1973) has been adopted by several scholars (e.g., Rao and Ruekert, 1994; Washburn et al., 2000; Bengtsson and Servais, 2005) to explain the function of the brand name in a co-branding alliance. Rao and

[4] Here, we do not provide a detailed review on the success factors of strategic alliance since this dissertation focuses on the success of co-branding. In section 6.1, we will include the success factors of strategic alliance into our conclusion.

Ruekert (1994) is a seminal piece in applying the signaling theory into co-branding research. They treated co-branding as a strategic alliance and analyzed why the partnership is formed by combining their brand names (i.e., as compared the cooperation in only the R&D level). They argued that the name of each brand can serve as a signal for product quality to the consumers. Hence each brand can offer its brand name as a benefit to the other. Depending on the use of different strategies, the alliance can then be forged. They concluded that, for products requiring quality enhancement, a reputable partner should be chosen; for products requiring attribute enhancement, a partner with the desired functional skill would be appropriate.

Following Rao and Ruekert's (1994) theoretical argumentations, Rao et al. (1999) empirically judged how co-branding can enhance the unobservable product quality. They used a set of television brands to test whether the high-quality brand can transfer the good perceptions to its partner with unobservable quality. The results showed a positive answer. After interviewing one hundred and twenty customers they found that a brand, which cannot credibly communicate good quality on its own, is able to enhance its quality perceptions when partnering with a high-quality brand. Their study is the seminal piece by applying the theory of information economics in empirical co-branding research.

In their influential paper, Washburn et al. (2000) stated that consumers can transfer the existing brand associations of the allying brands to the alliance, and the strength of the association can represent the magnitude of brand equity. In their empirical experiment eight hypotheses were tested to observe how the high-equity (low-equity) brand can be affected after forming an asymmetric alliance (i.e., a high-equity with a low-equity brand). Their results – similar to Rao et al. (1999) - indicated that the low-equity brand is enhanced by the asymmetric partnership rather than the high-equity brand. Surprisingly, their findings revealed that it is difficult to damage the high-equity brand, even when

it is paired with a lower one. In addition, however, differing from the above three studies, Voss and Gammoh (2004) explored the effects of “multiple” brand alliances and the results suggested that the perceived quality of an unknown brand is not improved when it allies with more than one brand.

Given the increased importance of industrial branding, Bengtsson and Servais (2005) explored the effects of co-branding on inter-organizational relation. The authors claimed that, on industrial markets, co-branding may be a viable strategy if a long-standing relation exists between the buyer and seller. The empirical results showed that a partnership of two manufacturers (brands) may help to increase the perceived compatibility between the current product categories of partnering brands (if an incompatibility exists before the alliance) and to enhance the reputation of the weaker brand for the industrial buyers. Although the authors did not explicitly mention the signaling theory, their results inferred that an existing well-known brand can provide an effective signal of a higher degree of identity and trust for an unknown brand by a partnership.

All in all, the collective studies from the signaling perspective all suggested that - in order to have a better profile for the alliance and succeed on the market - a lower-status brand (i.e., poorer quality, lower equity, lower reputation) should always consider cooperating with a higher-status brand while the higher-status brand will have relatively little to lose (Rao and Ruekert, 1994; Rao et al., 1999; Washburn et al., 2000; Bengtsson and Servais, 2005). Although the signaling theory is employed to investigate how the brand name can serve as a benefit to be offered or a single piece of information to be displayed in a partnership, the important issue of a continuing exchange for mutual benefits in a partnership (see p.611, Bourdeau et al., 2007; p.123, Seno and Lukas, 2007) has been completely disregarded.

The Bucklin and Sengupta (1993) study is the first to apply the theory of inter-organizational exchange (e.g., Cook, 1977) in analyzing the co-branding

alliance. They claimed that the purpose of an alliance is to reduce the uncertainties from the environment (i.e., market) by exchanging resource for mutual benefits. That is to say, a co-branding alliance can be successfully formed only when the partners exchange their resource to get mutual benefits. They used a measure of mutual benefits, namely the perceived effectiveness (i.e., the performance of an alliance), as an indicator to determine the degree of alliance success. The authors considered the alliance a joint project and introduced three important dimensions that can affect the perceived effectiveness:

1. Project management: the imbalance of power (e.g., one partner can force the other to change its sales policy), the managerial imbalance (e.g., the performance measures of two partners are different), and the conflict (e.g., disputes between firms);

2. Project payoff: the ex-ante views about the economic opportunities, namely the market opportunity (e.g., accessing new markets or enhancing reputations) and cost (e.g., advertisement of the co-branded product);

3. Partner match: the similarity of management style and company culture.

An empirical study was then conducted to test their framework. They examined 98 alliances in the computer and semiconductor industries and found that, after exchanging resource, the asymmetric resource endowment can cause imbalances in power and the managerial resource. Subsequently the imbalances can damage the success of the alliance. On the other hand, the compatibility in partner culture and management style is essential to the success of the partnership. They concluded that co-branding alliances prosper when projects have been well-selected in terms of the market opportunities and the resource required, when both partners have roughly similar market position, and when both partner draw up a contract for balancing their power and managerial structures.

The findings of Bucklin and Sengupta (1993) initiate the application of strategic alliance framework to discuss the success factors of co-branding on organizational levels. Following Bucklin and Sengupta (1993), Decker and Schlifter (2001) investigated whether and, if so, how co-branding could be a strategic instrument for achieving market success. According to their empirical survey, nearly 65% of the sample firms indicated that co-branding is considered to be an effective strategy for future development, and that co-branding is a suitable tactic for a product extension in an entirely new category. Furthermore, almost 90% of the sample firms agreed that co-branding can be used to signal the quality of the joint products. The results also showed that most of the firms use co-branding to attract new customers, and that the organizational fit is considered as one of the important factors determining the success of co-branding.

Sauvée and Coulibaly (2007) utilized the network theory (e.g., Henneberg and Mouzas, 2004) to propose an analytical framework in studying co-branding: they viewed each of the brands as a set of resource for the creation of value in the partnership; the authors considered the brand alliance to be a network consisting of the focal brands, the partners of the focal brands, the competitors, the distributors, and the end users. Moreover, the governance mechanisms (e.g., ownership and contractual rule) are also taken into consideration in their framework. They concluded that the key resource of the members in the network is associated with the value of co-branding. Although two case studies were included to connect their framework to real business, an important limitation exists: the authors did not relate their results to the success of co-branding.

A successive study (Sauvée and Coulibaly, 2008) fills this gap. Sauvée and Coulibaly (2008) is an extension to their previous study. After conducting two case studies, they reported that the existence (lifespan) of an inter-temporal co-branding alliance is determined by its stability, and this can be examined by three inter-organizational characteristics, namely the resource base, the

interaction process (e.g., cooperation or competition), and the balance of power. Overall, their findings echo Bucklin and Sengupta (1993) but their study is analyzed from a dynamic perspective (cf. Venkatesh et al., 2000).

The above three research articles discussed the success or failure of co-branding from the organizational aspects (i.e., inter-organizational exchange, resource endowments, balance of controlling power) but the authors did not thoroughly consider the effect of the asymmetric contributions of the partnering brands to the partnership (e.g., Amaldoss et al., 2000; Simonin and Ruth, 1998). Venkatesh et al. (2000) bridged this gap.

Similar to Sauvée and Coulibaly (2008), Venkatesh et al. (2000) discussed the alliance in a dynamic manner and the partnership can be viewed as the cooperation of two players (brands) with different functional performance levels (i.e., like the brands which require attribute enhancement in Rao and Ruekert (1994)). They viewed consumer preferences (customer size) as the resource owned by each brand (e.g., entertainment performers, e.g., singers) and argued that - after experiencing the co-branded product - some consumers who originally prefer one of the brands would change their preference to the other, due to the different functional performance of each brand. They named this kind of shifting behavior the "*shift-in preference*" and claimed that the emergence of the shift-in preference motivates the existence of alliances because this type of behavior indicates the exchange of resource in terms of consumer preferences for mutual benefits.

However, they claimed that the "shift-in" preference can influence each brand's preference share and that the preference share will be used to split the sales revenue of the co-branded products to each of the brands at each time point.[5] Consequently, one of the players can be a loser in this alliance, because its revenue from the alliance is smaller than in the baseline situation (i.e., if the

[5] Amaldoss et al. (2000) suggested, in order to prevent partners' free-riding behaviors, the revenue of alliance should be shared in proportion to the resource committed (i.e., contributions) by each player.

alliance is not formed). In other words, the loser will have to acquire more consumers from outside the alliance (i.e., a certain amount of market expansion) to maintain its original revenue level. They considered this type of market expansion as the necessary condition of alliance success, in that the alliance may break up if the anticipated amount of expansion is not forthcoming. In addition, the authors also showed that an equal level of shift-in ratios of both brands can lead to an ideal situation whereby the alliance can be built up without a positive amount of market expansion.

In summary, the research discussed in this section explores the strategic intents of one brand partner to form a co-branding alliance from two research streams. One stream of work emphasizes the signals of brand (names) (e.g., Rao and Ruekert, 1994; Washburn et al., 2000; Bengtsson and Servais, 2005) while the other stream of literature focuses on the organizational characteristics and the mutual benefits. Venkatesh et al. (2000) offered a more comprehensive study by considering both the effects of mutual benefits and brand signaling. However, using the framework of strategic alliance to study co-branding has an intrinsic limitation: the behavior of consumers is not fully taken into account (Hadjicharalambous, 2006). For example, the rationale behind the shift-in preference (i.e., preference change between the focal brands) is not further investigated in Venkatesh et al. (2000). Since co-branding is a combination of two brands and ultimately the brands are “owned” in the minds and hearts of consumers (Leuthesser et al., 2003), consumer evaluation is an indispensable issue in co-branding research. That is to say, co-branding should be also studied from the consumer behavior perspective (p.96, Rao and Ruekert, 1994; p.374, Hadjicharalambous, 2006).

2.3.2 The Analysis with regard to the Consumer Behavior Framework

In contrast to a small number of studies from the strategic alliance framework, a rich vein of literature has investigated this topic from the consumer behavior

framework during the past two decades (Leuthesser et al., 2003). With a large base of attitude research as their background, the behavioral researchers often use “attitudinal acceptance” to measure the effectiveness of a co-branding strategy. In particular, a great deal of attention has been paid to consumers’ attitudes toward the co-brand (e.g., Park et al., 1996; Samu et al., 1999; Desai and Keller, 2002; James et al., 2006) and the post-exposure attitudes toward each of the allying brands (e.g., Park et al., 1996; Rodrigue and Biswas, 2004; Abbo, 2005).

“Fit” is the most important factor in determining the attitudinal acceptance of the co-brand (Mathiesen, 2007). Aaker and Keller (1990) measured the concept of “fit” in three dimensions, namely complement, substitute, and transfer. Complement refers to that a particular need can be satisfied by a joint consumption of two products in different categories. Substitute pertains to the replacement of one product by the other to fulfill the same desire. The above two dimensions are discussed from a demand-side perspective but, from the supply-side of view, transfer refers to the “*perceived ability of any firm operating in the first product class to make a product in the second product class*” (Aaker and Keller, 1990). The authors used “fit” to examine the relation between the original and extended products in the field of brand extension. Their empirical results showed that a good perceived fit between original and extended product category enhances consumers’ attitudes toward the extend products.

We argue that it is also suitable to apply the concept of “fit” to analyze consumers’ attitudes in co-branding research since co-branding is one type of brand extension (Hadjicharalambous, 2006). To our knowledge, Park et al. (1996) is the first to use “fit” in co-branding research. They stated that the attribute complementarity (i.e., product-fit) plays an important role and they defined the term “complementarity” between the allying brands (e.g., say brand *A* and *B*) as:

1. Both brands have a set of relevant attributes (e.g., good-taste and

low-calories);

2. Two brands differ in attribute salience such that the attribute, which is not salient to one, is salient to the other (e.g., brand *A* is salient in good-taste and brand *B* is salient in low-calories);

3. The brand for which the attribute is salient has a higher perceived performance level on that attribute (e.g., brand *A* has a higher level on "good-taste" and brand *B* has a higher performance level on "low-calories").

In short, two brands complement each other only when their attribute salience and attribute (performance) level mesh well. The hypothetical co-branded cakemix is used in their experiments and the results showed that, similar to brand extension, a co-branding alliance with the attribute complementarity (i.e., a better product fit) produces a positive effect on consumer attitudes toward the co-brand and thus can lead to the effectiveness of a co-branding strategy.

Samu et al. (1999) confirmed the findings of Park et al. (1996) in the joint-advertising context. They found that the degree of complementarity between the products of partnering brands (product fit), the type of differentiation strategy (common or unique attributes), and the design of processing strategy (top-down or bottom-up) are the important factors in controlling the degree of effectiveness. They reported that a high level of complementary can quickly obtain consumers' recognitions of the co-branded product and maximize the awareness of the co-brand. In addition, Simonin and Ruth (1998) offered a different definition of "product fit". They viewed the "product fit" as a high correlation between the product categories of the partnering brands.

In addition to the product fit between the allying brands, the brand fit (i.e., consistent brand images) is also proved to have a considerable positive influence

on the attitudes toward the co-brand (Simonin and Ruth, 1998). Simonin and Ruth (1998) further found that the degree of brand familiarity moderates each brand's contribution to the evaluation of co-brand. The Baumgarth's (2004) work is basically a replication of Simonin and Ruth (1998) but he claimed that the positive effect of a high brand fit also exists in the context of joint-advertising. Following Simonin and Ruth (1998) and Baumgarth (2004), Bouten (2006) executed an empirical study and reported that a high brand fit is the most important determinant of the evaluation of the co-brand. Furthermore, she indicated that a better fit between the brand images of the allying brands and the co-branded product is also a plus to a favorable evaluation.

James et al. (2006) explored whether the fit of brand personalities of the allying brands is crucial for a successful co-branding. According to Aaker (1997), the term "brand personality" pertains to "*the set of human characteristics associated with a brand*". For example, *Absolut Vodka* can be described as a *"cool, hip, and contemporary 25-year old"* (p.347, Aaker, 1997). The authors argued that a better fit (similarity) of brand personalities between two parties is likely to generate a more favorable attitude toward the co-brand and an increased intension to purchase. Finally, the results of their experiment supported their argument and they concluded that the effectiveness of co-branding relies on both the concrete attribute performance and the fit of the abstract brand personalities.

Walchli (2007) viewed the level of "fit" as the degree of "(in)congruence" and analyzed how the between-partner congruency affects consumer evaluations of the co-brand. The results indicated that, under a high involvement processing condition, consumers tend to react more positively toward the co-brand if the partnering brands are perceived to be moderately incongruent (i.e., a moderate brand fit). Conversely, a lower level of attitudinal acceptance of the co-branded product occurs when a highly similar or dissimilar concept (i.e., a poor brand fit) is presented. Following Walchli (2007), the Hao's (2008) empirical study supported the positive influence of congruence on the favorability of the

co-brand and also reported that choosing a congruent partner can enlarge the focal brand's equity.

In the context of ingredient co-branding Desai and Keller (2002) empirically tested how a novel joint product (i.e., a first-time release in the existing product class) affects consumer evaluations. They examined two types of strategies: one strategy which aims to modify an existing attribute is called the "slot-filler expansion"; the other tactic which intends to add a new attribute is named the "new attribute expansion". For instance, that a new type of flavor is included in a tooth-paste is called a "slot-filler expansion" strategy; that the cough relief (a new function/attribute) is added in a candy is named a "new attribute expansion". Their experiments reported that, for a specific brand, partnering with another brand to introduce a "new-function" product (i.e., "co-branded ingredient") is the best option for the new attribute expansion strategy; however, a slot-filler expansion is better to be employed by a single brand. Although their results are somewhat controversial (cf. Park et al., 1996), an interesting finding is that they found the attitudinal favorability of a "co-branded ingredient" is lower when the perceived distance of the new product extension from the host brand is larger.

Other than the concept of "fit", several other factors can also affect consumer attitudes toward the co-brand. In a global co-branding setting, Voss and Tansuhaj (1999) investigated the influence of Country-of-Origin (COO) effect on the evaluation of the co-brand. In their experiments, they used Japanese and American camera brands to test several market entry strategies. The results indicated that brand evaluation of an unknown foreign brand is improved when it allies with a reputed domestic brand and this is a good strategy for entering the domestic market. They also reported that the stereotype of one country is an important factor in the process of consumers' evaluation. In the context of dual branding (i.e., both brands shared the same location, see section 2.1.2), Levin and Levin (2000) employed the assimilation and contrast theory (e.g., Lynch et al., 1991) to discover the impact of co-branding. Their findings revealed that a

higher evaluation of co-brand occurs when a broad range of overlap of features (e.g., both restaurants share food service and preparation) exists. James (2005) discussed the influences of association transfer between different categories. He claimed that the strength of brand associations is linked to the level of attribute performance and the amount of consumer benefit. The empirical results revealed that a positive association with one of the partnering brand may become negative when the co-branded product is released in a different product category.

Due to the importance of attitudinal favorability in behavioral research, the post-exposure (i.e., after the alliance) attitude toward the allying brands is also considered a crucial measure for a successful co-branding. For example, Leuthesser et al. (2003) have inferred that a co-branding strategy would be more effective if the favorability of post-exposure attitudes toward each of the partnering brands is enhanced or at least maintained. However, the favorability of post-exposure attitudes is directly influenced by the strength of reciprocal effect (i.e., spillover effect).

Reciprocal effect is initially used to explain the effects of extended products on the parent brands in the field of brand extension (e.g., Aaker and Keller, 1990) and has been recently applied into co-branding research to describe the influences of the attitudes toward the co-brand on each of the allying brands. As far as we know, the Park et al.'s (1996) work is the first to show that the magnitude of the spillover effects to the allying brands is asymmetric. They founded that, when there exists a high product fit in the alliance, the header brand (*Sony* in *Sony-Ericsson*) will experience a larger positive reciprocal effect than the modifier brand (e.g., *Ericsson* in *Sony-Ericsson*). However, when the header brand (e.g., *Sony*) is evaluated more favorably than the modifier, the overall evaluation of header is not improved after the alliance. Abbo (2005) confirmed the findings of Park et al. (1996) in the ingredient co-branding context. The author used the concept of "cue redundancy" (McCarthy and Norris, 1999) to explain why the positive reciprocal effect to the host brand (e.g., *Nutella* in

Nutella-Brossard chocolate) will be limited when the host brand pairs with a low-evaluated ingredient brand (e.g., *Brossard*).

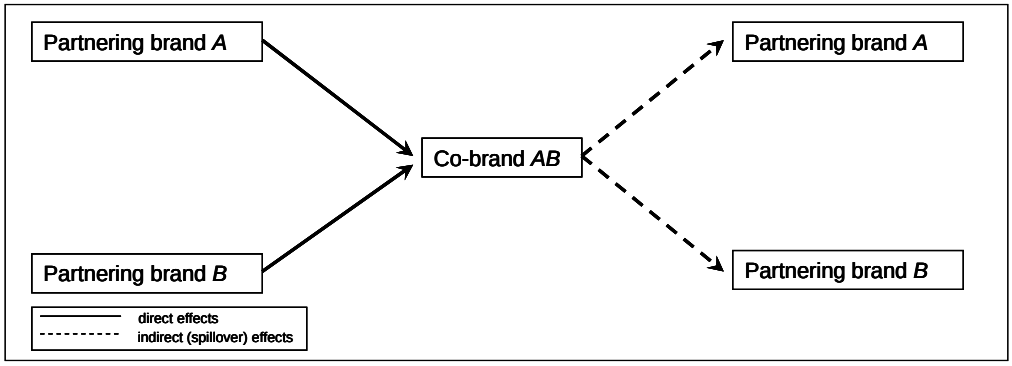
Simonin and Ruth (1998) echoed the fact of asymmetric effects but stated that the strength of reciprocal effects is moderated by the degree of brand familiarity: the brand with a lower level of familiarity receives a higher level of spillover effect. In another study, Baumgarth (2004) replicated the methodology and research hypotheses of Simonin and Ruth (1998) and confirmed the importance of brand familiarity. Rodrigue and Biswas (2004) partially extended the work of Simonin and Ruth (1998) by using two factors to categorize the ingredient co-branding alliances (e.g., *Dell* laptops with *Intel* chips): the dependency/independency of the ingredient brand (e.g., *Intel* chip is dependent because it cannot be consumed independently from *Dell* laptops) and non-exclusivity/exclusivity of the ingredient brand (e.g., whether *Intel* is also bundled with other brands). By an empirical investigation, they reported that the dependency positively moderates the degree of the spillover effect to the ingredient brand while non-exclusivity/exclusivity does not modify the level of spillover effect either to the host brand (*Dell*) or to the ingredient brand.

The above studies explain the influences of reciprocal effects on the partnering brands on the attitude level, but the discussions of the reciprocal effect on the belief level (i.e., belief revision) are rather scarce. To the author's knowledge, only two studies have investigated the mechanism of belief revisions in co-branding. Hillyer and Tikoo (1995) argued that, through a co-branding alliance (e.g. *Sony-Ericsson*), the beliefs of attribute performance of the second brand (e.g., *Ericsson*) can lead to an enhancement or impairment on the beliefs of the primary brand (e.g., *Sony*). Geylani et al. (2008) claimed that the beliefs of the partnering brands are changing after co-branding. They initiated a mathematical model to describe how consumers receive new attribute information from the co-branded product and use their perceptions of the co-branded product to update their original beliefs of the partner brands. We

argue that, given that consumers' attitudes are based on the underlying attribute beliefs (Fishbein and Ajzen, 1975), belief revisions is therefore related to the reciprocal effects on the attitude level. This issue will be further discussed in chapter 4.

In the first part of his influential dissertation, Huber (2005) has summarized previous findings and concluded that in a co-branding strategy two effects may be involved, namely the direct effect and the indirect (spillover) effect (see Fig. 2.11). He claimed that the two effects are closely connected to the objectives of co-branding: (1) to secure the economic success of the co-branded products, and (2) to realize the possible positive influences for the partnering brands. The author used a hypothetical co-brand "*Danone-Punica*" fruit-yogurt as an example to illustrate the objectives – on one hand, the co-branded yogurt can contribute to the economic success if consumers accept and re-purchase it; on the other hand, the joint product can alter the perceptions of each allying brand through the spillover effect.

Figure 2.11: The effects of co-branding



Source: adapted from Huber (2005)

In the second part of his work, the author built up a research model encapsulating nineteen theoretical hypotheses regarding consumer evaluations of the co-brand and the partnering brands. The model was then tested empirically

by the hypothetical German fruit-yogurt co-brands and analyzed with AMOS software (for structure equation analysis). Finally, their results confirmed again the positive impacts of product and brand fit (e.g., *Mueller-Granini* fruit-yogurt) on the evaluation of the co-brand, and the negative effects of a mismatching co-brand on each of the partnering brands. Particularly in the field of co-branding, their study was the first to empirically confirm the positive impacts of two consumer characteristics, these being the level of product involvements (Mittal and Lee, 1989) and the degree of brand orientations (Shim and Gehrt, 1996).

Overall the behavior researchers have suggested the success of co-branding (i.e., attitudinal acceptance) relies on several decisive factors such as the respective fits between the focal brands (e.g., Simonin and Ruth, 1998; Desai and Keller, 2002; James et al., 2006), country-of-origin effect (Voss and Tansuhaj, 1999), association transfer (James, 2005), product involvements and brand orientations (Huber, 2005), and the strength of reciprocal effects (Park et al., 1996; Baumgarth, 2004; Rodrigue and Biswas, 2004). Although the above studies provide a better understanding of the process of consumer evaluations, there is a critical limitation: no behavioral researchers[6] have shown how to further apply their findings to transform the attitudinal measure into the preferential indicator, which is a fundamental measure for brand managers to predict consumer brand choices and the market shares.

2.3.3 A Recapitulation

As illustrated above, different schools of researchers have applied different theories to offer the measures for a successful co-branding. Some scholars investigate the rationale underlying alliance formation by applying the signaling and inter-organizational exchange theories while some researchers concentrate on the psychological and behavioral changes in consumer evaluations of the

[6] Park et al. (1996) is an exception; they have utilized three pairs of the co-branded products to test consumers' preferences and choices. However, their results are not connected to the market shares.

co-brand and the allying brands. Although a few studies have offered a critical discussion of previous findings (e.g., Leuthesser et al., 2003; Hadjicharalambous 2006; Helmig et al., 2008), a chronological brief review with respect to the success of co-branding is still lacking. Table 2.4 closes this gap.

In view of the existing findings, we argue that previous investigations on this topic are still “incomplete”. Because they either lack of the behavior details or are inappropriate for predicting the market shares. Being restricted to these select factors may not provide a comprehensive analysis, just as someone knowing only that an elephant has the long legs claims that elephants run faster than antelopes. We need new approaches which can not only explicitly offer a measure of market outcome of a co-branding alliance but also provide the behavioral details. In the following section we will introduce two new approaches.

Table 2.4: A chronological review regarding the success of co-branding

Author(s)	Frame-work	Involved theories	Theoretical/ empirical	Major findings regarding the success of co-branding	Explicit/ embedded findings
Bucklin/Sengupta (1993)	S	Inter-organizational exchange (e.g., Cook, 1977)	E	• The compatibility in partner culture and management style is vital to the success of the alliance. • A successful co-branding occurs when both partners have roughly similar market position.	∨
Rao/Ruekert (1994)	S	Signaling (Spence, 1973)	T	• Choosing a reputable partner can provide a quality enhancement for the co-branded product. • For products requiring attribute enhancement, a partner with the desired functional skill will be appropriate.	-
Hillyer/Tikoo (1995)	C	Process model (e.g., Petty and Cacioppo, 1986)	T	• Through a co-branding alliance, the beliefs of attribute performance of the second brand can have positive or negative effects on the beliefs of the primary brand.	-
Park et al. (1996)	C	Concept specialization (e.g., Murphy, 1988)/Fit (Aaker and Keller, 1990)	E	• A better product fit (i.e., attribute complementarity) produces a positive effect on consumer attitudes toward the co-brand and leads to the effectiveness of a co-branding strategy. • Consumers' post-exposure attitudes toward each of the partnering brands are modified by the order of the brand names in co-branding.	∨
Venkatesh/ Mahajan (1997)	S	Signaling	E	• Due to the incongruence of the allying brands, co-branding does not always contribute to price premiums or the win-win outcomes.	-
Simonin/Ruth (1998)	C	Information integration (Anderson, 1981)/attitude accessibility (Fazio et al., 1989)/Fit	E	• A high brand fit (i.e., brand image consistency) or product fit (i.e., relatedness of product categories of two brands) has a positive influence on the attitudes toward co-brand. • The post-exposure attitudes are directly affected by the spillover effects from the attitudes toward the co-brand. • The degree of brand familiarity moderates each brand's contributions to the attitudes toward the co-brand and the post-exposure attitude toward each of the allying brands.	-
Rao et al. (1999)	S	Signaling	E	• A brand, which is unable to signal its quality by itself, can enhance its quality perceptions from partnering with a high perceived quality brand.	∨
Voss/Tansuhaj (1999)	C	Country of origin effect (e.g., Bilkey and Nes, 1982)	E	• In order to enter a domestic market, an unknown foreign brand is better to partner with a	-

				reputed domestic brand.	
Samu et al. (1999)	C	Association network model (e.g., Collins and Loftus, 1975)/Fit	E	• In the joint-advertising context a high level of complementary can quickly obtain consumers' recognitions of the co-branded product and maximize the awareness of the co-brand.	-
Washburn et al. (2000)	S	Signaling	E	• The low-equity brand is enhanced from the partnership than the high-equity one.	-
Venkatesh et al. (2000)	S	Inter-organizational exchange	E	• The success of a mid-term co-branding alliance depends on an anticipated amount of market expansion for the weak brand, which cannot acquire sufficient consumer preferences after co-branding.	∨
Decker/Schlifter (2001)	O	*	E	• The organizational fit is considered as one of the important factors determining the success of co-branding.	∨
Desai/Keller (2002)	C	Concept combination (Murphy, 1990)/Fit	E	• For a specific brand, partnering with another brand to introduce a "new-function" product (i.e., co-branded ingredient) is the best option for the new attribute expansion strategy; a slot-filler expansion is better to be employed by a single brand. • The attitudinal favorability of a co-branded ingredient is lower when the perceived distance (fit) of the new product extension from host brand is larger.	-
Levin/Levin (2000)	C	Assimilation and contrast effect (e.g., Lynch et al., 1991)	E	• In a dual branding context, the strength of the co-branding increases when a large number of shared activities between the two brands exist.	-
Leuthesser et al. (2003)	O	*	T	• A successful co-branding occurs when both the brands add value to the partnership. The added value comes from the complementarity between the allying brands and the potential customer base for the co-brand. • A high attitudinal favorability results from a better fit and the enhanced (or equal) post-exposure attitude toward the allying brands.	∨
Baumgarth (2004)	C	+	E	• The positive effect of a high brand fit also exists in the context of joint-advertising. • Brand familiarities can moderate the level of spillover effects.	∨
Voss/Gammoh (2004)	S	Signaling	E	• The perceived quality of an unknown brand does not continue improving when it allies with more than one brand.	-
Rodrigue/Biswas (2004)	C	+	E	• The dependency of the ingredient brand positively moderates the spillover effect to the ingredient brand.	-

Abbo (2005)	C	+	E	• A positive reciprocal effect to the host brand is limited when it pairs with a lower-evaluated ingredient brand.	-
Askegaard/ Bengtsson (2005)	O	Intertextuality (Barthes, 1977)	T	• Brands are symbols where consumers construct their identities and thus brand managers need to take care of the culture "meanings" of the two associating brands in a partnership.	-
Bengtsson/Servais (2005)	S	Signaling/Collective identity (e.g., Anderson et al., 1994)	E	• Co-branding may help to increase the perceived compatibility between current product categories of partnering brands. • An existing well-known brand can provide an effective signal of a higher degree of identity and trust for an unknown brand by a partnership.	-
Huber (2005)	C	Attitudes/ Motivations and involvements (e.g., Ajzen and Fishbein, 1980; Blackwell et al., 2005)	E	• The level of product involvement and the degree of brand orientation have positive impacts on the consumer evaluations of co-branding.	∨
James (2005)	C	Association transfer (e.g., Broniarczyk and Alba, 1994)	E	• The success of co-branding depends on consumers' reactions. • A positive association with one of the partnering brand may become negative when the co-branded product is released in a different product category.	∨
Bouten (2006)	C	Fit	E	• A high brand fit is the most important determinant of the evaluation of the co-brand.	∨
Hadjicharalambous (2006)	O	*	T	• Co-branding can be viewed as a sub-case of brand extension and researchers can apply the framework of brand extension in the field of co-branding.	-
James et al. (2006)	C	Fit	E	• The success of co-branding not only relies on a better performance provided by concrete product attributes but also depends on the fit of the abstract brand personalities.	∨
Walchli (2007)	C	Congruence theory (e.g., Meyers-Levy and Tybout, 1989)/Fit	E	• Under a high involvement processing condition, consumers tend to have more favorable attitudes toward the co-brand if the partnering brands are perceived to be moderately incongruent (i.e., a moderate brand fit).	∨
Sauvée/Coulibaly (2007)	S	Network theory (e.g., Henneberg and Mouzas, 2004)	T	• Co-branding can be though of as a network including the focal brands, the partners of the focal brands, the competitors, the distributors, and the end users. • The key resource of the members in the network is associated with the value of co-branding.	-

Geylani et al. (2008)	C	Fit/Accommodation model (e.g., Park et al., 1993)	E	• A moderate distance of the performance levels (i.e., beliefs) between the allying brands is the optimal solution in co-branding. • After co-branding, the beliefs of each of the allying brands may improve but the uncertainties of attribute beliefs may increase.	-
Hao (2008)	C	Congruence theory	E	• The between-partner congruence leads to a favorable evaluation towards the alliance and the effectiveness of co-branding. • A favorable country image can enhance the evaluation of co-branding in the global co-branding context.	∨
Helmig et al. (2008)	O	*	T	• The alliance will achieve success if the partner brands are perceived to have competencies by consumers.	∨
Sauvée/Coulibaly (2008)	S	+	T	• The lifespan of a dynamic co-branding alliance is determined by its stability.	-
Baumgarth/Rath (2009)	S	Fit	E	• A good fit of competence and a clear purpose of partner selections are essential to co-branding success.	-

Descriptions:

C *consumer behavior framework*
S *strategic alliance framework*
O *other frameworks*
E *empirical studies*
T *theoretical studies*
\+ *an extended study, which uses the same theories from existing articles*
* *theoretical conceptual model which summarizes existing results*
\- *embedded findings regarding the success of co-branding*
∨ *explicit findings: the phrase "success of co-branding" or "effectiveness of co-branding" appears in the articles*

2.4 Conclusions and Further Proceeding

2.4.1 Two New Approaches for Examining the Success of Co-branding

In this section, we suggest two approaches to offset the limitations of the existing studies. The “top-down” approach and the “bottom-up” approach are the extended work from the viewpoints of strategic alliance and consumer behavior, respectively. Both approaches can offer a measure of market outcome and explain the respective behavioral contents simultaneously. To our knowledge, these approaches have not been adopted to analyze the success of co-branding.

1. Top-down approach

The purpose of the top-down approach is to examine how the rationale of alliance formation can be stretched to the components of consumer evaluations.

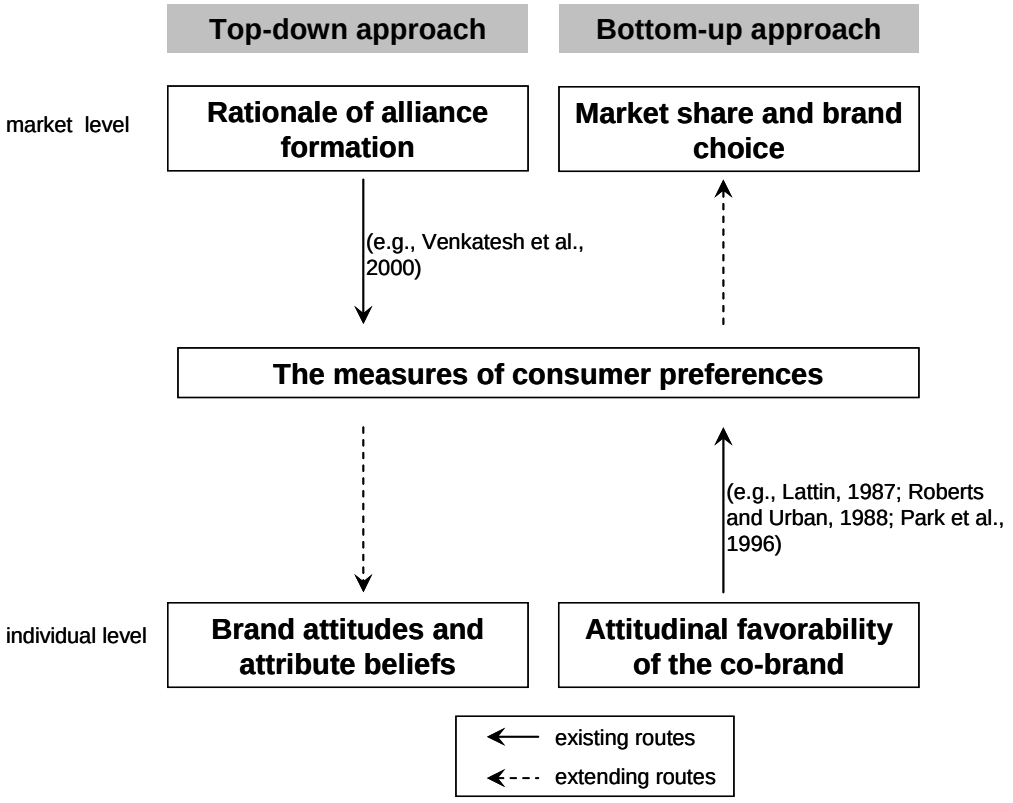
As already mentioned in section 2.3.1, in the framework of strategic alliance, an alliance is considered a mechanism for one brand to enlarge (or at least maintain) its market share: some researchers used the theory of inter-organizational exchange to argue that the partnership can be successfully formed when the partners exchange their resource for mutual benefits (e.g., Bucklin and Sengupta, 1993); some scholars applied the signaling theory to explore the rationale underlying an asymmetric partnership – a higher-status brand with a lower-status (e.g., Rao et al., 1999). Concerning the importance of the demand-side factors (e.g., consumer preferences), Venkatesh et al. (2000) have related the rationale of alliance formation to preference measures (i.e., the shit-in preference) but did not further examine the behavior details behind the preference measures. Therefore, we can offer a new insight into the explanation of the shift-in preference at the deeper levels of consumer evaluations, namely consumer attitudes and attribute beliefs, and can relate the rationale of alliance formation at the market level to these components at the individual level.

2. Bottom-up approach

The bottom-up approach attempts to investigate how the anticipated attitude (belief) changes influence consumer brand choice behavior as well as firms' market shares. It has traditionally been used in the field of marketing. For instance, Roberts and Urban (1988) linked consumers' attribute beliefs to the probability of brand choice by a logit formulation; Lattin (1987) used the compensatory vector model to connect an individual's utility (attitude) to his/her choice behavior. However this approach has never been applied in the context of co-branding.

As already indicated in section 2.3.2, behavioral researchers only focused on how co-branding causes the internal influences on the consumers (i.e., the change of brand attitudes) but did not relate the changes to firms' market shares. So, the problem in this research field is the lack of explicit measures of market outcome for brand managers to predict the effectiveness of co-branding. The bottom-up approach tries to close this gap. This approach first builds up the preferential measures and then applies suitable theories to connect to the brand choices and market shares. For example, after setting up the market structure (e.g., an oligopoly market), one can further utilize the formulation of attribute beliefs (e.g., Geylani et al., 2008) or the attitudinal measures (e.g., Park et al., 1996; Simonin and Ruth, 1998) to examine the pre- and post-alliance choice probabilities by adapting the *Luce's Axiom* (Luce, 1959) or the multinomial logit models. To conclude, the bottom-up approach investigates the connection from the attitudinal favorability at the individual level to the market outcomes at the market level. Fig. 2.12 presents these two approaches.

Figure 2.12: Two approaches for examining the success of co-branding



Although both approaches can use consumers' psychological measures to predict the market performance of a co-branding alliance (strategy), there exist three distinctions between the two approaches:

1. different theoretical applications: since we attempt to investigate both the underlying reasons of alliance formation and the respective behavioral changes simultaneously, the "top-down" approach therefore addresses the integration of relevant theories in the strategic alliance field and consumer behavior fields. However, the "bottom-up" approach only involves the theories in the consumer behavior field;

2. different settings of market structure: from a modeling point of view, the "bottom-up" approach may contain a more complicated setting in the

market structure than the “top-down” approach. That is to say, assuming that the consumers’ characteristics are identical in both approaches, the former usually needs a larger number of parameters to characterize the competing behaviors among several firms (i.e., except the duopoly market, there exist only two firms in the market) while the latter only deals with the exchange behaviors between the two partnering brands (see Venkatesh et al. (2000) for an example);

3. different levels of academic contributions: as indicated above, during the past decades, marketing researchers have adopted the “bottom-up” approach in forecasting the sales of the consumer goods (e.g., Erdem and Keane, 1996) but the “top-down” approach, which emphasizes on the connection between the two fields, is still lacking in co-branding field.

2.4.2 A Guideline of this Dissertation

In the last section, we have suggested two new approaches for examining the success of co-branding. However, the question lies in which approach will be applied in this dissertation.

This dissertation will adopt the “top-down” approach. This is not to say that the “bottom-up” approach is not important to this field or is not suitable for further investigations on this topic. Instead, we want to highlight three potential benefits generated from adopting the “top-down” approach:

1. We offer an interdisciplinary study. We investigate the effectiveness of co-branding by applying the theories from two scientific fields. This integrated analysis not only provides the normative guidelines for a successful formation of co-branding but also concerns the influence of consumer evaluations simultaneously. In short, this approach connects the two fields to offer a more complete examination on this topic;

2. We address the importance of inter-organizational exchange behaviors. As mentioned above, the bottom-up approach may contain a more complicated setting of the market structure than the top-down approach. However, there is always a trade-off between the number of parameters and the complexity of applying the result to reality. With a larger number of parameters we could also face an additional problem of measurement and validation. In this dissertation, we will choose to adopt the top-down approach, and thus will focus on analyzing the resource exchange behaviors between the partners.

3. We make a relatively larger contribution to the research society. Compared with the “bottom-up” approach, the “top-down” approach can show a more creative thinking for resolving this problem and can thus make a relatively large contribution to the field of co-branding.

In order to adopt the “top-down” approach, this dissertation will be positioned as an extension to the Venkatesh et al.’s (2000) work. As illustrated in section 2.3.1, Venkatesh et al. (2000) offered a comprehensive investigation on the rationale of alliance formation but we argued that they also initiated a starting point for connecting alliance success with the behavioral contents underlying the shift-in preference. The present study will first try to analyze these behavioral contents and then expound how these behavioral variables affect the success of co-branding.

To sum up, the success of co-branding, in this dissertation, will be defined as “*the successful formation of a co-branding alliance*” and it will be analyzed by the top-down approach together with a step-by-step process. Chapter 3 will take an initial step to explore the rationale of the shift-in preference on the attitude level. In chapter 4, we will take another step down to the belief level and adapt the Venkatesh et al. (2000)’s model to explore the relation among the belief revision, shift-in preference, and the necessary condition for a successful

co-branding. In chapter 5, we will present a numerical experiment to examine the effectiveness of co-branding in four hypothetical scenarios.

Chapter 3

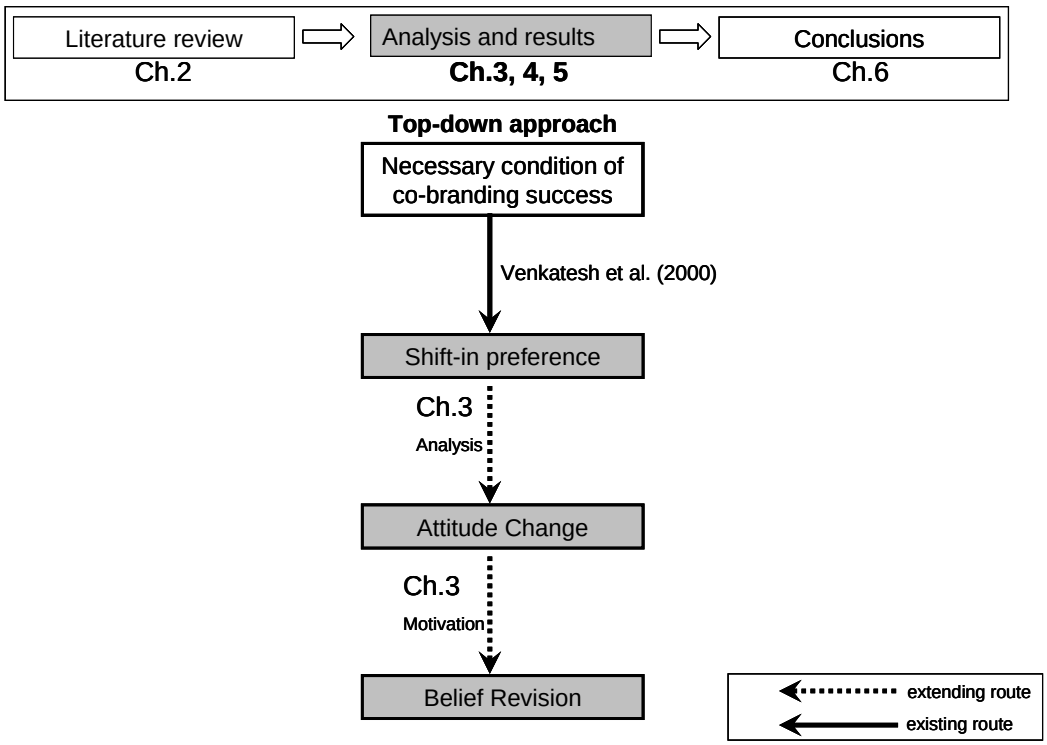
A Systematic Analysis of Preference Change in Co-branding

As indicated in chapter 2, Venkatesh et al. (2000) have stated that the effectiveness of co-branding is related to the shift-in preference, a “specific” type of preference exchange (change) between the allying brands. The purpose of this chapter is therefore first to provide the rationale underlying preference change on the attitude level, and secondly, to apply the results in a systematic discussion of the behavioral contents behind the shift-in preference. In short, this chapter will investigate why the pre- and post-alliance attitude toward each of the allying brands can be different and motivate the need for using the “core element” of consumer evaluations, namely the attribute beliefs, to investigate the effectiveness of co-branding in chapter 4.

The remainder of this chapter is arranged as follows. In section 3.1, we will introduce the components of consumer evaluations. In section 3.2, we will develop a conceptual model to illustrate consumers’ attitudinal changes in co-branding. In section 3.3, we will use this conceptual model to systematically analyze preference change and apply our results in a three-brand scenario. In section 3.4, we will deduce two insights and one suggestion for further investigations on the success of co-branding. In section 3.5, we will close this chapter with three future directions for research.

The position of this chapter in this dissertation is shown in Fig. 3.1.

Figure 3.1: The position of chapter 3



3.1 The Components of Consumer Evaluation

According to Lilien et al. (p.26, 1992), consumer evaluation consists of two components, namely perceptions and preferences.

Perceptions can be represented by *consumer beliefs*. The fields of psychology (e.g., Fazio, 1990) and economics (e.g., Lattin, 1987; Lancaster, 1990) both suggest that consumers can view each brand (product) as the combination of several attributes and thus consumers will develop opinions about where the brand stands on each of the attributes. These opinions are called the "attribute beliefs" and are the "core elements" of consumer evaluation. Traditionally, marketing researchers have often used consumers' attribute beliefs to measure their brand attitudes (e.g., Ginter, 1974; Lichtenthal and Goodwin, 2006).

Preferences are often utilized as the measure for managers to predict each brand's market share and, in fact, preferences can be represented by the rank order of *brand attitudes* (Bass and Talarzyk, 1972). For instance, if a consumer has a more positive attitude toward *Appetite* than any other brands in his consideration set, we will consider that he (she) prefers *Appetite* the most. Hence, the shift-in preference in the Venkatesh et al. (2000) study can be referred to the change of the rank order of the attitudes toward the two allying brands after co-branding.

Since we are interested to know the rationale behind the shift-in preference, our first step is to break down consumer preferences on the attitude level and then we will try to realize why consumers would change their attitudes toward each of the allying brands after they experience the co-branded products. In the following sections of this chapter, we call the “pre-alliance attitudes toward each of the partnering brands” the “prior attitudes” and name the “post-alliance attitudes toward each of the partnering brands” the “post-exposure attitudes”.

3.2 A Conceptual Model of Attitude Change in Co-branding

Related to this section are plenty of studies on consumers’ evaluation of co-branding. The corresponding cognitive process is a complex issue (p.15, James, 2005) and this process is basically built on three relevant psychological theories, namely the theory of information integration (Anderson, 1981), the theory of attitude accessibility (Fazio et al., 1989), and the contrast theory (Lynch et al., 1991). The first two are involved in the process of forming the composite concept while the last one is related to the “accommodation process” (i.e., the reciprocal effect).

In this section, we will review previous research results with respect to the attitude change in co-branding and offer four statements for further introducing three main effects (cf. Fig. 2.11), which can cause a change on consumers’ prior attitudes.

3.2.1 The Mutual Effect

The influence resulting from the “product fit” and the “brand fit” is called the “mutual effect” in this study. As mentioned in section 2.3.2, the product fit between the partnering brands has a direct impact on consumers’ attitudes toward the co-brand. Previous research results have shown that if there exists a high product fit (e.g., Park et al., 1996; Simonin and Ruth, 1998), consumers will have a favorable attitude toward the co-brand. Many studies have also used the product fit to construct a theoretical model or to conduct an empirical analysis in the field of co-branding (Boo and Mattila, 2002; Bouten, 2006).

Another important factor is the brand fit. A high fit of brand image (e.g., *Mercedes Benz* with *Louis Vuitton*) is proved to positively influence consumers’ attitudes toward the co-brand (Simonin and Ruth, 1998; Baumgarth, 2004). That is to say, if the consumers perceive a distinct consistency between the images of the allying brands, they will have a favorable attitude toward the co-brand. This consistency can be presented in the positioning strategy (e.g., both brands produce luxury products) or the overall performance (e.g., both brands are compatible in terms of market shares or sales volumes in their respective markets). Based on the findings of previous studies, we can formulate the following statement(s) about the mutual effect:

S_1: *A good (poor) product and brand fit results in a positive (negative) mutual effect and yields a favorable (unfavorable) attitude toward the co-brand.*

3.2.2 The Extension Effect

The prior attitude toward the parent brand is associated with the attitude toward the extended product in the brand extension context (Aaker and Keller, 1990). It can be measured in terms of the perceived quality (Zeithaml, 1988; Aaker and Keller, 1990) and the prior purchase experience (Swaminathan, 2003). That is to say, a high perceived quality or significant prior purchase experience

regarding the parent brands implies a favorable attitude toward them (Aaker and Keller, 1990; Swaminathan, 2003). Hence, “high perceived quality” and “significant prior purchase experience” can be utilized as indicators representing favorable prior attitudes toward a brand. In addition, a significant prior experience can be used as a measure to represent a higher level of brand loyalty (Swaminathan et al., 2001).

Several scholars have argued that the prior attitude plays an important role in the evaluation process of co-branding (Simonin and Ruth, 1998; Boo and Mattila, 2002; Lafferty and Goldsmith, 2005). Among these studies, Simonin and Ruth (1998) claimed that the prior attitude toward one of the partnering brands is positively related to the attitude toward the co-brand and the post-exposure attitude toward that brand. Since co-branding is one type of brand extension, we term the influence resulting from the prior attitude the “extension effect”. Thus, the following two statements can be written down:

S_2: *A favorable (unfavorable) prior attitude toward one of the partnering brands results in a positive (negative) extension effect and yields a relatively favorable (unfavorable) post-exposure attitude toward that brand.*

S_3: *A favorable (unfavorable) prior attitude toward one of the partnering brands results in a positive (negative) extension effect and yields a relatively favorable (unfavorable) attitude toward the co-brand.*

3.2.3 The Reciprocal Effect

The reciprocal effect on the attitude level first appears in the brand extension context (e.g., Aaker and Keller, 1990; Lane and Jacobson, 1997; Swaminathan, 2003) but has been applied to co-branding research as well (Park et al., 1996; Swaminathan, 1999). Different studies use different names to term this effect, such as the feedback effect (Park et al., 1996), the spillover effect (Simonin and Ruth, 1998), and the post-effect (Leuthesser et al., 2003). In this dissertation, the

reciprocal effect is defined as an influence resulting from the attitudes toward the co-brand on each of the allying brands. According to Simonin and Ruth (1998), the reciprocal effect yields a relatively favorable (unfavorable) post-exposure attitude toward each of the partners. Therefore, we conclude the following statement:

S_4: *A favorable (unfavorable) attitude toward the co-brand results in a positive (negative) reciprocal effect and yields a relatively favorable (unfavorable) post-exposure attitude toward each of the partnering brands.*

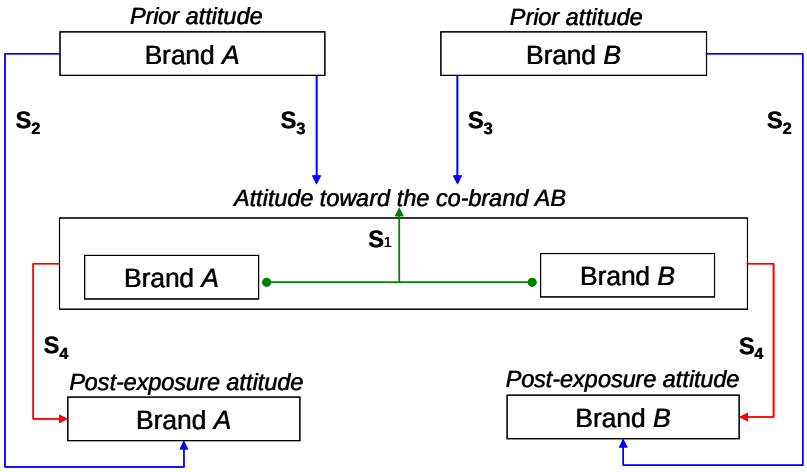
Table 3.1 summarizes previous research findings and the three main effects.

Table 3.1: The summary of three main effects

Main effects	Definition	Previous research results		Statement	Psychological foundations
The mutual effect	The influence resulting from the "product fit" and "brand fit".	The product fit	➢ Consumers will have a favorable attitude toward co-branding if the composite brand holds the complementing attributes(Park et al., 1996). ➢ A high relatedness between the product categories of the partnering brands(Simonin and Ruth, 1998).	➢ S1: A good (poor) product and brand fit results in a positive (negative) mutual effect and yields a favorable (unfavorable) attitude toward the co-brand.	1. information integration (Anderson, 1981) 2. attitude accessibility (Fazio et al., 1989) 3. contrast effect (Lynch et al., 1991)
		The brand fit	➢ Consumers will have a favorable attitude toward co-branding if a consistency exists between the images of the partnering brands (Simonin and Ruth, 1998; Bouten, 2006).		
The extension effect	The influence resulting from the "prior attitude".	The prior attitude	➢ The prior attitude toward the partnering brands is related positively to the consumer's attitude toward co-branding (Simonin and Ruth, 1998; Boo and Mattila, 2002). ➢ The prior attitude toward one the partnering brands is related positively to the postexposure attitude toward the same brand (Simonin and Ruth, 1998).	➢ S2: A favorable (unfavorable) prior attitude toward one of the partnering brands results in a positive (negative) extension effect and yields a relatively favorable (unfavorable) post-exposure attitude toward that brand. ➢ S3: A favorable (unfavorable) prior attitude toward one of the partnering brands results in a positive (negative) extension effect and yields a relatively favorable (unfavorable) attitude toward the co-brand.	
The reciprocal effect	The feedback effect resulting from the attitudes toward co-branding on each of the partnering brands .		➢ A favorable (unfavorable) attitude toward the co-branding will lead to an asymmetric reciprocal effect on each of the partnering brands (Park et al., 1996). ➢ The reciprocal effect will yield a favorable (unfavorable) postexposure attitude toward each of the partnering brands (Simonin and Ruth, 1998).	➢ S4: A favorable (unfavorable) attitude toward the co-brand results in a positive (negative) reciprocal effect and yields a relatively favorable (unfavorable) post-exposure attitude toward each of the partnering brands.	

In conclusion, the process of attitude change can be described as follows: The extension effect and the mutual effect have direct impacts on consumers' attitudes toward the co-brand (cf. S_1 and S_3). Besides, the post-exposure attitude toward each of the allying brands will be affected by both the extension effect and reciprocal effect (cf. S_2 and S_4). Therefore, the possibility that a consumer will change her/his brand attitudes toward each of the partnering brands after the alliance will depend on the strength of the interactions of these considered effects. Fig. 3.2 visualizes this process.

Figure 3.2: A conceptual model of attitude change in co-branding

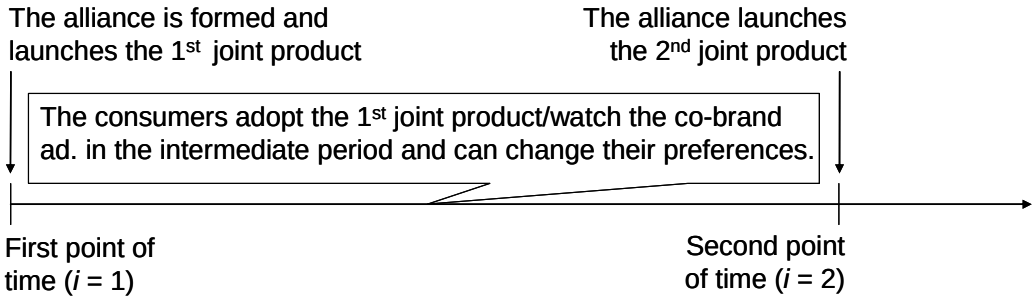


3.3 Analysis of Preference Change in Co-branding

As mentioned above, preferences are formed by the rank order of attitudes (Bass and Talarzyk, 1972). Hence, a change of the attitudes toward the allying brands can also trigger a preference change. To further discuss the latter topic, we assume that several brands (termed *A*, *B* and *Y*, *Z* in the following) exist in the same product class market (or a product category, see p.380, Kotler and Keller, 2006). Moreover, we consider two points of time as well as the intermediate period between both. At the first point of time ($i = 1$), the alliance is formed by brand *A* and *B* and releases the first co-branded product $J_{AB(1)}$. Brand

A and *B* are assumed to stop introducing their own products after the partnership is in effect. At the second point of time (i = 2), the alliance releases the second co-branded product $J_{AB(2)}$. We further assume that preference change occurs only after consumers have purchased the first co-branded product or watched the co-brand advertisements (Simonin and Ruth, 1998) in the intermediate period (i.e., between i = 1 and i = 2), and the consumer preferences at time i = 1 are not affected by co-branding. The sequence of events is summarized in Fig. 3.3.

Figure 3.3: The sequence of events



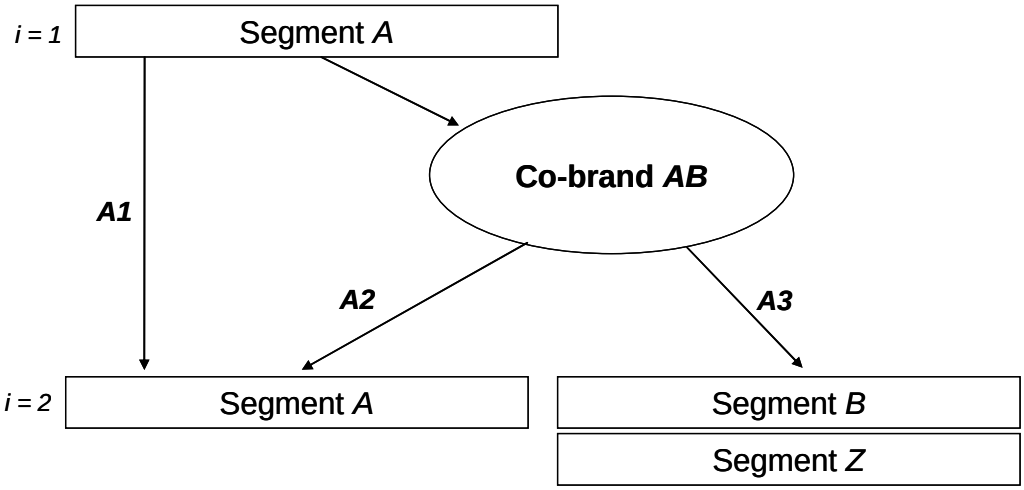
Besides, the considered market is assumed to comprise several market segments. The consumers belonging to one segment prefer one specific brand. Note that here the term “segment” refers to the “preference segment” consisting of a homogeneous group of consumers, who seek similar product benefits (p.245, Mowen and Minor, 1998; p.241, Kotler and Keller, 2006). At the first point of time, we categorize the segments into two groups: One group is composed of those segments preferring the partnering brands (segment *A* and *B*) and the other includes the segments preferring the competing brands (segment *Y* and *Z*). Since the rationale of preference change is identical for each of the segments in the same group, we only focus on the process of preference change in segment *A* and *Z* in the next sections.

3.3.1 The Preference Change in Segment A

To continue our analysis in this section, we have to assume that the consumers in segment *A* have a stable attitude toward brand *B* during the relevant time frame. That is to say, we only consider the reciprocal effect from the co-branded *AB* on brand *A*. This assumption is somewhat similar to the concept of comparative static analysis in economics and it will help us reduce the complexity of the following analysis. We will relax this assumption in Chapter 4. In addition, it should be noted that the co-brand *AB* does not have a reciprocal effect on consumers' attitude toward brand *Z*.

At time $i = 1$ all consumers belonging to segment *A* are assumed to prefer brand *A* and will purchase the first co-branded product in the intermediate period. The preference change in segment *A* can be explained by three routes (see Fig. 3.4).

Figure 3.4: Routes of preference change in segment A



3.3.1.1 Route A1

We argue that a certain fraction of the consumers in segment *A* have a stable preference at time $i = 2$. This stable preference results from their extremely

favorable prior attitude toward brand *A*. In other words, a significant positive extension effect (according to S_2) dominates the evaluation process. Two supporting arguments are provided below.

The first argument is related to brand familiarity, which can be defined as "the number of product-related experiences (product usage) that have been accumulated by consumers" (Alba and Hutchinson, 1987). Based on this definition, those consumers with an extremely favorable prior attitude toward brand *A* also have a significant prior purchase experience regarding this brand.[1] Since brand familiarity can positively moderate the impact of prior attitude on post-exposure attitude (Simonin and Ruth, 1998), a high level of brand familiarity will lead to a stable preference.

The second argument is related to brand loyalty. A favorable prior attitude implies brand loyalty (Dyson et al., 1996). Those consumers who have an extremely favorable prior attitude toward brand *A* can be assumed to be completely loyal to this brand. It is commonly recognized that brand loyalty is highly resistant to change (Blackwell et al., 2005). Therefore, the respective consumers are the most unlikely to change their brand attitudes after experiencing the first co-branded product $J_{AB(1)}$, because they will ignore the potential inconsistent information and defend their well-established attitudes (Smith and Mackie, 2007). Therefore, an extremely favorable prior attitude toward brand *A* results in a stable preference.

3.3.1.2 Route A2 and A3

Although the remaining consumers of segment *A* also have a favorable prior attitude toward brand *A*, their attitudes are more amenable to change compared

[1] As already mentioned, the prior attitude can be measured by prior purchase experience (see Swaminathan, 2003).

to those of the completely loyal consumers (Swaminathan et al., 2001). Hence, at time i = 2, their preferences may stay with brand *A* or switch to another brand depending on the different levels of perceived product and brand fits.

If the respective consumers perceive a better fit from the alliance, a positive mutual effect will exist and, subsequently, the consumers will have a favorable attitude toward the co-brand *AB* (S_1) as well as a positive reciprocal effect toward brand *A* (S_4). The resulting favorable post-exposure attitude implicates that the consumers still prefer brand *A* (route A2).

However, if the consumers perceive a poorer fit, their post-exposure attitudes toward brand *A* will be unclear. The negative mutual effect (originated from a poorer fit), together with the positive extension effect (S_3), will influence their attitude toward co-brand *AB* (S_1). The interplay may generate a favorable or an unfavorable attitude toward the co-brand and yield a positive or negative reciprocal effect (S_4) on brand *A*.

Hence, consumers may still prefer brand *A* (route A2) because the rank order of their attitudes at time 2 is the same as that at time 1. On the other hand, it is also possible that their attitude toward brand *A* is adversely affected and thus the rank order of their brand attitudes changes. In this case, the degree of favorability of brand *A* is lower than other brands and thus the rank order is changing. Finally, their preference is likely to shift to any other competing brand (say, brand *Z*) or to stay with brand *B* (route A3). Table 3.2 summarizes the interaction of the three effects and the preference change in segment *A*.

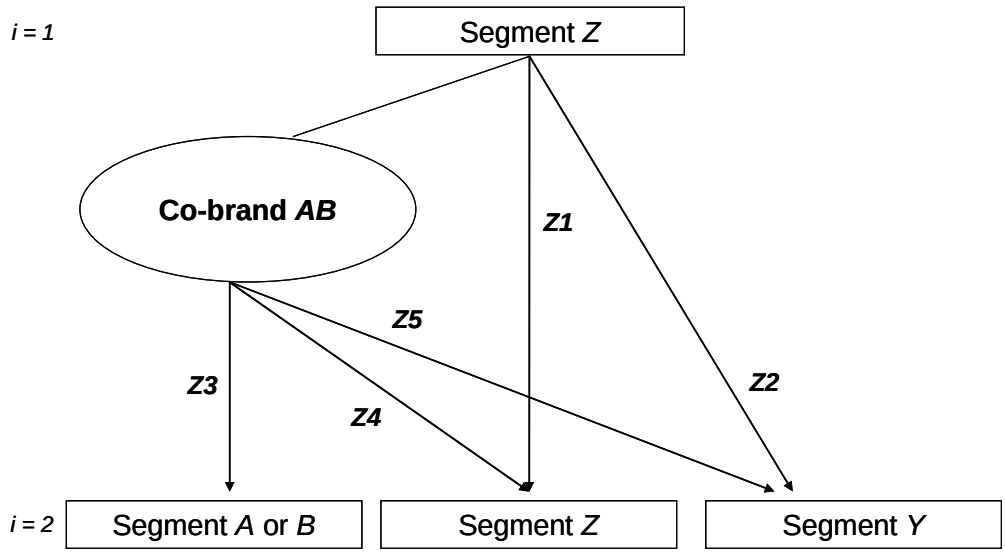
Table 3.2: Preference change in segment A

Route	Extension effect	Mutual effect	Reciprocal effect	Final segment
A1	Highly positive	-	-	Segment *A*
A2	Positive	Positive	Positive	Segment *A*
	Positive	Negative	Positive	Segment *A*
	Positive	Negative	Negative	Segment *A*
A3	Positive	Negative	Negative	Segment *B* (the partner) or Segment *Z* (the competing brand)

3.3.2 The Preference Change in Segment Z

At time $i = 1$, all consumers belonging to segment *Z* have a favorable prior attitude toward brand *Z* and therefore prefer this brand. However, their preferences may also change at time $i = 2$. As shown in Fig. 3.5, we can use five routes to expound the phenomenon of preference change. It should be noted that the reciprocal effect from the co-brand *AB* does not affect the attitude toward brand *Z*.

Figure 3.5: Routes of preference change in segment Z



3.3.2.1 Route Z1 and Z2

We argue that one group of consumers has a habitual buying behavior due to the well-established attitude toward brand *Z*. Hence, these consumers' preferences are stable (route Z1). Besides, some members of segment *Z* are not aware of co-brand *AB* and may shift their preferences to one of the remaining (but not explicitly considered) brands named *Y* in our example due to variety seeking (route Z2).

3.3.2.2 Other Routes in Segment Z

The rest of the consumers in segment *Z* are assumed to watch the co-brand advertisements or to purchase the first co-branded product $J_{AB(1)}$ in the intermediate period. In this case, the possibility of staying with brand *Z* depends on the interaction of the strength of the three main effects. If these consumers have a favorable attitude toward co-brand *AB*, a positive reciprocal effect on one of the allying brands *A* and *B* will exist (S_4). Besides, if these consumers have a favorable prior attitude toward brand *A* (or *B*), they will have a favorable post-exposure attitude toward that brand (S_2). Accordingly, their attitude toward brand *A* (or *B*) will be enhanced and the rank order of the brand attitudes may change. Their preference is likely to stay with brand *A* (or *B*) (route Z3).

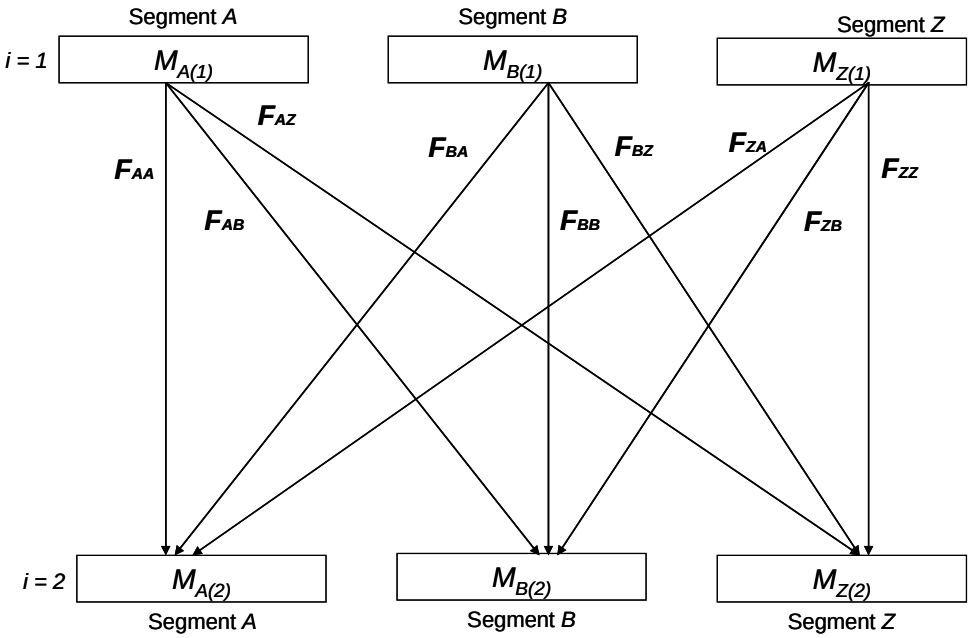
Conversely, if the consumers have an unfavorable attitude toward co-brand *AB*, a negative reciprocal effect will exist and dilute their attitude toward brand *A* and *B*. Thus, their preferences will not stay with brand *A* or *B* at time $t = 2$. In this case, since the consumers' initial preference is brand *Z* and their attitude toward brand *A* (*B*) is diluted at time $t = 2$, they will definitely not stay with brand *A* (*B*). Consequently, depending on the rank order of their attitudes, the preferences may stay with brand *Z* (route Z4) or shift to a different competing brand *Y* (route Z5).

3.3.3 An Application in a Three-brand Scenario

In this section, we apply the results of the above analysis in a three-brand scenario. This scenario will help us present the above analysis more clearly because it is in a relatively simple context (i.e., two partnering brands with only one competing brand). Let us now assume that the market of interest consists of exactly three brands: *A*, *B*, and *Z*. Brand *A* and *B* are supposed to form a co-branding partnership while brand *Z* is the competing brand. Each brand is assumed to be preferred by one preference segment (i.e., the consumers in the same segment have a homogeneous brand preference; e.g., segment *A* prefers *A*), and each consumer prefers only one brand at a certain point of time. Besides, $M_{A(1)}$, $M_{B(1)}$ and $M_{Z(1)}$ denote the sizes of segment *A*, *B* and *Z* at time $i = 1$; $M_{A(2)}$, $M_{B(2)}$ and $M_{Z(2)}$ represent the counterparts at time $i = 2$.

The relation between preference change and segment size can then be explained as follows: Co-brand *AB* is formed at time $i = 1$ and the consumers belonging to the three segments may change their preferences at time $i = 2$. If so, segment size $M_{A(2)}$ of brand *A* will be composed of three parts, namely F_{AA}, F_{BA}, and F_{ZA}. Here, F_{AA} refers to the proportion of consumers who stay with segment *A,* whereas F_{BA} and F_{ZA} denote the proportions of consumers who shift their preferences from brand *B* or *Z* to *A*. The same explanations can be applied to the notations of segment *B* and *Z*. Fig. 3.6 concludes this evolution.

Figure 3.6: Preference change and the evolution of segments



3.4 Implications for Analyzing the Success of Co-branding

3.4.1 Insights for Analyzing the Success of Co-branding

In this section, we demonstrate how our analysis of preference change can provide insights into two prior findings with respect to the success of co-branding.

Drawing from the consumer behavior framework, Leuthesser et al. (2003) have inferred that the co-branding alliance can be successful, if the post-exposure attitudes of their customers toward the allying brands are at least maintained. In our analysis their argument can be validated by measuring the aggregated market size of the partnering brands in Fig. 3.6. That is to say, if the brand attitudes of the consumers in segments *A* and *B* are at least maintained at time 2, the aggregated market size of *A* and *B* will remain the same (i.e., $M_{A(1)} + M_{B(1)} = M_{A(2)} + M_{B(2)}$ holds in Fig. 3.6). In other words, the co-branding

alliance will be successful in terms of the market share (i.e., the aggregated market size is at least the same as it was before the alliance started). In particular, the market share can be even larger if there are some new customers from the competing brand (F_{ZA} and F_{ZB} in Fig. 3.6).

However in reality it is difficult to reinforce or even maintain the post-exposure attitudes toward the allying brands, because co-branding faces a risk generated from an inappropriate match of the partnering brands and a possible negative reciprocal effect: the poorer product or brand fit can influence consumer attitudes towards the co-brand and subsequently some consumers may prefer one of the competing brands (route A3 in Fig. 3.4). Finally, the aggregated customer size will shrink when the alliance is in effect (i.e., a smaller aggregated size as compared with the initial size). To conclude, the effectiveness of co-branding relies heavily on the decision of partner selection (p.1, Hao, 2008).

On the other hand, drawing on the strategic alliance framework, Venkatesh et al. (2000) have argued that the success of co-branding is related to the shift-in preference (F_{AB} and F_{BA} in Fig. 3.6) because this type of preference change offers mutual benefits for the allying brands to exchange consumer preferences in their partnership. This argument has also been confirmed in branding research. Kippenberger (2000) and Leuthesser et al. (2003) have inferred that the shift-in preference offers a benefit for one brand to build up its brand awareness at the other's customer base. For instance, the hypothetical co-branded pizza *Appetite-Bio* can be utilized by *Appetite* to build up its brand awareness in *Bio*'s customer base, and can provide an opportunity for *Bio* to penetrate the customer segment of *Appetite* as well. Without this incentive *Appetite* and *Bio* may not cooperate and thus the alliance may break up.

Furthermore, we find that the underlying reasons behind the shift-in preference are rather complicated. This kind of behavior can be explained by the route A3 in section 3.3.1.2. Route A3 concludes that only those customers, who

are not completely loyal to one of the allying brands (i.e., the extension effect is not strong), are prone to change their brand preference when a poorer fit brings about a negative reciprocal effect. Therefore, the emergence of the shift-in preference is a consequence resulting from the interactions of several psychological factors in consumer evaluation.

To sum up, our systematic analysis of preference change in the current chapter is robust, because we can use the results to provide insights either for the strategic alliance framework or for the consumer behavior framework. Since this study attempts to adopt the top-down approach for including more behavioral contents into the framework of strategic alliance, both insights are equally important to the following analysis.

3.4.2 A Suggestion for the Following Analysis in this Dissertation

The present chapter provides a better understanding of the shift-in preference by relating it to attitude change, but we do not intend to examine further the relation between attitude change and co-branding success. Instead, due to the following two reasons, we suggest that the effectiveness of co-branding should be analyzed from the "basic unit" of consumer evaluation, namely the attribute beliefs.

First, as indicated in section 3.4.1, the rationale behind the shift-in preference is associated with the concept of "fit", and the judgment of fit is usually connected to a deeper level of consumer evaluation: brand associations and beliefs (Grime et al., 2002). In the field of brand extension, a better fit indicates that a consistency (similarity) exists between the existing product and the extended product (Aaker and Keller, 1990; Keller and Aaker, 1992; Sunde and Brodie, 1993). In that case the extension is considered logical and congruent with the parent brand (Tauber, 1981) and consumers are likely to generate strong brand associations and to transfer their existing beliefs to the extended product (Sheinin, 2000). The above findings explain why consumers' attitudes toward the

extended products are positively influenced by a better fit.

But in the co-branding context, the evaluation of co-branding is a process of transfer of attribute beliefs from the allying brands (Park et al., 1996). That is to say, the judgment of fit is also related to the comparison of attribute beliefs between each of the allying brands (Park et al., 1996; Geylani et al., 2008). Therefore the current analysis of attitude change cannot provide an accurate and detailed explanation of how consumers deal with the comparison of attribute beliefs, and an investigation of the shift-in preference on the belief level is indispensable. In addition, defining the fit on the belief level is also beneficial for us to analyze the particular type of co-branding alliances discussed in this study – "functional co-branding alliances" – because we can use the attribute beliefs to formulate the different characteristics of the two brands (see section 2.2.3).

Secondly, in contrast to the reciprocal effect on the attitude level, we want to address the importance of the reciprocal effect on the belief level. In the brand extension literature researchers have claimed that the feedback effect occurs both on the attitude (see section 3.2.3) and belief levels (e.g., Loken and Roedder John, 1993; Park et al., 1993; Roedder John et al., 1998; Milberg, 2001). The feedback effect can be positive on the attitude level (e.g., Aaker, 1990), when an extension is introduced with a good fit, or can be negative on the belief level (i.e., belief dilutions, see Loken and Roedder John, 1993), if there is a lower level of similarity between the beliefs of the extended products and the existing beliefs. Besides, a recent study (p.48, Sheinin, 2000) has argued that the belief dilutions (or enhancements) are likely to lead to respective attitude changes because attitudes are based on underlying beliefs (Fishbein and Ajzen, 1975). However, in the field of co-branding, we find that very little effort has been dedicated to the reciprocal effects on the belief level (see Hillyer and Tikoo, 1995; Geylani et al., 2008). Therefore we can make a distinct contribution to the co-branding field by filling this research gap.

Following this the next step of our study is to investigate the rationale behind the shift-in preference on the belief level, and to focus on the influences of belief revisions on the success of co-branding. In addition, this research strategy is in line with one research suggestion of Venkatesh et al. (2000), who have reported that one of the ways to extend their research is to give different characteristics (e.g. characterizing by different attribute beliefs) to the allying brands and to re-examine the necessary condition for a successful co-branding.

Now the question is, which approach (i.e., quantitative or qualitative) will be adopted in our analysis. As discussed in section 2.3.3, currently there exists a limited amount of mathematical modeling work on the topics of co-branding success (see p.49, Huber, 2005); extant research with respect to the success of co-branding is usually conducted either by proposing a qualitative model (e.g., Leuthesser et al., 2003; Helmig et al., 2008) or by experiments (e.g., Park et al., 1996; Simonin and Ruth, 1998). Similarly, among several studies working on belief revision in the co-branding context, the Geylani et al.'s (2008) work is the only one to use a mathematical model for explaining how consumers perceive the fit and update their beliefs. Therefore using a mathematical modeling approach to connect co-branding success with the belief revisions can bridge this gap and can also advance our knowledge by providing a concrete measure to predict the outcome.

3.5 Limitations and Future Research Opportunities

To conclude, the current chapter presents the casual relationship between the important factors of preference change and, to our knowledge, this chapter is the first study to systematically analyze preference change in the context of co-branding. However, there are three limitations needed to be mentioned.

First of all, the impact of the brand order is not fully considered in our analysis (e.g., *Sony-Ericsson* or *Ericsson-Sony*). Park et al. (1996) has stated that the header brand (*Sony* in *Sony-Ericsson*) may experience a larger positive

reciprocal effect than the modifier brand (e.g., *Ericsson* in *Sony-Ericsson*) (see section 2.3.2). Future research should address this issue since we expect that the position may also have impacts on consumer preferences.

Furthermore, we did not discuss the role that brand familiarity plays in consumer evaluation of co-branding. Simonin and Ruth (1998) concluded that the brands with different levels of familiarity make unequal contributions to the formation of the composite concept and receive asymmetric reciprocal effects. One can then use the level of brand familiarity as a moderator when measuring each brand's contributions to the alliance and the reciprocal effect.

Finally, we did not address the fit of product category between the current and the co-branded products because the products of a functional co-branding alliance stem from the same product categories (e.g., *Appetite* and *Bio*). Hence, the fit should be high.

Chapter 4

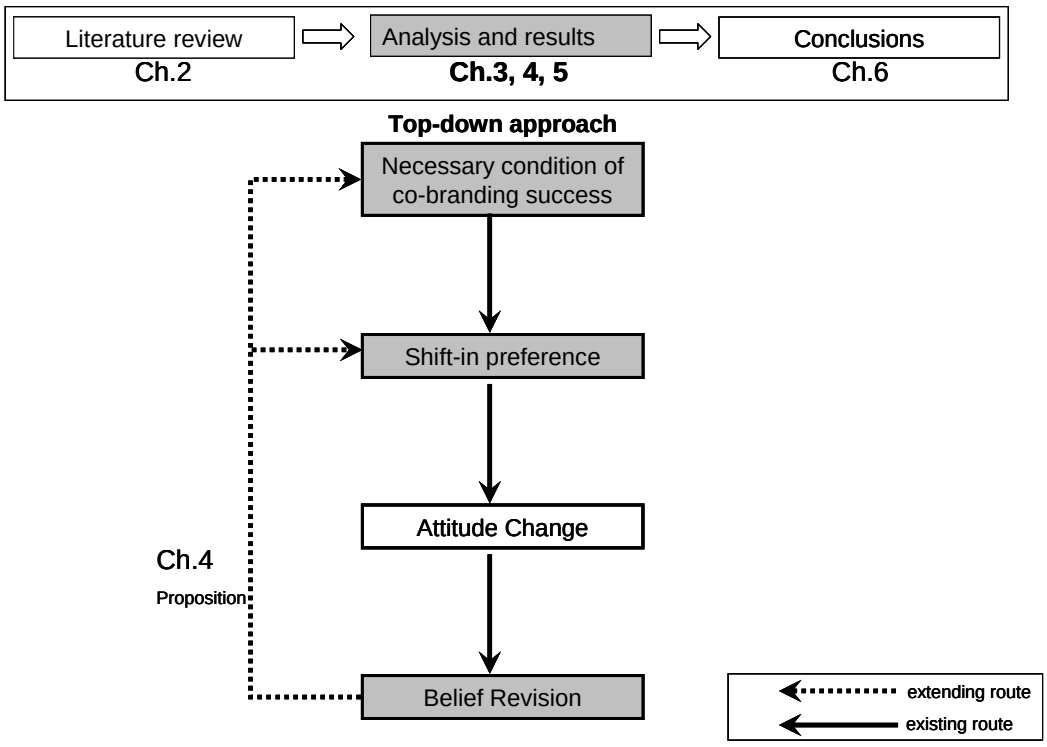
A Model of Belief Revision and the Success of Co-branding

The aim of this chapter is to quantify the impacts of belief revision on co-branding success. Our work in this chapter is also congruent with one of the suggestions of Venkatesh et al. (p.24, 2000). We are going to begin with a model adaptation by using two product-related attributes to characterize the allying brands. We then formulate how the existing attribute beliefs about each of the partnering brands merge and transfer to the co-branded products, and how the beliefs about the joint product reflect back to the existing beliefs. Finally, we will show how the relative magnitude of belief revision affects the amount of required market expansion (i.e., the necessary condition for co-branding success).

This chapter is structured as follows. In section 4.1, we will offer a brief review of the Venkatesh et al. (2000) model. In section 4.2, we will formulate the mechanism of belief revision and add this mechanism to the Venkatesh et al. (2000) model. In section 4.3, we will provide four propositions to show the influences of belief revision and additionally conclude two decision rules of partner selections. In section 4.4, we will offer three marketing implications and discuss five limitations in our mathematical model.

The position of this chapter in this dissertation is shown in Fig. 4.1.

Figure 4.1: The position of chapter 4



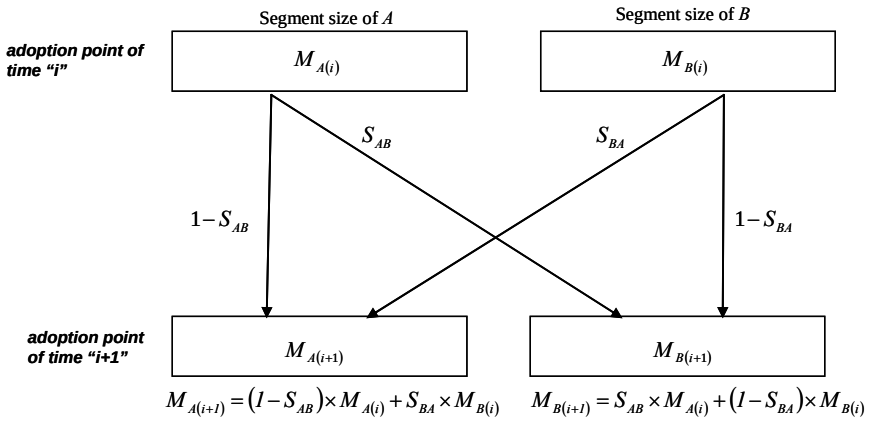
4.1 A Review of the Venkatesh et al. (2000) Model

By referring to the Bass (1969) diffusion model, Venkatesh et al. (2000) built up a dynamic framework to investigate the necessary condition of alliance success. In their model, two brands (celebrity performers, e.g., singers), *A* and *B*, are the prospective partners in a mid-term co-branding alliance. Initially, at time $i = 1$ (with $i = 1,2,3,\ldots,I$), the market comprises two segments of sizes $M_{A(1)}$ and $M_{B(1)}$ that prefer *A* and *B*, respectively. Note that here the term "segment" refers to the "preference segment" consisting of a homogeneous group of consumers, who seek similar needs and benefits (p.241, Kotler and Keller, 2006). In the field of marketing the relative size of different preference segments is often regarded as the measure of "market share" (cf. Hauser and Shugan, 1983). In the baseline situation (i.e., before the alliance is formed), each consumer at segment *A* (*B*) is assumed to adopt the product $J_{A(i)}$ ($J_{B(i)}$) at time *i*, and hence

the potential market size for $J_{R(i)}$ is $M_{R(i)}$, where $M_{R(i)} = M_{R(1)}$ ($R \in \{A, B\}$ and indicates the allying brands).

If the alliance is in effect (see Fig. 4.2), it will release the *i*-th joint product $J_{AB(i)}$ at time *i*, and each of the consumers who prefer *A* or *B* is assumed to adopt one unit of $J_{AB(i)}$ (accordingly, the total market size is at least $M_{A(1)} + M_{B(1)}$) during the intermediate period between time *i* and *i+1*. The authors further argued that, at time *i+1*, the consumers initially belonging to segment *A* (*B*) may change their preference to *B* (*A*) due to their consumption experiences from $J_{AB(i)}$. Therefore, the segment size of *A* can change from $M_{A(i)}$ to $(1-S_{AB})\times M_{A(i)} + S_{BA} \times M_{B(i)}$ and the segment size of *B* can change from $M_{B(i)}$ to $S_{AB} \times M_{A(i)} + (1-S_{BA})\times M_{B(i)}$, where S_{AB} and S_{BA} represent the proportions of consumers who shift their preference from *A* to *B* and from *B* to *A*, respectively (i.e., the shift-in ratios).

Figure 4.2: The evolution of alliance in Venkatesh et al. (2000)



The Venkatesh et al. (2000) study is mainly based on four assumptions: (1) the segments are not overlapping and each consumer prefers only one brand at each time point, (2) the consumers will not shift their preferences to a third player within the relevant periods, (3) the shift-in ratios are modeled as time-independent variables, and (4) as already mentioned in section 2.3.1, each of the players will split the (sales) revenue of the joint products according to its

share of preference at each time point.

The authors further reported that, eventually, the share of preference will change from $M_{R(1)}/(M_{A(1)}+M_{B(1)})$ at the beginning of the alliance to an equilibrium level (hereafter, the equilibrium share) of $S_{BA}/(S_{AB}+S_{BA})$ for A and $S_{AB}/(S_{AB}+S_{BA})$ for B. That is to say, one of the partners can be a loser in the partnership when its equilibrium share is smaller than its initial share. In other words, the weak partner has to acquire more consumers from outside the alliance (i.e., requiring a certain amount of market expansion) to maintain its original revenue level (cf. Appendix A.1). This type of market expansion is regarded as the necessary condition for a successful alliance formation. As a consequence thereof, the alliance may break up if the anticipated amount of expansion is not forthcoming. The sufficient amount of required expansion (denoted by ΔM) is expressed as:

$$\Delta M \geq Max\left\{M_{A(1)}\left(\frac{S_{AB}}{S_{BA}}\right)-M_{B(1)}, M_{B(1)}\left(\frac{S_{BA}}{S_{AB}}\right)-M_{A(1)}\right\} \quad \text{for} \quad S_{AB,}\, S_{BA} \neq 0\,. \quad (4.1)$$

4.2 An Extension of the Venkatesh et al. (2000) Model

We keep the above assumptions (1), (2), and (4), but additionally consider the shift-in ratio as a function of parameters that capture the mechanism of the belief revision. In the following we will concretize this mechanism and re-examine equilibrium shares as well as the necessary condition – the amount of required expansion.

4.2.1 Aspects of the Market Structure

We consider a specific product category (e.g., coffee, car, soft drinks, pizza, mobile) consisting several firms (cf. Balachander and Stock, 2009). We assume that each firm produces only one type of product, which is branded by using each firm's name (e.g., *BenQ* computer monitors). Besides, we suppose that

price is equal for all the brands (products). So, the only difference among all the brands is the different perceived performance level of product-related attributes (e.g., tastes, shapes, colors). Two firms (or brands), named *A* and *B*, are the prospective partners to form a "functional co-branding alliance" (see section 2.2.3). At time *i*, each of the two brands either releases its own product $J_{R(i)}$ if the alliance is not formed or cooperates with each other to release the *i*-th joint product $J_{AB(i)}$.

Similar to Venkatesh et al. (2000), we assume that initially the market of interests has two preference segments of sizes $M_{R(1)}$ ($M_{R(1)} > 0$) that prefer *A* and *B*, respectively. However, different from Venkatesh et al. (2000), we name the initial members of segment *A* (*B*) group *a* (*b*) and assume that *a* (*b*) is more familiar with *A* (*B*) than *B* (*A*) within the relevant time periods. In a broader sense group *a* (*b*) can be viewed as the loyal customers of *A* (*B*). If we use $M^{G}_{R(1)}$ to denote the customer size of *G* ($G \in \{a, b\}$ and indicates groups), who stay with brand *R* at time 1, then $M_{A(1)} = M^{a}_{A(1)}$ and $M_{B(1)} = M^{b}_{B(1)}$ holds.

In short, the adapted model keeps the spirit of the Venkatesh et al. (2000) model but, as Fig. 3.3 demonstrates, specifies the events that occur during the intermediate period between the first and second time points – preference change.

4.2.2 Formation of Initial Preferences

We will apply the expectancy-value model[1] (Bass and Talarzyk, 1972; Fishbein and Ajzen, 1975) to formulate consumer preference, since it has been widely recommended for explaining preference formation (Roberts and Morrison, 2002; Agarwal and Malhotra, 2005). Note that the expectancy-value model is categorized into compensatory preference models (p.89, Lilien et al., 1992), which suggest that the weakness of one attribute can be compensated by

[1] Throughout this chapter, we assume that consumers are highly involved in the process of evaluation and thus they have a deeper processing toward the evaluated object. Our assumption is suitable for the use of the expectancy-value model (p.125, Hillyer and Tikoo, 1995; p.200, Kotler and Keller, 2006).

the strength of another. In contrast to the compensatory model, the non-compensatory model (e.g., conjunctive model (Urban and Hauser, 1993), lexicographic model (Gigerenzer and Goldstein, 1996)) claims that the shortcoming of one attribute cannot be compensated by the strength of the other attributes.

Two relevant product-related attributes, *x* and *y*, are used to characterize brand *A* and *B*. The preference of group *G* at time *i* is formulated as a relative score composed of group *G*'s relative weights of attribute importance $w^{K,G} > 0$ ($K \in \{x, y\}$ and indicates attributes), and group *G*'s belief of each attribute of each brand $P_{R(i)}^{K,G} > 0$ (for notational simplicity, we will not specify each element for attributes, groups, and brands in the remaining of this dissertation). By the expectancy-value model, *G*'s preference score $\Phi_{R(i)}^{G}$ can be expressed as:

$$\Phi_{R(i)}^{G} = \sum_{K} w^{K,G} \times P_{R(i)}^{K,G} \ . \tag{4.2}$$

Practically, $w^{K,G}$ can be measured by asking a representative sample of consumers to divide 100 points between the two attributes, according to how important each attribute is to them. The number of points assigned to each attribute can be used as an indicator of the relative importance of that attribute (Wilkie and Pessemier, 1973; Mackenzie, 1986). Besides, $P_{R(i)}^{K,G}$ can be represented by the perceived levels that a specific attribute possesses (Wilkie and Pessemier, 1973; Lilien et al., 1992), and can be measured by rating scores in a fixed interval (e.g., from 0 to 100, see Geylani et al., 2008). In addition, the assumption underlying this type of rating method is a "the-more-the-better" attribute nature (Shocker and Srinivasan, 1979). That is to say, the attributes in our model, *x* and *y*, are assumed to be good attributes. In other words, for each attribute consumers prefer more to less. For example, laptops may be described on two dimensions like "power" and "ease of use" where consumers always prefer "more powerful" and "easier to use". Our setting here is consistent with Horsky and Nelson (1992) and Vandenbosch and Weinberg (1995). In contrary to

our the-more-the-better nature, the "idea-point" model (e.g., Lehmann, 1971; Carpenter and Nakamoto, 1989) assumes that, for some attributes (e.g., the width of a car), consumers may get negative utility values if the perceived attribute level is beyond a specific level (the ideal-point).

In the following sections, we will deal with three types of attribute beliefs: (1) pre-alliance beliefs about the partnering brands (hereafter, pre-alliance beliefs), (2) the beliefs about the first co-branded product (hereafter, co-branding beliefs), and (3) post-alliance beliefs about the partnering brands (hereafter, post-alliance beliefs).

4.2.2.1 Pre-alliance Beliefs

Let us further assume that the consumers belonging to different groups have identical pre-alliance beliefs (i.e., $P_{R(1)}^{K,G} = P_{R(1)}^{K}$ holds), and that attribute x is salient to A whereas y is salient to B. Hence, the initial attribute level of x (y) of A (B) can be assumed to be larger than the initial (i = 1) level of x (y) of B (A)[2]:

$$P_{A(1)}^{x} > P_{B(1)}^{x}, \tag{4.3}$$

$$P_{B(1)}^{y} > P_{A(1)}^{y}. \tag{4.4}$$

Besides, let D^K denote the initial attribute-level difference of attribute K between A and B. Hence,

$$D^{x} = P_{A(1)}^{x} - P_{B(1)}^{x}, \tag{4.5}$$

$$D^{y} = P_{B(1)}^{y} - P_{A(1)}^{y}. \tag{4.6}$$

Furthermore, the differences of each attribute are assumed to be the same. That is to say,

[2] Our setting can be referred to Geylani et al. (2008). They posited that an attribute, which is salient to one brand, usually has a better performance than the performance of the same attribute of other brands.

$$D = D^x = D^y . \tag{4.7}$$

Eq. (4.7) is motivated from Geylani et al. (p.736, 2008), who also assumed an equal attribute-level difference in their experiment conditions (see Table A.1 in Appendix A.2). With Eq. (4.7) we can also use the updating parameters to capture the magnitude of the belief revision. As suggested by Park et al. (1996) and Geylani et al. (2008), we use the initial attribute-level difference to define the fit between the partnering brands.[3]

Definition 4.1 (the fit)

When the initial attribute-level difference is positive (i.e., $D > 0$), there exists a better fit (complementarity); when the initial attribute-level difference is zero (i.e., $D = 0$), there exists a poorer fit (similarity).

We will assume that a better fit exists in the following sections and the case of similarity will be discussed only in section 4.3.2.

4.2.2.2 Relative Weight of Attribute Importance

Group G's relative weight of attribute importance of attribute K is quantified as $w^{K,G} \in (0,1)$, and we can use the following relationships of $w^{K,G}$ to capture the between-group heterogeneity:

$$w^{x,a} > w^{y,a}, \text{ where } \sum_K w^{K,a} = 1, \tag{4.8}$$

$$w^{y,b} > w^{x,b}, \text{ where } \sum_K w^{K,b} = 1 . \tag{4.9}$$

Eqs. (4.8) and (4.9) show that group a considers attribute x to be more

[3] Please note that, as we will see later, preference change can occur when there exists a good fit. The setting here is different from route A2 in section 3.3.1.2 because, in that case, we simply assume that the consumers cannot change their attitudes towards two allying brands simultaneously and here we relax that assumption.

important and group *b* concerns *y* more.

Finally, Eqs. (4.2) and (4.7) together with the inequalities (4.8) and (4.9) imply

$$\Phi^{a}_{A(1)} > \Phi^{a}_{B(1)}, \tag{4.10}$$

$$\Phi^{b}_{B(1)} > \Phi^{b}_{A(1)}. \tag{4.11}$$

The inequalities (4.10) and (4.11) explain why the initial preference of group *a* (*b*) is brand *A* (*B*).

4.2.3 Mechanism of Belief Revision

We now address what happens to the consumers when (after) they experience the first co-branded product. It is known that product experience causes consumers to revise their existing beliefs (Sheinin, 2000) and the revision process is complicated in co-branding (James, 2005) – a combination and a modification.

Co-branding involves a cooperative relation between two brands. Hence, for the consumers, co-branding actually represents the new and relevant information relative to the allying brands: “new” because the co-branded product is regarded as a new product (Hadjicharalambous, 2006) and “relevant” because co-branding combines two existing brands’ names. The information then causes consumers to transfer and merge their existing associations with the allying brands to co-branding beliefs (Park et al., 1996; James, 2005; Geylani et al., 2008).

As shown in section 2.2.3, the co-branded products released from a functional co-branding alliance usually possess a set of complementing attributes (i.e., $D > 0$). However, the complementarity also shows the incongruent attribute information (Park et al., 1996; James, 2005). Consequently, the inconsistent information has two effects on consumer evaluations: (1) consumers will have

confusions about the true levels of the co-branded products (Park et al., 1996) and (2) consumers will modify their pre-alliance beliefs (Geylani et al., 2008), and this modification is related to the model of accommodation (Park et al., 1993; Thorbjørnsen, 2005). Both effects will be discussed in this subsection.

4.2.3.1 Co-branding Beliefs

Co-branding beliefs $J_{AB(1)}$ can be modeled as:

$$P^x_{AB(1)} = \lambda^x_A \times P^x_{A(1)} + \lambda^x_B \times P^x_{B(1)} + \varepsilon, \text{ where } \lambda^x_R \in [0,1] \text{ and } \sum_R \lambda^x_R = 1, \qquad (4.12)$$

$$P^y_{AB(1)} = \lambda^y_A \times P^y_{A(1)} + \lambda^y_B \times P^y_{B(1)} + \varepsilon, \text{ where } \lambda^y_R \in [0,1] \text{ and } \sum_R \lambda^y_R = 1. \qquad (4.13)$$

By the theory of information integration (Anderson, 1981), pre-alliance beliefs are integrated into co-branding beliefs (James, 2005; Geylani et al., 2008). Therefore, in Eqs. (4.12) and (4.13), λ^K_R denotes the relative contributing weight of each attribute of each brand to co-branding beliefs.[4] Besides, a random term ε is added to represent the confusions about the true attribute levels (i.e., attribute uncertainty) of the first co-branded product.[5]

Hence, co-branding beliefs are represented by the weighted average of pre-alliance beliefs plus the confusion ε. We further assume that ε is uniformly distributed on the interval $[-\theta, \theta]$. The setting of the interval can be referred to Geylani et al. (2008), who also assumed that beliefs are symmetrically distributed around the mean. Here the symmetry of co-branding beliefs (cf. Eqs. (4.12) and (4.13)) is managed by assuming that the parameters of the uniform distributions are the "additive inverses" of each other. Besides, the uniform distribution is utilized to easily obtain analytical results on the shift-in ratios (i.e., $S^a_{AB(1)}$ and $S^b_{BA(1)}$) in section 4.2.4. Moreover, we assume

[4] We assume that the actual attribute levels of the first joint product are a convex combination of the existing beliefs of the partnering brands (i.e., by deleting the confusion term in Eqs. (4.12) and (4.13)). The formulation here is motivated from Geylani et al. (2008).

[5] In our model, we do not separately discuss consumers' confusions about *x* and *y*. Instead, we assume that all the consumers have the same confusion about the attribute beliefs of co-branded product. We will relax this assumption in scenario 5-4 in chapter 5.

that $\theta(D)$ is strictly increasing in *D*, because confusions are positively related to the magnitude of the initial attribute-level difference (cf. p.732, Geylani et al., 2008), so

$$\theta(D) = \delta D\,, \tag{4.14}$$

where δ is a confusion parameter and $\delta \in$ (0, 1/2). Here, the upper limit of δ ensures that both *x* of *A* and *y* of *B* have a negative revision (see Eqs. (4.20) and (4.23)) and both *y* of *A* and *x* of *B* have a positive revision (see Eqs. (4.21) and (4.22)). The rationale behind the negative and positive revisions will be provided in section 4.3.1.

If we posit that both brands contribute the same (i.e., λ_R^K = 1/2) to co-branding beliefs, Eqs. (4.12) and (4.13) can be written as:

$$P_{AB(1)}^{x} = \frac{1}{2}\left(P_{A(1)}^{x} + P_{B(1)}^{x}\right) + \varepsilon\,, \tag{4.15}$$

$$P_{AB(1)}^{y} = \frac{1}{2}\left(P_{A(1)}^{y} + P_{B(1)}^{y}\right) + \varepsilon\,. \tag{4.16}$$

Followed by Eq. (4.7) and making suitable algebraic manipulations in Eqs. (4.15) and (4.16), $P_{AB(1)}^{K}$ can be given by

$$P_{AB(1)}^{x} = P_{A(1)}^{x} - \frac{1}{2}D + \varepsilon = P_{B(1)}^{x} + \frac{1}{2}D + \varepsilon\,, \tag{4.17}$$

$$P_{AB(1)}^{y} = P_{A(1)}^{y} + \frac{1}{2}D + \varepsilon = P_{B(1)}^{y} - \frac{1}{2}D + \varepsilon\,. \tag{4.18}$$

4.2.3.2 Post-alliance Beliefs

Post-alliance (i.e. at time *i* = 2) beliefs about the partnering brands for the consumer group *G* can be given by

$$P_{R(2)}^{K,G} = \gamma_R^{K,G} \times P_{AB(1)}^{K} + \left(1 - \gamma_R^{K,G}\right) \times P_{R(1)}^{K}, \text{ where } \gamma_R^{K,G} \in [0,1]. \tag{4.19}$$

As mentioned earlier, the rationale behind Eq. (4.19) is associated with the

model of accommodation: co-branding beliefs are linked with pre-alliance beliefs and a revision of pre-alliance beliefs exists. The updating weight, $\gamma_R^{K,G}$, determines the degree of revisions.

Substituting $P_{AB(1)}^{K}$ from Eqs. (4.17) and (4.18) into Eq. (4.19) yields Eqs. (4.20) to (4.23), which show each group's belief revision of each of the attributes of the allying brands:

$$P_{A(2)}^{x,G} = P_{A(1)}^{x} - \frac{1}{2}\gamma_A^{x,G} D + \gamma_A^{x,G}\varepsilon\,, \tag{4.20}$$

$$P_{A(2)}^{y,G} = P_{A(1)}^{y} + \frac{1}{2}\gamma_A^{y,G} D + \gamma_A^{y,G}\varepsilon\,, \tag{4.21}$$

$$P_{B(2)}^{x,G} = P_{B(1)}^{x} + \frac{1}{2}\gamma_B^{x,G} D + \gamma_B^{x,G}\varepsilon\,, \tag{4.22}$$

$$P_{B(2)}^{y,G} = P_{B(1)}^{y} - \frac{1}{2}\gamma_B^{y,G} D + \gamma_B^{y,G}\varepsilon\,. \tag{4.23}$$

4.2.4 Ratio of Shift-in Preference

The differences between pre-alliance and post-alliance beliefs result in the shift-in preference of each group. Assuming $S_{AB(1)}^{a}$ to be the probability of group *a*'s consumers shifting their preferences from *A* to *B* after having consumed the first joint product:

$$S_{AB(1)}^{a} = Pr\left(\Phi_{B(2)}^{a} > \Phi_{A(2)}^{a}\right), \text{ where } Pr(\bullet) \text{ is a probability function.} \tag{4.24}$$

Substituting $\Phi_{R(i)}^{a}$ from Eq. (4.2) into Eq. (4.24) yields

$$S_{AB(1)}^{a} = Pr\left(w^{x,a} P_{B(2)}^{x,a} + w^{y,a} P_{B(2)}^{y,a} > w^{x,a} P_{A(2)}^{x,a} + w^{y,a} P_{A(2)}^{y,a}\right). \tag{4.25}$$

Similarly, $S_{BA(1)}^{b}$ denotes the probability of preference change for an individual at group *b* and is expressed as:

$$S_{BA(1)}^{b} = Pr\left(\Phi_{A(2)}^{b} > \Phi_{B(2)}^{b}\right). \tag{4.26}$$

Replacing $\Phi_{R(i)}^{b}$ in Eq. (4.26) by Eq. (4.2), we get

$$S^{b}_{BA(1)} = Pr\left(w^{x,b}P^{x,b}_{A(2)} + w^{y,b}P^{y,b}_{A(2)} > w^{x,b}P^{x,b}_{B(2)} + w^{y,b}P^{y,b}_{B(2)}\right). \quad (4.27)$$

Indeed, the probability measures $S^{a}_{AB(1)}$ and $S^{b}_{BA(1)}$ also represent the expected ratio of the shift-in preference of group *a* and *b*, respectively.

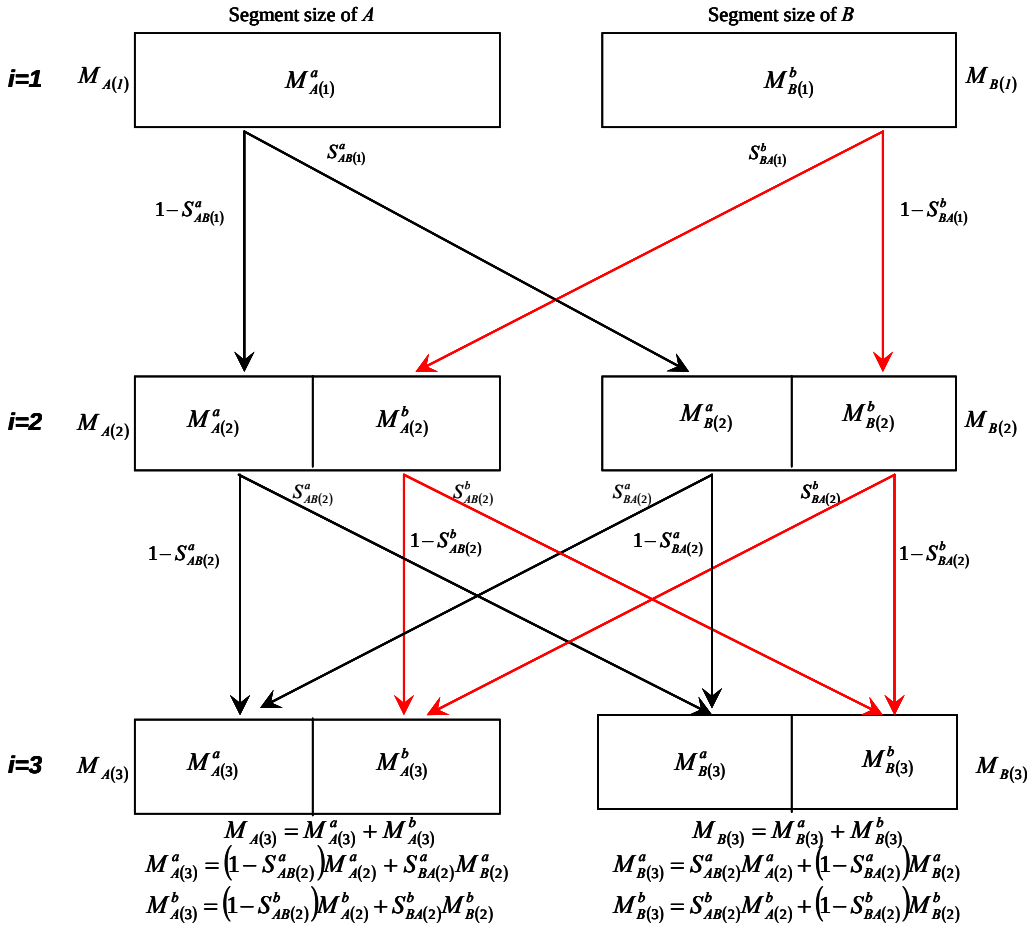
4.2.5 The Equilibrium Share and the Necessary Condition

Since we formulate the shift-in ratio as a function, our dynamical structure is different from Venkatesh et al. (2000) (cf. Fig. 4.2). We show the structure in Fig. 4.3 and explain the details of deriving the necessary condition as follows. According to our setting, from $i = 2$, each segment consists of the members from *a* and *b*, two sub-segments (e.g., $M_{A(2)} = M^{a}_{A(2)} + M^{b}_{A(2)}$ and $M_{B(2)} = M^{a}_{B(2)} + M^{b}_{B(2)}$). Hence, our model can be considered to have two independent dynamical systems[6] – the evolutions of *a* (i.e., the state variables are $M^{a}_{A(i)}$ and $M^{a}_{B(i)}$) and *b* (i.e., the state variables are $M^{b}_{A(i)}$ and $M^{b}_{B(i)}$).

For example, as shown in Fig. 4.3, the evolution of *a* during the second intermediate period (i.e., between time 2 and time 3) can be explained as follows: A proportion $S^{a}_{AB(2)}$ of the $M^{a}_{A(2)}$ consumers shift their preference to *B* while the remaining $\left(1-S^{a}_{AB(2)}\right)\times M^{a}_{A(2)}$ consumers still stay with *A*. By the same token, a proportion $S^{a}_{BA(2)}$ of the $M^{a}_{B(2)}$ consumers change their preference to *A* and a total amount of $\left(1-S^{a}_{BA(2)}\right)\times M^{a}_{B(2)}$ consumers stay with *B*. Finally, $M^{a}_{A(3)}$ and $M^{a}_{B(3)}$ will equal $\left(1-S^{a}_{AB(2)}\right)\times M^{a}_{A(2)} + S^{a}_{BA(2)}\times M^{a}_{B(2)}$ and $S^{a}_{AB(2)}\times M^{a}_{A(2)} + \left(1-S^{a}_{BA(2)}\right)\times M^{a}_{B(2)}$, respectively. The above process builds up also during the third intermediate period and hereafter. Therefore, to derive the equilibrium share of each brand, the steady states of $M^{a}_{A(i)}$, $M^{b}_{A(i)}$, $M^{a}_{B(i)}$, and $M^{b}_{B(i)}$ must be identified.

[6] To our knowledge, we do not alter the underlying stochastic diffusion pattern behind the two-dimension discrete dynamical system in Venkatesh et al. (p.10, 2000). We simply adapt their model to separate the customers into two groups (i.e., giving different characteristics to each segment), and hence we have two such dynamical systems.

Figure 4.3: The evolution of alliance from i = 1 to i = 3



We now need two more assumptions to reduce the complexity of our analytical results. First, we assume that two brands are equally reputed in terms of the segment size (see p.6, Venkatesh et al., 2000), so $M_{A(1)} = M_{B(1)} = M$. Please note that the equal segment size of two brands is just a benchmark. In section 5.2.3, we will offset this assumption. Secondly, we assume that the consumers have a "static updating" structure when they evaluate co-branding. That is to say, the belief revision only occurs after they have adopted the first co-branded product (i.e., between time 1 and time 2). This assumption is based on the need of parsimony and a second very important reason, namely the lack of a theoretical and empirical confirmation. We find that previous studies in

co-branding discuss the belief revision only in the context of "static updating" (i.e., pre- and post-alliance, see Hillyer and Tikoo, 1995; James, 2005; Geylani et al., 2008). Although a number of studies have argued that consumers can continuously update their beliefs because of attribute learning during different periods (e.g., Erdem and Keane, 1996; Rust et al., 1999), all of them are not conducted in the context of co-branding. Since the process of belief revision in co-branding is more complicated than in other new product development strategies, it is not rigorous for us to apply the "dynamic" concept without further confirmations from related research in co-branding field.

Based on the second assumption, from the second time point, the perceived level of each attribute of each brand will be fixed and, by applying Eqs. (4.25) and (4.27), $S^a_{AB(1)} = S^a_{AB(i)} = \left(1 - S^a_{BA(i)}\right)$ and $S^b_{BA(1)} = S^b_{BA(i)} = \left(1 - S^b_{AB(i)}\right)$ hold when $i \geq 2$.[7] Hence, the equilibrium of $M^a_{A(i)}$, $M^a_{B(i)}$, $M^b_{A(i)}$, and $M^b_{B(i)}$ will be reached at time 2: the steady state of $M^a_{A(i)}$ and $M^a_{B(i)}$ will be $\left(1 - S^a_{AB(1)}\right) \times M$ and $S^a_{AB(1)} \times M$, respectively; the steady state of $M^b_{A(i)}$ and $M^b_{B(i)}$ will be $S^b_{BA(1)} \times M$ and $\left(1 - S^b_{BA(1)}\right) \times M$, respectively. That is to say, the equilibrium of $M_{A(i)}$ and $M_{B(i)}$ will be $\left(1 - S^a_{AB(1)} + S^b_{BA(1)}\right) \times M$ and $\left(S^a_{AB(1)} + 1 - S^b_{BA(1)}\right) \times M$, respectively. The share of preference is changing from $1/2$ for each of the two brands at the beginning of the alliance to an equilibrium level of $\left(1 - S^a_{AB(1)} + S^b_{BA(1)}\right)/2$ for *A* and $\left(1 + S^a_{AB(1)} - S^b_{BA(1)}\right)/2$ for *B*. So, following the logic of Venkatesh et al.'s (2000) proof, the amount of required expansion will be at least $\left(2/\left(1 - S^a_{AB(1)} + S^b_{BA(1)}\right) - 2\right) \times M$ for firm (brand) *A* and $\left(2/\left(1 + S^a_{AB(1)} - S^b_{BA(1)}\right)\right) \times M$ for firm (brand) *B* (see Appendix A.3 for the details). Table 4.1 compares our results with Venkatesh et al. (2000).

As can be seen from Table 4.1, the algebra expression of required expansion of each partner in our model is different from Venkatesh et al. (2000) because the

[7] One can view each consumer group as composed of two sub-categories of "stayers" and "shifters". For instance, an $S^a_{AB(1)}$ value of 0.3 can be illustrated as group *a* comprised of 30% "shifters" and 70% "stayers" and we wish to address the possibility that some "shifters" show their loyalty occasionally and some "stayers" have sporadic switching behaviors after *i* = 2. This setting is consistent with Venkatesh et al. (p.9, 2000).

equilibrium is achieved at the second period, which is a special case in their setting. However, one can observe that, in both the models, if there are fewer outgoing customers from *A* (*B*) (i.e., a smaller $S^{a}_{AB(1)}$ ($S^{b}_{BA(1)}$)), a smaller amount of expansion will be required for *A* (*B*). The similar result also holds if there are more incoming customers to *A* (*B*) (i.e., a larger $S^{b}_{BA(1)}$ ($S^{a}_{AB(1)}$)).

Table 4.1: A comparison of equilibrium share and necessary condition

		The Venkatesh et al. (2000) model[8]	Our model
Equilibrium shares	*A*	$S_{BA}/(S_{AB}+S_{BA})$	$(1-S^{a}_{AB(1)}+S^{b}_{BA(1)})/2$
	B	$S_{AB}/(S_{AB}+S_{BA})$	$(1+S^{a}_{AB(1)}-S^{b}_{BA(1)})/2$
Required expansion	*A*	$\Delta M_A \geq [(S_{AB}-S_{BA})/S_{BA}]M$	$\Delta M_A \geq (2/(1-S^{a}_{AB(1)}+S^{b}_{BA(1)})-2)M$
	B	$\Delta M_B \geq [(S_{BA}-S_{AB})/S_{AB}]M$	$\Delta M_B \geq (2/(1+S^{a}_{AB(1)}-S^{b}_{BA(1)})-2)M$
Required expansion for alliance		$\Delta M \geq Max[\Delta M_A, \Delta M_B]$	

4.3 Propositions

In this section, we will derive four propositions from the above model. The propositions will explore the impacts of the negative (positive) belief revisions on the required expansion for each focal brand. Besides, we will provide two decision rules regarding the criteria of the partner selection. It should be noted that the four propositions are not universally valid. Instead, they are only effective under the specific profit-sharing mechanism in Venkatesh et al. (2000).

4.3.1 Belief Revision and the Success of Co-branding

Let us get back to the shift-in ratios, $S^{a}_{AB(1)}$ and $S^{b}_{BA(1)}$. If we substitute $P^{K,a}_{R(2)}$ from Eqs. (4.20) through (4.23) into Eq. (4.25) and after some simple algebra,

[8] To compare the results, the equal segment size of each brand is also assumed in the Venkatesh et al. (2000) model.

we get

$$S^{a}_{AB(1)} = Pr\left\{ w^{x,a} D\left[\frac{1}{2}\gamma_A^{x,a} + \frac{1}{2}\gamma_B^{x,a} - 1 \right] + w^{y,a} D\left[1 - \frac{1}{2}\gamma_A^{y,a} - \frac{1}{2}\gamma_B^{y,a} \right] \right.$$
$$\left. > \varepsilon\left(w^{x,a}\left(\gamma_A^{x,a} - \gamma_B^{x,a} \right) + w^{y,a}\left(\gamma_A^{y,a} - \gamma_B^{y,a} \right) \right) \right\}. \qquad (4.28)$$

Similarly, substituting $P^{K,b}_{R(2)}$ from Eqs. (4.20) through (4.23) into Eq. (4.27), we obtain

$$S^{b}_{BA(1)} = Pr\left\{ w^{x,b} D\left[1 - \frac{1}{2}\gamma_A^{x,b} - \frac{1}{2}\gamma_B^{x,b} \right] + w^{y,b} D\left[-1 + \frac{1}{2}\gamma_A^{y,b} + \frac{1}{2}\gamma_B^{y,b} \right] \right.$$
$$\left. > \varepsilon\left(w^{x,b}\left(\gamma_B^{x,b} - \gamma_A^{x,b} \right) + w^{y,b}\left(\gamma_B^{y,b} - \gamma_A^{y,b} \right) \right) \right\}. \qquad (4.29)$$

Besides, let μ denotes the ratio of relative weights of attribute importance and assuming that

$$\mu = \left(w^{x,a} / w^{y,a} \right) = \left(w^{y,b} / w^{x,b} \right). \qquad (4.30)$$

Note that the equal ratio of two groups is a benchmark and will be relaxed in scenario 5-3 in chapter 5. By Eqs. (4.8) and (4.9), the following condition holds:

$$\mu > 1. \qquad (4.31)$$

Eqs. (4.28) to (4.31) can be used for proving four useful propositions.

Now we define the term(s) “negative (positive) belief revisions”. As indicated in section 4.2.3, the inconsistent attribute information in co-branding will cause consumers to update their pre-alliance beliefs. That is to say, compared with pre-alliance beliefs of *x* (*y*) of *A* (*B*), the joint product is perceived to have a poorer attribute performance (cf. Eqs. (4.17) and (4.18)). Through the process of “accommodation”, pre-alliance beliefs about these two specific attributes may be diluted due to the inconsistency between the existing beliefs and co-branding beliefs. We call this type of updating behavior a “negative (belief) revision” (cf. Eqs. (4.20) and (4.23)). On the contrary, a “positive (belief) revision” may exist

(cf. Eqs. (4.21) and (4.22)) on pre-alliance beliefs about y (x) of A (B), because, in contrast to pre-alliance beliefs of y (x) of A (B), the co-branded product is perceived to have a better attribute performance. The above arguments echo the result in Geylani et al. (2008) (see Fig. 1 in Geylani et al. (2008)). As far as we know, belief revision has often been discussed in the field of brand extension (e.g., Loken and Roedder John, 1993; Sheinin, 2000; Milberg, 2001) but seldom appears in co-branding research.

Of course, the positive (negative) revision can lead to a change on consumer preferences in various conditions, but we narrow down our focus on two specific cases where the brand familiarity moderates the magnitude of the belief revision.

Case 1: The consumers of each group are more sensitive to the changes of initial beliefs of their originally preferred brand.

Case 1 is inspired by Grime et al. (2002), who have inferred that a consumer with a higher level of familiarity with one brand tends to update that brand's initial beliefs more when she (he) receives inconsistent information from the (co-branded) extended products. As indicated in section 4.2.1, the consumers at each group are more familiar with their initial preferred brand, and therefore will have more belief revision of that brand. Mathematically speaking, this implies

$$\gamma_A^{K,a} > \gamma_B^{K,a}, \tag{4.32}$$

$$\gamma_B^{K,b} > \gamma_A^{K,b}. \tag{4.33}$$

Proposition (Prop.) 4.1a and 4.1b illustrate the influence of negative revisions under the assumption of Case 1: when A (B)'s customers have a relative large negative updating on A (B). Prop. 4.1a and 4.1b can exist simultaneously.

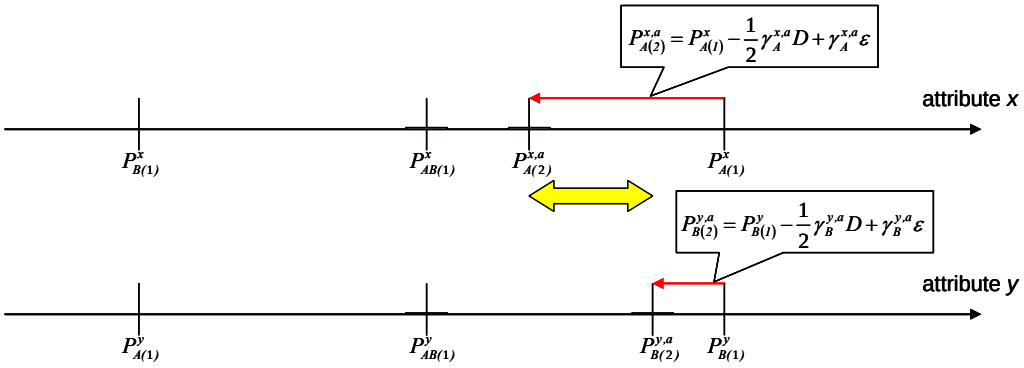
Proposition 4.1a

Under certain conditions ($\gamma_A^{y,a} = \mu\gamma_B^{x,a}$ and $1 \geq \gamma_A^{x,a} > \gamma_A^{y,a} > \gamma_B^{x,a} > \gamma_B^{y,a} > 0$), the amount of *A*'s expansion ($\left(2/\left(1 - S_{AB(1)}^{a} + S_{BA(1)}^{b}\right) - 2\right)M$) becomes larger, ceteris paribus, when the difference between $\gamma_A^{x,a}$ and $\gamma_B^{y,a}$ ($\left(\gamma_A^{x,a} - \gamma_B^{y,a}\right)$) increases.

The intuition behind Prop. 4.1a is that group *a*'s relatively large negative revision of *A* can decline brand (firm) *A*'s intention (or interests) for (in) the alliance. Fig. 4.4 shows that, when the customers of *A* (i.e., group *a*) have a relatively larger amount of negative revision of *A* than *B*, pre-alliance belief of *x* of *A* will be diluted more. Consequently, a larger portion of *A*'s customers will shift their preference to *B* after co-branding.

In particular, if they split the sales revenue of the co-branded products by preference share, *A* eventually has to require a relatively large amount of expansion for entering this partnership. Such a condition is a weak prospect for *A*.

Figure 4.4: The negative revision of group a



Proof. By using Eqs. (4.30) and (4.32), Eq. (4.28) can be rearranged as:

$$S^{a}_{AB(1)} = Pr\left[\frac{w^{y,a} D\left(\frac{1}{2}\mu\gamma_A^{x,a} + \frac{1}{2}\mu\gamma_B^{x,a} - \mu + 1 - \frac{1}{2}\gamma_A^{y,a} - \frac{1}{2}\gamma_B^{y,a}\right)}{w^{y,a}\left(\mu\gamma_A^{x,a} - \mu\gamma_B^{x,a} + \gamma_A^{y,a} - \gamma_B^{y,a}\right)} > \varepsilon\right]. \tag{4.34}$$

By canceling out $w^{y,a}$ and assuming $1 \geq \gamma_A^{x,a} > \gamma_A^{y,a} > \gamma_B^{x,a} > \gamma_B^{y,a} > 0$ and $\gamma_A^{y,a} = \mu\gamma_B^{x,a}$, Eq. (4.34) can be rewritten as

$$S^{a}_{AB(1)} = Pr\left[D\left(\frac{1-\mu}{\mu\gamma_A^{x,a} - \gamma_B^{y,a}} + \frac{1}{2}\right) > \varepsilon\right]. \tag{4.35}$$

If we use ρ to represent $\left(\gamma_A^{x,a} - \gamma_B^{y,a}\right)$, Eq. (4.35) can be written as follows:

$$S^{a}_{AB(1)} = Pr\left\{D\left[\frac{1-\mu}{(\mu-1)\left(\rho + \gamma_B^{y,a}\right) + \rho} + \frac{1}{2}\right] > \varepsilon\right\}. \tag{4.36}$$

Furthermore, let L be the term $D\left[\frac{(1-\mu)}{(\mu-1)\left(\rho + \gamma_B^{y,a}\right) + \rho} + \frac{1}{2}\right]$, we get

$$S^{a}_{AB(1)} = Pr(L > \varepsilon). \tag{4.37}$$

Because ε is uniformly distributed on the interval $[-\theta, \theta]$, we get

$$S^{a}_{AB(1)} = (L + \theta)/2\theta, \text{ if } -\theta < L < \theta\,^{9}. \tag{4.38}$$

Since $\partial S^{a}_{AB(1)} / \partial L > 0$ and $\partial L / \partial \rho > 0$, we get

$$\partial S^{a}_{AB(1)} / \partial \rho > 0. \tag{4.39}$$

[9] Our results are discussed only when $0 < S^{a}_{AB(1)} < 1$ and $0 < S^{b}_{BA(1)} < 1$. This condition also holds in Prop. 4.1b, 4.2a, and 4.2b. The rationale can be explained as follows. When both ratios are equal to 0, the alliance can break up. We will discuss this case in section 4.3.2. It is also impossible for the two brands to forge the alliance if one of the ratios is equal to 0 because eventually one brand with a positive ratio will be vulnerable to losing all of its customers (see p.12, Venkatesh et al., 2000). Finally, if both the ratios are equal to 1, the preference share for each brand does not change at all, and thus there is no required expansion.

Moreover, the required expansion (necessary condition) for A to forge the alliance (ΔM_A) is at least

$$\left[\frac{2}{1-S^{a}_{AB(1)}+S^{b}_{BA(1)}}-2\right]M\,. \tag{4.40}$$

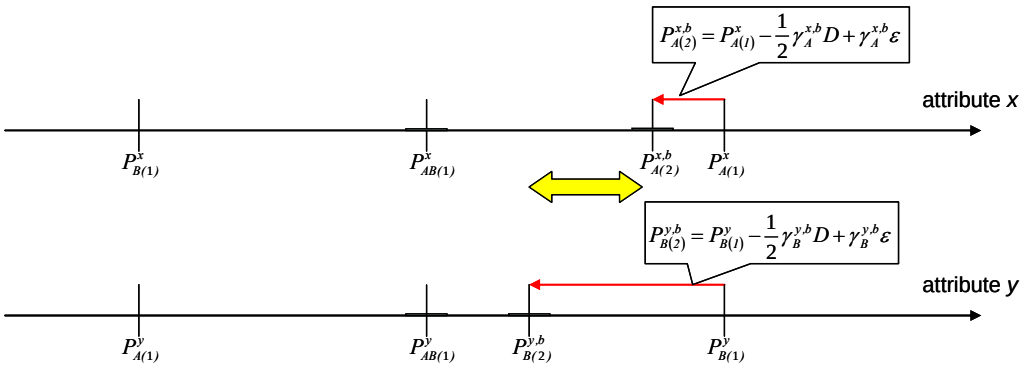
If assuming all the other variables being the same in Eq. (4.40), one can easily confirm that the amount of required expansion for A will increase as $\rho=\left(\gamma^{x,a}_{A}-\gamma^{y,a}_{B}\right)$ increases. Q.E.D.

Proposition 4.1b

Under certain conditions ($\gamma^{x,b}_{B}=\mu\gamma^{y,b}_{A}$ and $1\geq\gamma^{x,b}_{B}>\gamma^{y,b}_{B}>\gamma^{x,b}_{A}>\gamma^{y,b}_{A}>0$), the amount of B's expansion ($\left(2/\left(1+S^{a}_{AB(1)}-S^{b}_{BA(1)}\right)-2\right)M$) becomes larger, ceteris paribus, when the difference between $\gamma^{y,b}_{B}$ and $\gamma^{x,b}_{A}$ ($\left(\gamma^{y,b}_{B}-\gamma^{x,b}_{A}\right)$) increases.

The intuition of Prop. 4.1b is analogous to Prop. 4.1a: group b's relatively large negative revision of B (see Fig. 4.5) can decline brand (firm) B's interest in this partnership.

Figure 4.5: The negative revision of group b



Proof**.** Since the proof of Prop. 4.1b is very similar to that of Prop. 4.1a, we put it in Appendix A.4.

Prop. 4.1a(b) successfully explains how a successful formation of co-branding alliances is related to consumers' negative updates of attribute beliefs. Obviously, due to the complexity of the process of belief revisions in co-branding, a quantitative prediction of the outcome of a co-branding partnership is only possible by applying the suggested modeling framework. Other than the influences of negative revision, we will offer a specific example (proposition) in case 2 to explain how the relative magnitude of "positive revision" can also affect the success of co-branding.

Case 2: The consumers of each group do not easily change pre-alliance beliefs of their originally preferred brand.

Case 2 is contrary to case 1 and is motivated by Sheinin (2000). He inferred that a consumer with a higher degree of familiarity with one brand tends to have a relative stable belief of that brand when she (he) receives new and inconsistent attribute information from the co-branded product. Therefore, in this case, the consumers at each group will have less revision of pre-alliance beliefs of their initial preferred brand. Mathematically speaking, this implies

$$\gamma_A^{K,a} < \gamma_B^{K,a}, \tag{4.41}$$

$$\gamma_B^{K,b} < \gamma_A^{K,b}. \tag{4.42}$$

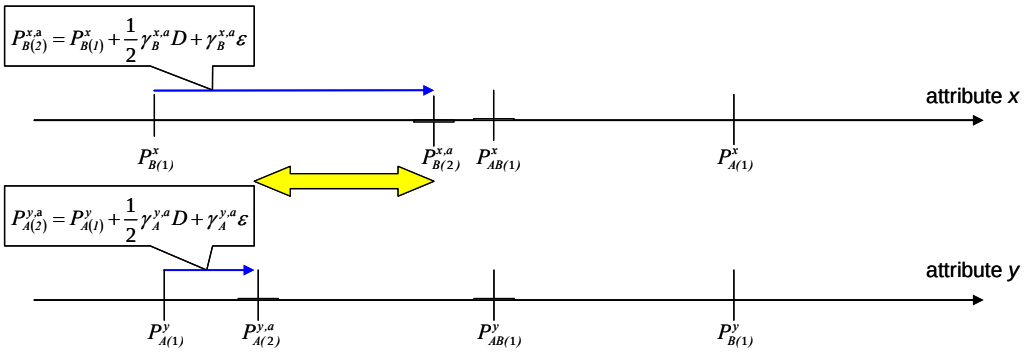
By the inequalities (4.41) and (4.42), we provide the following proposition(s) to claim that the relative magnitude of group *a* (*b*)'s positive revisions on the two allying brands may also enlarge the amount of required expansion of *A* (*B*). Prop. 4.2a and Prop. 4.2b describe the above phenomenon, and they can exist simultaneously.

Proposition 4.2a

Under certain conditions ($\gamma_B^{y,a} = \mu\gamma_A^{x,a}$ and $1 \geq \gamma_B^{x,a} > \gamma_B^{y,a} > \gamma_A^{x,a} > \gamma_A^{y,a} > 0$), the amount of *A*'s expansion ($\left(2/\left(1 - S_{AB(1)}^{a} + S_{BA(1)}^{b}\right) - 2\right)M$) becomes larger, ceteris paribus, when the difference between $\gamma_B^{x,a}$ and $\gamma_A^{y,a}$ ($\left(\gamma_B^{x,a} - \gamma_A^{y,a}\right)$) increases.

An explanation for Prop. 4.2a is that group *a*'s relatively large positive revision of *B* can diminish brand (firm) *A*'s intention for building up this alliance. As Fig. 4.6 shows, when the customers of *A* have a relatively large amount of positive revision of *B*, pre-alliance belief of *y* of *B* will be enhanced much more. As a result, a larger portion of *A*'s customers will change their preference to *B* after co-branding. If the partners follow the specific profit-sharing arrangement of Venkatesh et al. (2000), brand (firm) *A* will need more incoming customers to forge this alliance.

Figure 4.6: The positive revision of group a



Proof. Followed by Eqs. (4.30) and (4.41) and substituting $w^{x,a}$ from Eq. (4.28) by $\mu w^{y,a}$, Eq. (4.28) can be rearranged as:

$$S^{a}_{AB(1)} = Pr\left[\frac{D\left(\frac{1}{2}\mu\gamma^{x,a}_{A} + \frac{1}{2}\mu\gamma^{x,a}_{B} - \mu + 1 - \frac{1}{2}\gamma^{y,a}_{A} - \frac{1}{2}\gamma^{y,a}_{B}\right)}{\left(\mu\gamma^{x,a}_{A} - \mu\gamma^{x,a}_{B} + \gamma^{y,a}_{A} - \gamma^{y,a}_{B}\right)} < \varepsilon\right]. \tag{4.43}$$

Assuming $1 \geq \gamma^{x,a}_{B} > \gamma^{y,a}_{B} > \gamma^{x,a}_{A} > \gamma^{y,a}_{A} > 0$ and $\gamma^{y,a}_{B} = \mu\gamma^{x,a}_{A}$, Eq. (4.43) can be given by

$$S^{a}_{AB(1)} = Pr\left[D\left(\frac{1-\mu}{-\mu\gamma^{x,a}_{B} + \gamma^{y,a}_{A}} - \frac{1}{2}\right) < \varepsilon\right]. \tag{4.44}$$

If we use τ to represent $\left(\gamma^{x,a}_{B} - \gamma^{y,a}_{A}\right)$, Eq. (4.44) can be written as follows:

$$S^{a}_{AB(1)} = Pr\left\{D\left[\frac{1-\mu}{-(\mu-1)\left(\tau + \gamma^{y,a}_{A}\right) - \tau} - \frac{1}{2}\right] < \varepsilon\right\}. \tag{4.45}$$

Let V be the term $D\left[\frac{(1-\mu)}{-(\mu-1)\left(\tau + \gamma^{y,a}_{A}\right) - \tau} - \frac{1}{2}\right]$, we obtain

$$S^{a}_{AB(1)} = Pr(V < \varepsilon) = 1 - Pr(V > \varepsilon). \tag{4.46}$$

Since ε is uniformly distributed on the interval: $[-\theta, \theta]$,

$$S^{a}_{AB(1)} = 1 - (V + \theta)/2\theta = (\theta - V)/2\theta, \text{ if } -\theta < \mathrm{V} < \theta. \tag{4.47}$$

Because $\left(\partial S^{a}_{AB(1)} / \partial V\right) < 0$ and $\left(\partial V / \partial \tau\right) < 0$, we get

$$\left(\partial S^{a}_{AB(1)} / \partial \tau\right) > 0. \tag{4.48}$$

Moreover, the required expansion for A to establish the alliance (ΔM_{A}) is at least

$$\left[\frac{2}{1-S^{a}_{AB(1)}+S^{b}_{BA(1)}}-2\right]M\,. \qquad (4.49)$$

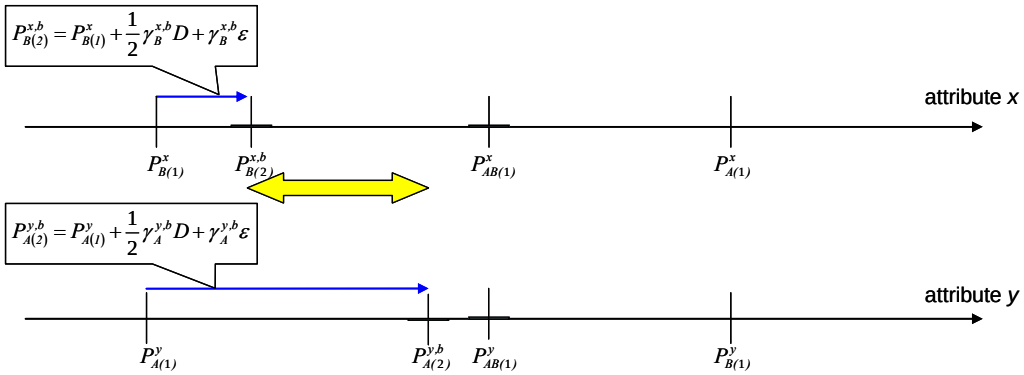
If assuming all the other variables being the same in Eq. (4.49), one can easily confirm that the volume of required expansion for A will increase as $\tau=\left(\gamma_B^{x,a}-\gamma_A^{y,a}\right)$ increases. Q.E.D.

Proposition 4.2b

Under certain conditions ($\gamma_A^{x,b}=\mu\gamma_B^{y,b}$ and $1\geq\gamma_A^{x,b}>\gamma_A^{y,b}>\gamma_B^{x,b}>\gamma_B^{y,b}>0$), the amount of B's expansion ($\left(2/\left(1+S^{a}_{AB(1)}-S^{b}_{BA(1)}\right)-2\right)M$) becomes larger, ceteris paribus, when the difference between $\gamma_A^{y,b}$ and $\gamma_B^{x,b}$ ($\left(\gamma_A^{y,b}-\gamma_B^{x,b}\right)$) increases.

The intuition of Prop. 4.2b is as follows. As Fig. 4.7 demonstrates, when B's customers have a relatively large amount of positive revision of A, B needs more incoming customers to sustain its initial level of revenue. As a result, brand (firm) B's intention for forming the alliance can be diminished.

Figure 4.7: The positive revision of group b



Proof. Since the proof of Prop. 4.2b is very similar to that of Prop. 4.2a, we put it in Appendix A.5.

Note that the above propositions all address the "worse" cases because we

want to highlight the difficulties of alliance success (Doorley, 1993). Table 4.2 summarizes the results of the four propositions in this section.

Table 4.2: Main results of Prop. 4.1a(b) and 4.2a(b)

Related brand (firm)/ Proposition		Shift-in ratio[10]	Required expansion	Results
A	4.1a	$S^{a}_{AB(1)} = \frac{L+\theta}{2\theta}, \mathrm{L} \in (-\theta, \theta)$	$\left[\frac{2}{1 - S^{a}_{AB(1)} + S^{b}_{BA(1)}} - 2\right] M$	let $\rho = \left(\gamma^{x,a}_{A} - \gamma^{y,a}_{B}\right)$, $\frac{\partial S^{a}_{AB(1)}}{\partial \rho} > 0$
	4.2a	$S^{a}_{AB(1)} = \frac{\theta - V}{2\theta}, \mathrm{V} \in (-\theta, \theta)$		let $\tau = \left(\gamma^{x,a}_{B} - \gamma^{y,a}_{A}\right)$, $\frac{\partial S^{a}_{AB(1)}}{\partial \tau} > 0$
B	4.1b	$S^{b}_{BA(1)} = \frac{Q+\theta}{2\theta}, \mathrm{Q} \in (-\theta, \theta)$	$\left[\frac{2}{1 + S^{a}_{AB(1)} - S^{b}_{BA(1)}} - 2\right] M$	let $\eta = \left(\gamma^{y,b}_{B} - \gamma^{x,b}_{A}\right)$, $\frac{\partial S^{b}_{BA(1)}}{\partial \eta} > 0$
	4.2b	$S^{b}_{BA(1)} = \frac{\theta - Z}{2\theta}, \mathrm{Z} \in (-\theta, \theta)$		let $\omega = \left(\gamma^{y,b}_{A} - \gamma^{x,b}_{B}\right)$, $\frac{\partial S^{b}_{BA(1)}}{\partial \omega} > 0$

Note: $L = D\left[\frac{(1-\mu)}{(\mu-1)(\rho+\gamma^{y,a}_{\mathrm{B}})+\rho} + \frac{1}{2}\right]$, $\mathrm{V} = \mathrm{D}\left[\frac{(1-\mu)}{-(\mu-1)(\tau+\gamma^{y,a}_{A})-\tau} - \frac{1}{2}\right]$, $\mathrm{Q} = \mathrm{D}\left[\frac{(1-\mu)}{(\mu-1)(\eta+\gamma^{x,b}_{\mathrm{A}})+\eta} + \frac{1}{2}\right]$, $\mathrm{Z} = \mathrm{D}\left[\frac{(1-\mu)}{-(\mu-1)(\omega+\gamma^{x,b}_{B})-\omega} - \frac{1}{2}\right]$.

[10] For notational simplicity, we use the same notation to denote the shift-in ratio of *A* (or *B*) (e.g., $S^{a}_{AB(1)}$ represents the shift-in ratio of *A* in Prop. 4.1a and Prop. 4.2a) although the values in different propositions may differ.

4.3.2 Rules of Partner Selection in Co-branding

Choosing an adequate partner is the most essential and the very initial decision to co-branding success (Rao and Ruekert, 1994; Simonin and Ruth, 1998; Walchli, 2007; Hao, 2008). To our knowledge, this research topic has been analyzed by utilizing the signaling theory (e.g., Rao and Ruekert, 1994) and the fit theory (e.g., Park et al., 1996). In this subsection, we will first conclude two decision rules of partner selection from previous findings, and then adapt our model to give a quantitative example for concretizing the rule.

As discussed in section 2.3.1, the research articles with respect to the signaling perspective have all suggested that the lower-status brand partner (e.g., lower brand equity, poorer quality, and lower reputation) are better to ally with a higher-status brand for enhancing the quality perceptions of their co-branded products (Rao and Ruekert, 1994; Rao et al., 1999; Washburn et al., 2000; Bengtsson and Servais, 2005; Choi and Jeon, 2007). In fact their findings showed the positive influence of “complementarity” nature (i.e., high-status with low-status) on co-branding alliances. From the perspective of fit, the importance of complementarity has also been discussed by researchers. For example, Park et al. (1996) have reported that a better product fit between the partners – attribute complementarity (cf. Definition 4.1) – can lead to a more favorable attitude toward the co-brand.

However, the above results have been challenged by two recent studies (Walchli, 2007; Geylani et al., 2008). Walchli (2007) echoes the usefulness of a complementary brand alliance, but argues that the difference between the two brands should not exceed a certain level. The author referred the concept of fit to the congruence theory (e.g., Mandler, 1982). After an experiment of evaluating three hypothetical magazines for business readers, he found that in a high-involvement condition consumers may regard the identical (congruent) brand pair (e.g., *Business Week-Fortune*) as a redundant and not complement

task, and thus have no interests in resolving it. On the other hand, consumers may also feel frustrated to resolve a complementary but highly different (highly incongruent) brand partnership (e.g., *Business Week-People*). His interesting results suggested that only the brand pair perceived to be moderately different (e.g., *Business Week-The Wall Street Journal*) results in a more positive evaluation than other cases.

Geylani et al. (2008) applied the sub-typing theory (Weber and Crocker, 1983; Loken and Roedder John, 1993) and the theory of inconsistency discounting (Lynch and Ofir, 1989; Shugan, 2006) to investigate whether co-branding can reinforce or damage the beliefs of the allying brands. They claimed that consumers will view the co-branded product as an exception to the allying brands, when they perceive a larger difference between the attribute levels of the allying brands (i.e., D in Eq. (4.7)). Consequently, consumers tend to significantly increase the attribute uncertainty of the co-brand, and are less likely to modify the pre-alliance beliefs. The authors further argued that, when the allying brands have an extreme difference in the attribute level, consumers will not modify their pre-alliance beliefs. Considering the possibility of enhancing the pre-alliance beliefs, it is optimal for one allying brand to find a partner with attribute complementarity (i.e., a better product fit), but it is perceived to have only a moderately higher attribute level[11]. The Geylani et al. (2008) work succeeds in their mathematical formulation, but the authors did not relate their findings to co-branding success.

In view of the above findings, manager can use the following two decision rules when making decisions of partner selection:

[11] Note that we do not find a real example for this result. We have expressed our request to the authors, but, unfortunately, they cannot provide any example of this.

Rule 4.1 (the signaling perspective)

In order to improve the quality perception of the co-brand, it is better for a lower-status brand partner to ally with a higher-status partner.

Rule 4.2 (the fit perspective)

In order to enhance the attitudes toward the co-branded products, it is better for one brand to choose a complementary brand (partner) with only a moderate attribute-level difference.

Following the Geylani et al. (2008) work, we argue that, in the extremely different case, the co-branding alliance may break up very soon (e.g., at the second time point in our model). The underlying reasons can be explained as follows. When the theory of sub-typing (inconsistent discounting) is in effect, and an extremely incongruence between the beliefs of allying brands exists, consumers will feel frustrated to resolve the high discrepancy (Walchli, 2007). Finally they will not modify their pre-alliance beliefs, and thus the respective shift-in ratios, $S^{a}_{AB(1)}$ and $S^{b}_{BA(1)}$, are simultaneously zero. Therefore the partnership can break off very soon, in that there is no mutual benefit (i.e., without exchanging preferences) and no incremental impact over the baseline situation (p.12, Venkatesh et al., 2000). Example 4.1 illustrates our argument in a quantitative manner.

Example 4.1

To give a simple example, we first express the sub-typing model mathematically by the following equation:

$$\left(\partial \gamma_R^{K,G} / \partial D\right) < 0 . \tag{4.50}$$

Eq. (4.50) is inspired from Geylani et al. (p.733, 2008). It states that consumers will possess a smaller (larger) updating weight, when they perceive a larger

(smaller) amount of initial attribute-level difference.

So, we assume that the following map exists: $\gamma_R^{K,G}(D)$: $[0,+\infty)\to[0,1]$ and is defined as:

$$D\mapsto \gamma_R^{K,G}(D):=1/(D+1). \tag{4.51}$$

It is clear that in Eq. (4.51) the sub-typing model is in effect (i.e., $\gamma_R^{K,G}{}'(D)<0$) and the following equation holds

$$\lim_{D\to+\infty}\gamma_R^{K,G}(D)=0. \tag{4.52}$$

In this case, according to Eq. (4.19), the post-alliance beliefs in the second period ($P_{R(2)}^{K,G}$) will be the same as pre-alliance beliefs ($P_{R(1)}^{K}$). The probability measures $S_{AB(1)}^{a}$ in Eq. (4.25) and $S_{BA(1)}^{b}$ in Eq. (4.27) will be simultaneously zero because $\Phi_{A(2)}^{a}>\Phi_{B(2)}^{a}$ and $\Phi_{B(2)}^{b}>\Phi_{A(2)}^{b}$. Since there is no mutual benefit in the first intermediate period, this alliance may break up (i.e., when $S_{AB(1)}^{a}=0$ and $S_{BA(1)}^{b}=0$) at time 2.

Note that in the above example we simple assume a case where *D* goes to infinity. Therefore, from a practical point of view, the example can only be validated when we use the "dollar metric scales" (e.g., Pessemier et al., 1971; Agarwal and Rao, 1996), which is often used for a consumer to identify the price premium that she (he) would prefer to pay in order to switch another brand. Besides, the above example makes a contribution to the co-branding field, because we combine the viewpoints from the strategic alliance framework and the consumer behavior framework.

Other than the example presented above, we also argue that the "similar" brand pair (i.e., a poorer fit, *D* = 0) may end up very quickly when the book-keeping model (e.g., Loken and Roedder John, 1993) is in effect. In contrast to the sup-typing model, the book-keeping model suggests that the amount of incongruent attribute information has a positive impact on the

magnitude of the belief revision. In the field of co-branding, it infers that consumers will revise more, when they perceive a larger amount of incongruent attribute information between the two brands. So, if the allying brands are similar in terms of attribute levels and the book-keeping model is in effect, consumers may think of the identical nature as the redundant information, and thus have no incentives to resolve it (Walchli, 2007). As a result, consumers will not update pre-alliance beliefs and the partnership may be terminated due to the lack of preference exchange[12].

Summing up, we argue that it is not suitable for one brand to ally with the other one when the attribute beliefs of the two brands are extremely different ($D \to +\infty$) or similar ($D = 0$), because consumers may either face a difficulty or perceive a redundancy when modifying their existing beliefs.

4.4 Discussions

In contrast to the Venkatesh et al. (2000) model, our model emphasizes the influences of relative magnitude of belief revisions ($\gamma_R^{K,G}$) and examines the link between belief revision and the necessary condition of co-branding success. We briefly review the marketing implications in the following.

First, previous research in brand extension suggests that the reciprocal effect exists on the belief level (i.e., belief revisions, see Loken and Roedder John, 1993; Sheinin, 2000; Milberg, 2001). Our results show that belief revision can also occur in co-branding. We claim that the inconsistent attribute information behind a “better fit” (cf. definition 1) may cause consumers to modify their pre-alliance beliefs. Brand managers should also consider the more abstract level of consumer evaluations – namely belief revisions, since the relative magnitude of belief dilutions (or enhancements) on the allying brands may decline (or strengthen) each brand (firm)’s intention to form the alliance (cf. Eqs. (4.39),

[12] Note that we cannot provide a mathematical example to validate this argument, since our model assumes that the initial attribute-level difference (D) is always strictly positive.

(4.40), (4.48), and (4.49)).

Moreover, our formulation of belief revisions in section 4.2.3 is motivated from Geylani et al. (2008). But, compared with the Geylani et al. (2008) model, our work incorporates the impacts of brand familiarity (i.e., Case 1 and 2), and connects belief revision to the brand choice probabilities (i.e., shift-in ratios). Ultimately one can realize why co-branding may jeopardize or reinforce the images of partnering brands by belief revisions, and how the success of co-branding may depend on those revisions from the propositions offered by both studies.

Thirdly, in order to achieve co-branding success, we support the argument that the partnering brands should have a set of relevant attributes, but the attribute levels are better perceived as moderately apart (Geylani et al., 2008). For example, if brand *A* is perceived as bad in the attribute “good-taste”, it is not wise for brand *A* to choose a partner that is perceived as very good (an extremely different condition) or bad (a similar condition) in the same attribute. The above three implications will help the prospective brands to build up a successful co-branding alliance.

There are five limitations in our model. First, our propositions are only valid when assuming a fixed amount of the aggregated market size and a special rule of profit-sharing – proportional to the resource committed to the partnership (i.e., preference share). Both assumptions seldom appear in real business world, but at a minimum our results motivate an important issue for managing such an alliance (cf. Amaldoss et al., 2000): how to control the resource commitment of each partner. Of course, it is possible that in some industries profit-sharing is based on more subjective issues (e.g., the length of contract), which are worthy of consideration in future studies.

Secondly, from the brand manager’s perspective, it might be interesting to get a sense of the amount of required expansions for both brands and to check when

the required expansion is unlikely to occur (i.e., the anticipated amount of expansion is 0). Hence, some numerical experiments are needed. It would be more helpful if we could offer some scenarios that are closer to reality. (e.g., allowing the segment sizes, $M_{A(1)}$ and $M_{B(1)}$, are different). The next chapter will complete this task.

Thirdly, we did not compare the relative magnitude between pre- and post-alliance attitudes toward each of the partnering brands. As argued by Leuthesser et al. (2003), when the attitudes toward the partnering brands are maintained after co-branding (e.g., $\Phi^G_{A(2)} \geq \Phi^G_{A(1)}$), the co-branding strategy will be more effective. Hence, one can explore how the necessary condition will be affected in this case. We believe that this is an interesting topic worthy further research.

Fourthly, we did not consider the effect of "attitude accessibility" (Fazio et al., 1989) when formulating co-branding beliefs. Park et al. (1996) have argued that the beliefs in salient attributes, compared with the beliefs in less salient attributes, contribute more to co-branding beliefs, since one attribute with a greater strength of association (i.e., a larger salience) is easier to remember. That is to say, in our model the belief in attribute *x* (*y*) of brand *A (B)* will make a larger contribution to the belief in *x (y)* of the joint product. Hence, the assumption that the values of λ^x_R and λ^y_R are equal to 1/2 should be released in future research.

Last but not least, in fact our model is a first step toward a model with dynamic updating behavior in co-branding. Our suggestion of dynamic belief updating is inspired by the models describing brand choice dynamics in the marketing field (e.g., Roberts and Urban, 1988; Erdem and Keane, 1996). These models all assumed that consumer preferences are formulated by nature of multi-attributes. Moreover, whenever new products are released, consumers are assumed to be uncertain about the real attribute performance of these new products due to the inherent product variability (cf. Roberts and Urban, 1988;

Erdem and Keane, 1996) or idiosyncratic perceptions (cf. Erdem and Keane, 1996). Thus, each time consumers are able to use the attribute information they obtained to update their prior attribute beliefs, and hence, ceteris paribus, dynamic belief updating may change brand preferences as well as choice behaviors at any subsequent time point.

However, due to the lack of empirical support of dynamic updating in co-branding, we suggest that future research can first validate the dynamic updating by conducting experiments investigating the relation between belief revision and preferences (cf. James, 2005). If the empirical experiment has a positive result, our formulation of belief revision in section 4.2.3 can then be adapted to answer two key questions relevant to positioning and advertising policies respectively (cf. Erdem and Keane, 1996): how can the shift-in ratio of each brand be influenced by (1) different positioning of the co-branded products at different time points and (2) the one-shot advertising message for signaling the attribute performance (i.e. used for reducing confusions).

The first question can be solved by modeling the dynamics of the contributing weights λ_R^K in Eqs. (4.12) and (4.13). That is, at every time point the co-brand may release different types of products featuring different compositions of attribute performances (i.e., $\lambda_R^K \neq 1/2$, e.g., the *Sony-Ericsson* W-series mobiles focus on the walkman function). Thus the different positioning at each point may cause different magnitudes of confusions about the real attribute levels of the co-brand (cf. Eq. (4.14)), and can influence the values of shift-in ratios as well as the success of co-branding. The second question can be answered by formulating the dynamics of δ. For example we can model δ as the advertising parameter (e.g., $\delta_{(i+1)} = \delta_i / c$, where c is a positive constant) to reduce the magnitudes of confusions when the real attribute levels are identified more clearly through the time. In doing so, our model can offer strategic insights into policy evaluations for the partnering brands. However, adding the above dynamic settings will cause a significant increase in the complexity of deriving the equilibrium share

(cf. section 4.2.5). This technical problem is not the main task to be completed in this dissertation, and hence it can be solved in future studies.

Chapter 5

A Numerical Experiment of Belief Revision and Co-branding Success

As indicated in section 4.4, we need a numerical experiment to show the amount of required (market) expansion for both brands (firms) simultaneously and to analyze whether – and, if so, when - a co-branding alliance can be successfully formed in different situations. The current chapter aims to satisfy this need, and therefore it will be viewed as the supplement to Prop. 4.1a(b) and 4.2a(b). In particular, we will investigate the existence of an ideal situation whereby both brands (firms) can form a co-branding partnership without additional market expansions.

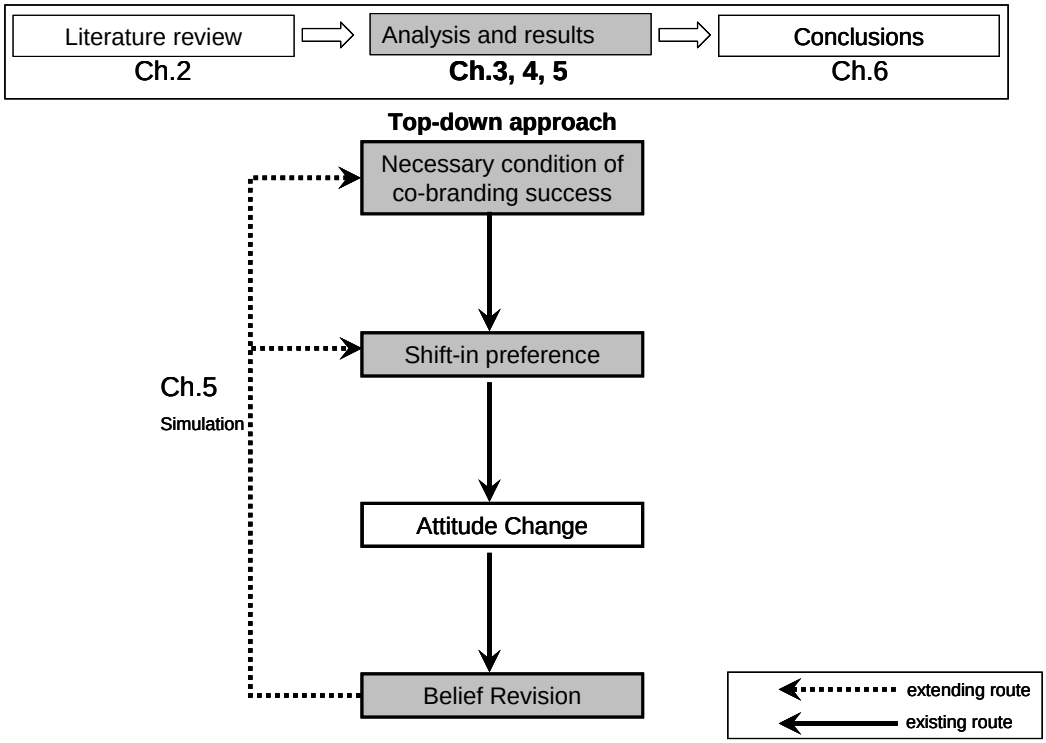
This chapter is structured as follows. We begin with a sensitivity analysis (SA) in section 5.1 because SA is considered an important step in the process of model building (Saltelli et al., 2000) and testing. Hence, the first part of this chapter will provide a value (set) for each parameter and observe how the different values of parameters affect the output of variables. To reduce the redundancy we will only offer the sensitivity analysis for Prop. 4.1a because the structure of Prop. 4.1a(b) and Prop. 4.2a(b) are identical.

In section 5.2, we will show our experiments in four different scenarios. Here we will set up a hypothetical brand alliance and examine how the amount of required (market) expansion is influenced by the relative magnitude of negative

belief revisions (i.e., combining Prop. 4.1a and 4.1b). Scenario 5-1 assumes that the two customer groups (e.g., group *a* and *b* in chapter 4) have the same structure of parameters. Following this, each of the subsequent scenarios is presented by relaxing one specific assumption in our mathematical model (i.e., by assigning different parameter values over the two customer groups). Finally, we summarize the findings and implications in section 5.3.

The position of this chapter in this dissertation is shown in Fig. 5.1.

Figure 5.1: The position of chapter 5



5.1 A Sensitivity Analysis

5.1.1 Setting the Parameters

Prop. 4.1a is used as an example to show how we select the value for each parameter. Actually, we separate the parameters involved in Prop. 4.1a into two

categories. The first category is called the "brand characteristics" and is composed of the initial segment size of brand A ($M_{A(1)}$), pre-alliance beliefs ($P^{K}_{R(1)}$), the initial attribute-level difference (D), and co-branding beliefs ($P^{K}_{AB(1)}$). The second category is named the "consumer characteristics" and includes the relative weight of attribute importance ($w^{K,a}$), the confusion parameter (δ), and the updating weights ($\gamma^{K,a}_{R}$, excluding the variable $\gamma^{x,a}_{A}$). Table 5.1 demonstrates the two parameter categories.

Table 5.1: The categories of parameters

Category	Parameters
Brand characteristics	$M_{A(1)}$, $P^{x}_{A(1)}$, $P^{y}_{A(1)}$, $P^{x}_{B(1)}$, $P^{y}_{B(1)}$, $P^{x}_{AB(1)}$, $P^{y}_{AB(1)}$, D
Consumer characteristics	$w^{x,a}$, $w^{y,a}$ $\gamma^{y,a}_{A}$, $\gamma^{x,a}_{B}$, $\gamma^{y,a}_{B}$ δ

For ease of calculation, we let $M_{A(1)}$ = 100 (for notational simplicity, hereafter we drop the time index of the market size in this section). $P^{x}_{A(1)}$ and $P^{y}_{B(1)}$ are set to be 80 whereas $P^{y}_{A(1)}$ and $P^{x}_{B(1)}$ are set to be 46; the values of the above levels are out of a one-hundred measure.[1] Hence, the value of initial attribute-level difference D equals 34. Moreover, according to Eqs. (4.15) and (4.16), $P^{K}_{AB(1)}$ is formulated as the sum of the midpoint between 46 and 80 and confusions. For the "consumer characteristics" category, the value of each parameter is chosen from a set. In section 4.2.2.2, we have assumed that the consumers at group *a* concern the attribute *x* more (cf. Eq. (4.8)) so that the ratio of relative weights of attribute importance μ is larger than 1 (cf. Eq. (4.30)). Indeed, μ can also represent different levels of consumers' taste over attribute *x* and *y* (Hauser and Shugan, 1983). Since our purpose is not to address an extreme consumer taste, we choose μ from the set {1.1, 1.2, 1.3, 1.4}.

[1] These values are chosen from Geylani et al. (p.739, 2008) and are rounding off to the nearest integrals.

Besides, in section 4.2.3.1, we have formulated consumers' confusions about the co-brand as a random variable (ε), and its value can be determined by the confusion parameter δ. To select the value of confusion parameter properly, we refer the values to the findings of Geylani et al. (p.739, 2008). They have showed that the standard deviation of consumers' confusion is reasonable between 5.88 and 7.85. If mapping those values into our setting, δ can be chosen from the set {0.3, 0.333, 0.367, 0.4}.[2] Besides, in order to have a different range of ρ (i.e., $\rho = \gamma_A^{x,a} - \gamma_B^{y,a}$), we let $\gamma_A^{x,a}$ (hereafter, the negative updating weight of *A*) be the input variable and let $\gamma_B^{y,a}$ (hereafter, the negative updating weight of *B*) be a parameter chosen from the set {0.1, 0.2, 0.3}. Table 5.2 shows the value (set) of each parameter.

Table 5.2: The value of parameters

Parameters		**Value**
Brand characteristics[3]	$M_{A(1)}$	100
	$P_{A(1)}^{x}$	80
	$P_{A(1)}^{y}$	46
	$P_{B(1)}^{x}$	46
	$P_{B(1)}^{y}$	80
	D	34
Consumer characteristics	$\mu = \frac{w^{x,a}}{w^{y,a}} = \frac{\gamma_A^{y,a}}{\gamma_B^{x,a}}$ [4]	{1.1, 1.2, 1.3, 1.4}
	$\gamma_B^{y,a}$	{0.1, 0.2, 0.3}
	δ	{0.3, 0.333, 0.367, 0.4}

Because in each run of experiment each of the parameters has a fixed value, we have 48 ($4 \times 3 \times 4$) different codes (or different types of updating behaviors)

[2] The standard deviation of ε is equal to $(\delta D)/\sqrt{3}$. Please see Eq. (4.14).

[3] We do not include co-branding beliefs, $P_{AB(1)}^{K}$, since the value is determined by δ.

[4] In the proof of Prop. 4.1a, we assume that $\gamma_A^{y,a} = \mu\gamma_B^{x,a}$ (cf. Eq. (4.35)).

representing all the combinations of the parameter value sets listed above. Table 5.3 offers some examples of codes. For the parameter details of all the 48 codes, please see Table A.2 in Appendix A.6.

Table 5.3: The example of codes

Code[5]	μ	δ	$\gamma_B^{y,a}$
A31	1.1	0.3	0.1
Aa1	1.1	0.333	0.1
Ab1	1.1	0.367	0.1
A41	1.1	0.4	0.1
A42	1.1	0.4	0.2
A43	1.1	0.4	0.3
B41	1.2	0.4	0.1
C41	1.3	0.4	0.1
D41	1.4	0.4	0.1

5.1.2 The Graphical Visualization

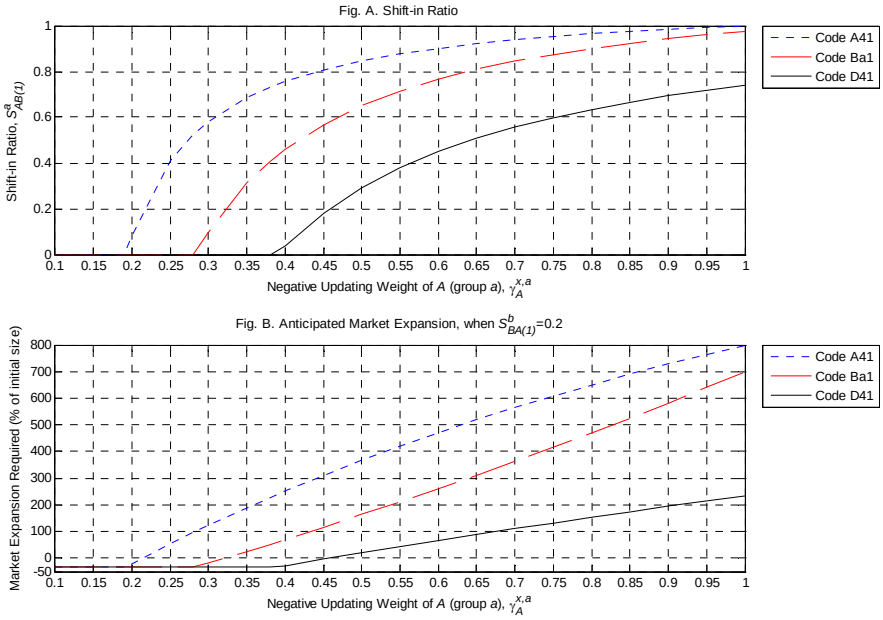
We use the programming language MATLAB to simulate and visualize Prop. 4.1a in this subsection.

As mentioned above, to formulate different values of ρ (i.e., $\rho = \gamma_A^{x,a} - \gamma_B^{y,a}$), we let $\gamma_B^{y,a}$ be the parameter and operate $\gamma_A^{x,a}$ as the input variable. We choose the value of $\gamma_A^{x,a}$ from 19 discrete numbers with a step size at 0.05 on the interval [0.1, 1]. The lower limit of $\gamma_A^{x,a}$ is 0.1 because we assume $1 \geq \gamma_A^{x,a} > \gamma_A^{y,a} > \gamma_B^{x,a} > \gamma_B^{y,a} > 0$ in Prop. 4.1a and let the minimum value of $\gamma_B^{y,a}$ equals to 0.1. At each run of experiment, we apply one code and show the relation between the input variable ($\gamma_A^{x,a}$) and two output variables, namely

[5] For the codes, we use different English letters and numbers to represent the value of parameters (from the left-hand side): *A* denotes 1.1, *B* denotes 1.2, *C* denotes 1.3, *D* denotes 1.4; *a* represents 0.333, *b* represents 0.367; *1* denotes 0.1, *2* denotes 0.2, *3* denotes 0.3, *4* denotes 0.4.

the group a's shift-in ratio ($S^{a}_{AB(1)}$) and the amount of required expansion of A (ΔM_A). A visualized example of the outcome is demonstrated in Fig. 5.2.

Figure 5.2: A visualized example of Prop. 4.1a



Three different codes representing different parameter sets are applied in Fig. 5.2. As illustrated in the above figure, for all the three codes, the value of shift-in ratio of group a ($S^{a}_{AB(1)}$) and the amount of required expansion of A (ΔM_A) increase when group a has a larger negative updating weight of A ($\gamma^{x,a}_{A}$) or, equivalently speaking, when the difference between $\gamma^{x,a}_{A}$ and $\gamma^{y,a}_{B}$ (i.e., ρ) becomes larger. The details of parameters in Fig. 5.2 are provided in Table 5.4 and the details of input and output variables can be found in Table A.3 in Appendix A.7.

Table 5.4: Details on the parameters in Fig. 5.2

Code	μ	$w^{x,a}$	$w^{y,a}$	δ	$\gamma_B^{y,b}$
A41	1.1	0.524	0.476	0.4	0.1
Ba1	1.2	0.545	0.455	0.333	0.1
D41	1.4	0.583	0.417	0.4	0.1

Indeed the concave curves presented in Fig. 5.2A describe different types of updating behaviors. As an example, when the negative updating weight $\gamma_A^{x,a} = 1$, brand *A* is expected to lose all of its customers (i.e., group *a*) to brand *B* in code *A41* (the blue dotted line) while, at the same weight , only 74% of the customers of brand *A* are expected to shift their preference to *B* in code *D41* (the black solid line). In this case, the different types of updating behaviors are caused by the different values of consumers' tastes (μ) (cf. Hauser and Shugan, 1983; Ansari et al., 1994). The rationale can be explained as follows. As mentioned in section 3.3, the consumers at the same preference segment (i.e., group) seek similar benefits. That is to say, if the consumers at group *a* place a larger emphasis on attribute *x* (i.e., a relatively large value of μ), they can receive more attribute-related benefits from the higher level of *x* of brand *A* (Mowen and Minor, 1998), and consequently they will have a smaller possibility to shift their preference to *B* (i.e., a relatively small value of $S_{AB(1)}^a$).

Moreover, in Fig. 5.2B, the shift-in ratio of *B*, $S_{BA(1)}^b$, is assumed to be 0.2 for deriving the amount of required expansion of *A*, and the expansion is expressed as a percentage of its initial market size of *A* (i.e., 100). The amount of expansion of *A* will be zero if $S_{AB(1)}^a = 0.2$ (e.g., $\gamma_A^{x,a} = 0.4575$ in code D41), and this will lead to an ideal situation whereby both brands, in the alliance, have the same preference share as that in the baseline situation (i.e., if the alliance is not formed). In that case, the partnership can be easily established without additional expansions.

5.2 Scenario Analyses

To describe the "functional co-branding alliance" presented in section 2.2.3, a hypothetical co-branding alliance formed by two brands (firms), *Appetite* (*A*) and *Bio* (*B*), is used as an example in the following. The two equally reputed brands are assumed to release several co-branded pizzas, *Appetite-Bio*, on the market. We use the co-branded pizza as an example because the food industry is the most commonly used stimuli in prior experimental studies in co-branding (Askegaard and Bengtsson, 2005). In so doing, future research can empirically test our results much easier.

At the beginning of the alliance, *Appetite* (*Bio*) has one group of loyal customers, group *a* (*b*), who are more familiar with *Appetite* (*Bio*) than *Bio* (*Appetite*). The two brands are assumed to be evaluated by two product-related attributes "good-taste" (*x*) and "low-calories" (*y*). Initially, *Appetite* (*Bio*) has a relatively high perceived attribute level on "good-taste" ("low-calories") while *Bio* (*Appetite*) has a relatively low level on the same attribute. This co-branding alliance also presents a better product-fit to the consumers (cf. definition 4.1). As explained in section 4.3.1, after co-branding, the belief of "good-taste" ("low-calories") of *Appetite* and the belief of "low-calories" ("good-taste") of *Bio* will receive a negative (positive) revision.

Starting from the above scenario we will simulate the influences of group *a*(*b*)'s negative revisions on *A*(*B*)'s intention regarding a partnership simultaneously (which corresponds to the combination of Prop. 4.1a and 4.1b). That is to say, we will utilize *a*'s updating weight of *x* of *A* ($\gamma_A^{x,a}$) and *b*'s updating weight of *y* of *B* ($\gamma_B^{y,b}$) as a set of input variables[6], and observe the corresponding changes of the necessary condition for the successful formation (i.e., the amount of required expansion, ΔM).

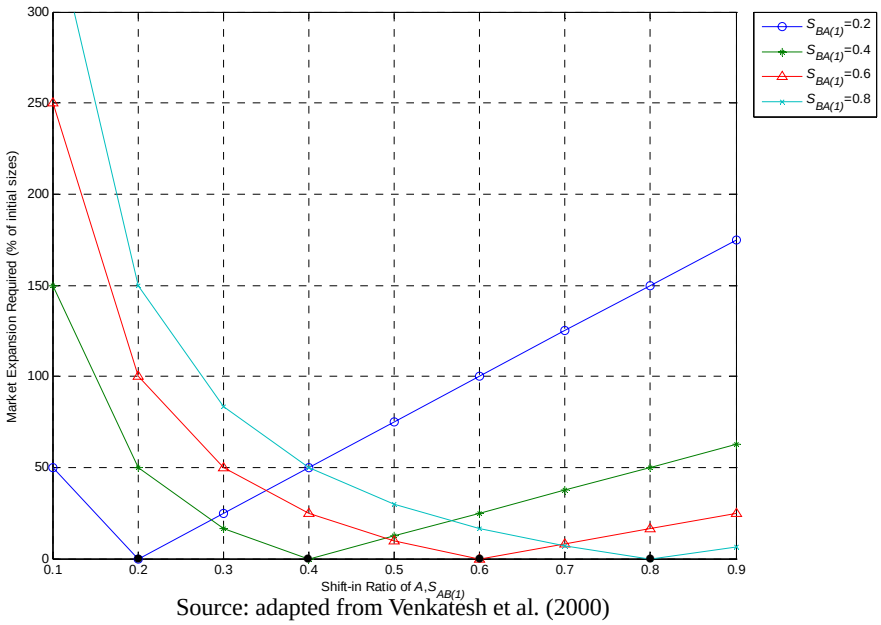
[6] As mentioned in section 5.1.2, to simulate Prop. 4.1a, we let $\gamma_B^{y,a}$ be a parameter and employ $\gamma_A^{x,a}$ as the input variable to determine different values of $\rho = \gamma_A^{x,a} - \gamma_B^{y,a}$; similarly, to simulate Prop. 4.1b, we fix the value of $\gamma_A^{x,b}$ and use $\gamma_B^{y,b}$ as the input variable to determine different values of $\eta = \gamma_B^{y,b} - \gamma_A^{x,b}$.

In short, the following scenarios will demonstrate how the necessary condition for the successful formation is affected by the difference of the negative belief revisions between *Appetite* and *Bio* (caused by each brand's loyal customers). In particular, in each scenario we also investigate whether the amount of required expansion can be zero, and this is an ideal situation whereby a co-branding alliance can be formed without additional expansions.

5.2.1 A Review of the Venkatesh et al.'s (2000) Simulation

Our experiment is an extension to Venkatesh et al. (2000). They related the amount of required expansion to a set of the shift-in ratios of the focal players. Fig. 5.3 replicates their results by using our notations. We choose the values of variables from the same range as Venkatesh et al. (2000). The value of $S_{AB(1)}$ is chosen from 9 discrete numbers with a step size of 0.1 on the interval [0.1, 0.9], and the value of $S_{BA(1)}$ is chosen from the set {0.2, 0.4, 0.6, 0.8}. The details of input and output variables can be found in Table A.4 in Appendix A.8.

Figure 5.3: Required market expansion of alliance success



Source: adapted from Venkatesh et al. (2000)

The amount of required expansion for the alliance (ΔM) is expressed as a percentage of the initial aggregated sizes of *Appetite* and *Bio* (we assume that initially each of the brands has 100 loyal customers) in the above figure. They found that the ideal situation can occur when the two brands' shift-in ratios are the same (i.e., represented by the black bullet points in Fig. 5.3 and these points indicate the amount of required expansion is 0). In other words, a similar value of shift-in ratio assures alliance success. They further claimed that some conditions, where the shift-in ratios are not the same, are still a prior strong for the alliance. For example, when *Appetite*'s shift-in ratio is 0.3 and *Bio*'s shift-in ratio is 0.4, the alliance requires only a modest expansion (i.e., 16.67%). They also argued that when *Appetite*'s shift-in ratio is 0.1 and *Bio*'s shift-in ratio is 0.4, the required expansion is rather large (i.e., 150%) and this is a priori weak condition for alliance formation. In brief, their simulation provides a concrete measure of alliance success.

Since we adapted their model to offer the behavioral contents behind the shift-in ratio, we are more interested in using consumers' updating weights as the input variables to observe the corresponding evolution of required expansion in the scenarios where the respective parameters (e.g., μ and δ) are either identical (scenario 5-1) or different (scenario 5-2, 5-3, 5-4) over the two customer groups.

5.2.2 Scenario 5-1: Identical Structure of Parameters

In scenario 5-1, we show the evolution of required expansion when the two groups have the same value for all the parameters. In other words, the customers of *Appetite* and the customers of *Bio* have a homogeneous updating behavior. The details of parameters are provided in Table 5.5. In doing so, it will be more straightforward to visualize how the relative magnitude of each group's negative revisions ($\gamma_A^{x,a}$ and $\gamma_B^{y,b}$) influences the successful formation. Noted that we will not consider the cases where the value of $\gamma_A^{x,a}$ ($\gamma_B^{y,b}$) is not bigger than

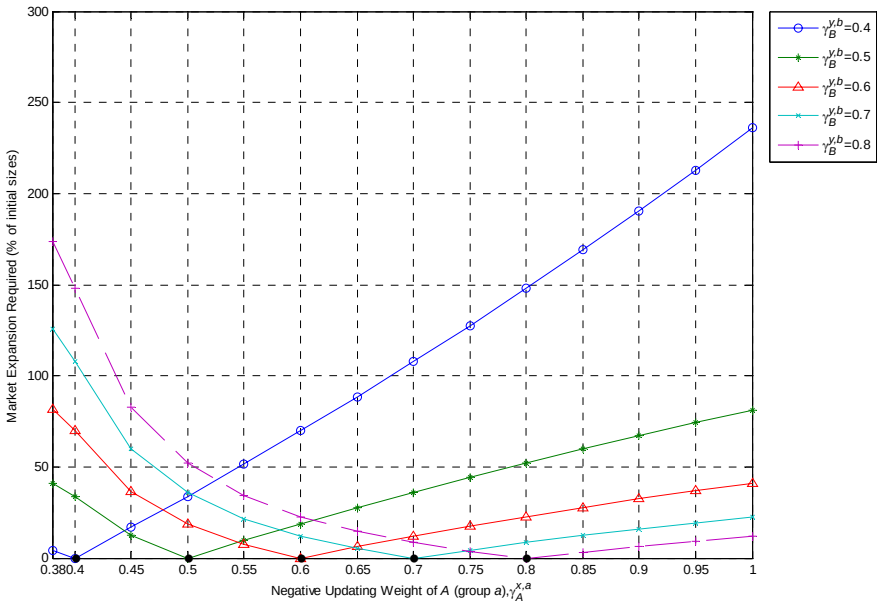
0.38 because in those cases *Appetite*'s (*Bio*'s) customers will not update their attribute beliefs of *Appetite* (*Bio*). Thus the corresponding shift-in ratio is 0 and this can in turn result in a failure of alliances (see p.12, Venkatesh et al., 2000). This condition also holds in scenario 5-2 and 5-3.

Table 5.5: Details on the parameters in scenario 5-1

Group *a*	M	μ	δ	$w^{x,a}$	$w^{y,a}$	$\gamma_B^{y,a}$	$\gamma_A^{x,a}$
	100	1.4	0.4	0.583	0.417	0.1	(0.38, 1)
Group *b*	M	μ	δ	$w^{y,b}$	$w^{x,b}$	$\gamma_A^{x,b}$	$\gamma_B^{y,b}$
	100	1.4	0.4	0.583	0.417	0.1	(0.38, 1)

Fig. 5.4 shows the relation between different value sets of negative updating weights (i.e., $\gamma_A^{x,a}$ and $\gamma_B^{y,b}$) and the amount of required expansion. The required expansion (ΔM) is expressed as a percentage of the original aggregated market size (i.e., 200). The details of input and output variables can be found in Table A.5 in Appendix A.9.

Figure 5.4: Results for scenario 5-1 (identical structure of parameters)



Venkatesh et al. (2000) claimed that the emergence of an ideal situation results from the same shift-in ratio of both brands, but our model addresses the importance of belief revisions. Fig. 5.4 demonstrates that an ideal situation can only exist when the magnitude of the negative revisions of *Appetite*'s customer on *Appetite* and *Bio*'s customers on *Bio* is the same **(**i.e., $\gamma_A^{x,a} = \gamma_B^{y,b}$, represented by the black bullet points). In those cases the "preference share" of *Appetite* (*Bio*) in the alliance will remain the same as that before the alliance (i.e., one-half). Therefore, no brands (firms) are worse off in the alliance, thus achieving a successful formation.

Apart from the ideal situation, a certain amount of expansion will be required. We argue that the alliance can be still effective when the difference of the negative belief updates between *Appetite* and *Bio* falls into a tolerating range (e.g., $\gamma_A^{x,a} = 0.6$ and $\gamma_B^{y,b} = 0.7$). Because in those cases the alliance needs just a modest expansion (i.e., below 16.67%, consistent with Venkatesh et al. (2000)). Conversely, when the difference of the negative updates on each of the brands is larger (e.g., $\gamma_A^{x,a} = 0.8$ and $\gamma_B^{y,b} = 0.4$), the expansion is rather large (around 150%). In this case, a larger portion (i.e., 63%) of *Appetite*'s consumers will shift their preferences to *Bio*. As a consequence, *Appetite* acts as the loser in terms of preference share in the partnership (i.e., the share shrinks from 50% to 20%). Therefore, it is more difficult for *Appetite* to agree to form this partnership. This condition is a priori weak for the brands to establish or sustain the alliance.

In sum, if an identical parameter structure for *Appetite* and *Bio* exists, each brand's customers are better to have the same level of negative revisions on that brand.

5.2.3 Scenario 5-2: Different Initial Segment Sizes

In section 4.2.5, we have used the segment size of each brand to signal the corresponding brand's initial "reputation" (p.5, Venkatesh et al., 2000) and assumed that the two brands are equally reputed. In this scenario, we relax this

assumption to observe the evolution of required expansion, when the allying brands' reputations are different (i.e., $M_{A(1)} \neq M_{B(1)}$, ceteris paribus). The details of parameters are provided in Table 5.6.

Table 5.6: Details on the parameters in scenario 5-2

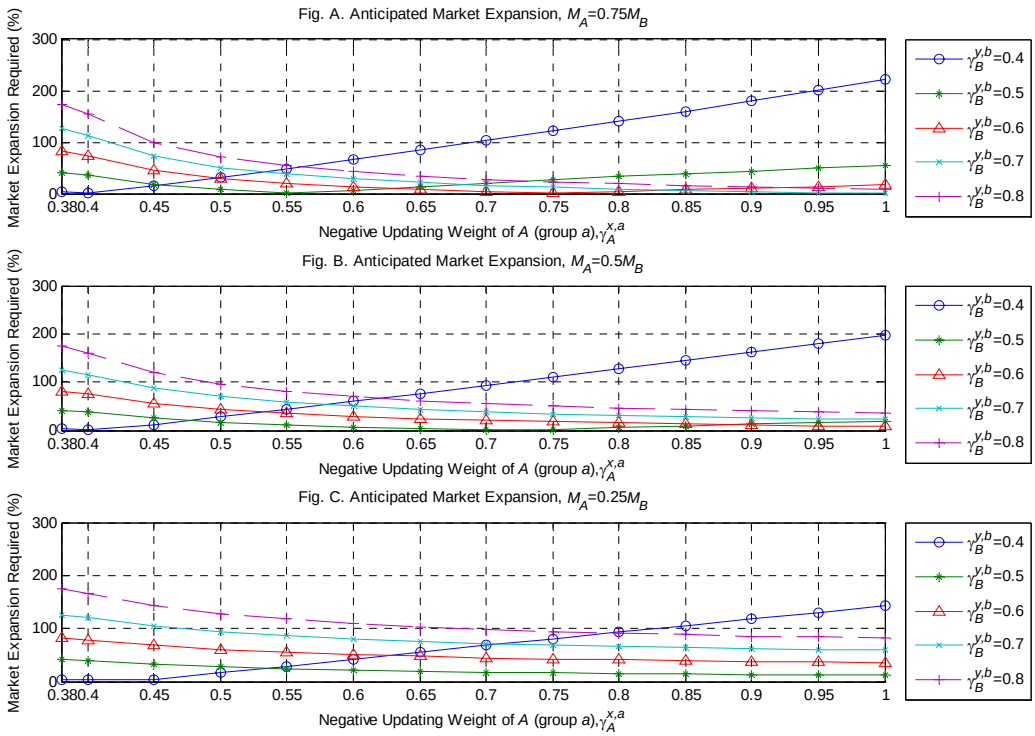
Group *a*	M_A[7]	μ	δ	$w^{x,a}$	$w^{y,a}$	$\gamma_B^{y,a}$	$\gamma_A^{x,a}$
	{75, 50, 25}	1.4	0.4	0.583	0.417	0.1	(0.38, 1)
Group *b*	M_B	μ	δ	$w^{y,b}$	$w^{x,b}$	$\gamma_A^{x,b}$	$\gamma_B^{y,b}$
	100	1.4	0.4	0.583	0.417	0.1	(0.38, 1)

We plot three different graphs to show the relation between different value sets of negative updating weights and the amount of required expansion in Fig. 5.5. In Fig. 5.5A, $M_A = 0.75 \times M_B$; in Fig. 5.5B, $M_A = 0.5 \times M_B$; in Fig. 5.5C, $M_A = 0.25 \times M_B$. As can be seen, the results in this scenario are different from that in scenario 5-1. Here, the ideal situation does not exist **(**i.e., the respective curve cannot reach the bottom**)**[8] when $\gamma_B^{y,b} \geq 0.7$ in Fig. 5.5A, $\gamma_B^{y,b} \geq 0.6$ in Fig. 5.5B, and $\gamma_B^{y,b} \geq 0.5$ in Fig. 5.5C. In addition, the required expansion is not modest (at least 22.9%) when $\gamma_B^{y,b} \geq 0.7$ in Fig. 5.5B and $\gamma_B^{y,b} \geq 0.6$ in Fig. 5.5C. In those two cases, the amount of expansion is more difficult to be achieved. The details of input and output variables can be found in Table A.7, A.8, and A.9 in Appendix A.10.

[7] For notational simplicity, we drop the notation of time index of the market size in the following sections.

[8] In Fig. 5.5, the curve with a kink-point (e.g., $\gamma_B^{y,b} \leq 0.6$ in Fig. 5.5A) will reach the bottom (i.e., an ideal situation exists). However, we cannot always show this specific point (e.g., for $\gamma_B^{y,b} = 0.4$, $\gamma_A^{x,a}$ is around 0.40387 in Fig. 5.5A) because the value of $\gamma_A^{x,a}$ is chosen with a step size of 0.05.

Figure 5.5: Results for scenario 5-2 (different initial segment sizes)



In fact, the non-existence of an ideal situation can be attributed to the incompatible brand reputations. For instance, when *Bio*'s customers have a considerable negative update on *Bio* (e.g., $\gamma_B^{y,b} \geq 0.6$ in Fig. 5.5B), the equilibrium share of *Bio* in the alliance is always smaller than its initial level of 66.7%. Eventually, *Bio* must expand its market size if it partners with *Appetite*. On the other hand, *Appetite* benefits from the alliance as it can always achieve its initial preference share of 33.3%. Hence, this alliance is not appealing to *Bio* and *Bio* would definitely make a retreat. Thus, we can conclude that it is better for *Appetite* and *Bio* to have the same level of "reputation" because this helps both brands (firms) acquire a sufficient share from the alliance. In addition, a compatible brand reputation can also be thought of as one type of the "similar resource endowment" (cf. Bucklin and Sengupta, 1993) since we assume that consumer preferences are considered to be the resource to be exchanged in a

partnership. Note that the results of scenario 5-2 do not violate Rule 4.1. Here co-branding success and partner selection are analyzed from the perspective of inter-organizational exchange, which is different from the signaling perspective.

5.2.4 Scenario 5-3: Different Relative Weights of Attribute Importance

In scenario 5-3, we relax the assumption of the same ratio of relative weights of attribute importance over two groups (μ) in our mathematical model (cf. Eq. (4.30)). That is to say, we allow the customers of *Appetite* and *Bio* to have different ratios of relative weights (i.e., $\mu^a \neq \mu^b$, ceteris paribus). By using the expectancy-value model, a larger ratio of relative weights may contribute to a higher level of attitudinal favorability of one brand and, as a consequence thereof, a higher degree of brand loyalty (Dyson et al., 1996). For example, when the customers of *Appetite* (*Bio*) concern the attribute "good-taste" ("low-calories") more, μ becomes larger (cf. Eq. (4.30)). Accordingly, the attitudes of *Appetite*'s (*Bio*'s) customers toward *Appetite* (*Bio*) will be enhanced (cf. Eq. (4.2)) because *Appetite* (*Bio*)'s customers receive more benefits from the better performance level of "good-taste" ("low-calories") of *Appetite* (*Bio*) (Mowen and Minor, 1998). Equivalently speaking, the customers of *Appetite* (*Bio*) will have a relatively high degree of brand loyalty to *Appetite* (*Bio*). In the broader sense the brand loyalty here can be referred to the "attribute loyalty" (cf. Hillyer and Tikoo, 1995), because consumers are loyal to a brand possessing more specific attribute-related benefits that they are seeking.

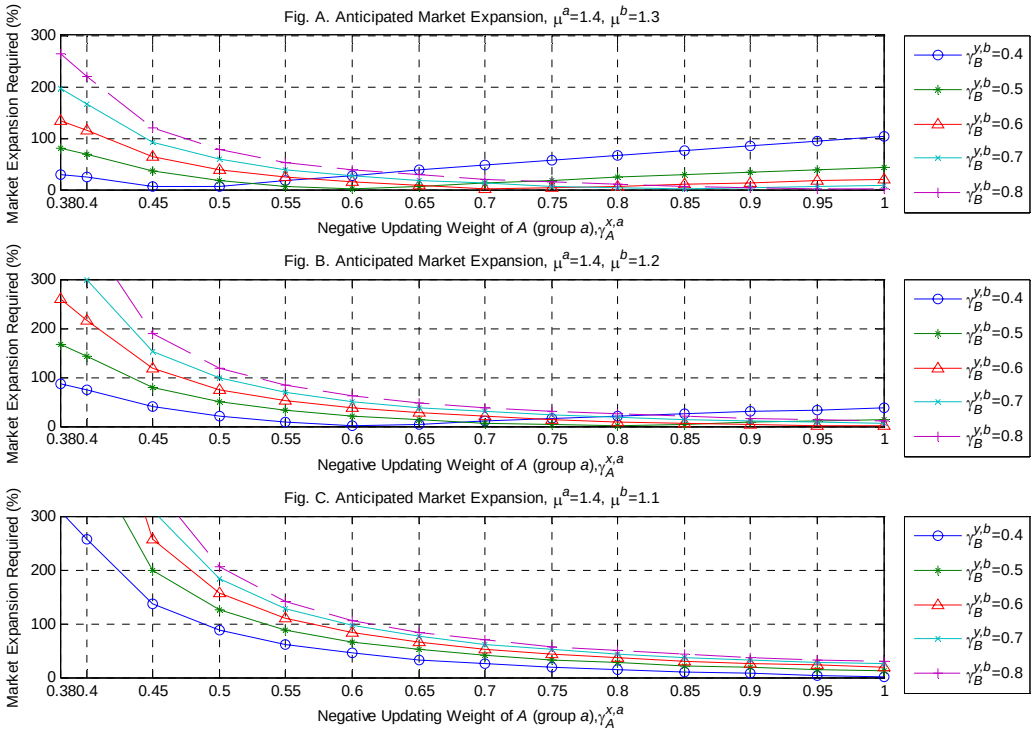
So, the purpose of this scenario is to illustrate the evolution of required expansion when *Appetite*'s and *Bio*'s customers have different levels of loyalty to *Appetite* and *Bio*, respectively. The details of parameters in scenario 5-3 are provided in Table 5.7.

Table 5.7: Details on the parameters in scenario 5-3

Group	M	μ^a	δ	$w^{x,a}$	$w^{y,a}$	$\gamma_B^{y,a}$	$\gamma_A^{x,a}$
a	100	1.4	0.4	0.583	0.417	0.1	(0.38, 1)
Group	M	μ^b	δ	$w^{y,b}$	$w^{x,b}$	$\gamma_A^{x,b}$	$\gamma_B^{y,b}$
b	100	{1.3, 1.2, 1.1}	0.4	{0.565, 0.545, 0.524}	{0.435, 0.455, 0.476}	0.1	(0.38, 1)

We plot three different graphs to show the relation between different value sets of negative updating weights and the amount of required expansion in Fig. 5.6. In Fig. 5.6A, the difference of loyalty level between *Appetite*'s and *Bio*'s customers ($\mu^a = 1.4$ and $\mu^b = 1.3$) is smaller than in Fig. 5.6B ($\mu^a = 1.4$ and $\mu^b = 1.2$) and in Fig. 5.6C ($\mu^a = 1.4$ and $\mu^b = 1.1$). Similar to the results in scenario 5-2, the ideal situation is not likely to occur (i.e., the amount of required expansion is always positive) in some specific cases in Fig. 5.6B (i.e., when $\gamma_B^{y,b} \geq 0.7$) and in Fig. 5.6C. The details of input and output variables can be found in Table A.10, A.11, and A.12 in Appendix A.11.

Figure 5.6: Results for scenario 5-3 (different weights of attribute importance)



In this scenario, the non-existence of an ideal situation is caused by the different levels of customer loyalty of *Appetite* and *Bio*. For example, *Bio* always loses a relatively large amount of its customers when, compared to *Appetite*, the loyalty level of its customers is relatively low (Fig. 5.6C). In this case, *Bio* always has a shrinking equilibrium share (i.e., lower than 50%) if it allies with *Appetite*, and *Appetite* always dominates *Bio* by grabbing a larger equilibrium share (revenue) in the alliance. This might be a major reason for a failure of a partnership (cf. Venkatesh et al., 2000). Summing up, it is better for *Appetite* and *Bio* to have an equal level of customer loyalty because this can prevent the occurrence of the dominance case.

5.2.5 Scenario 5-4: Different Confusion Parameters

Scenario 5-4 relaxes another assumption: we investigate the evolution of required expansion when the customers of *Appetite* and *Bio* have different levels of confusions about the attribute beliefs of *Appetite-Bio*. The details of parameters in this scenario are provided in Table 5.8.

Table 5.8: Details on the parameters in scenario 5-4

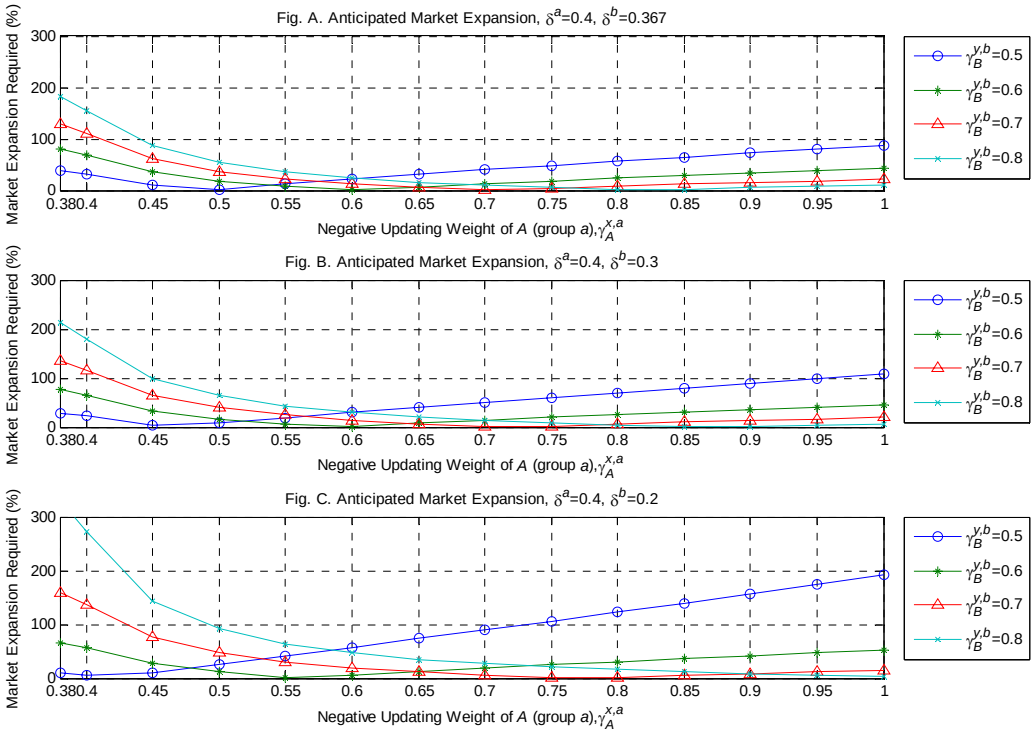
Group	M	μ	δ^a	$w^{x,a}$	$w^{y,a}$	$\gamma_B^{y,a}$	$\gamma_A^{x,a}$
a	100	1.4	0.4	0.583	0.417	0.1	(0.38, 1)
Group	M	μ	δ^b	$w^{y,b}$	$w^{x,b}$	$\gamma_A^{x,b}$	$\gamma_B^{y,b}$ [9]
b	100	1.4	{0.367; 0.3;0.2}[10]	0.583	0.417	0.1	(0.5, 1)

Fig. 5.7 illustrates this evolution and the details of input and output variables can be found in Table A.13, A.14, and A.15 in Appendix A.12. In Fig. 5.7A, $\delta^a = 0.4$ and $\delta^b = 0.367$; in Fig. 5.7B, $\delta^a = 0.4$ and $\delta^b = 0.3$. We find that the ideal situation can occur in both figures.

[9] In this scenario, we do not provide an experiment when $\gamma_B^{y,b} = 0.4$ because in that case *Bio*'s shift-in ratio is 0.

[10] The Euclidean distance among each value of δ^b is not the same because we pick up an outlier (i.e., 0.2) to show that the different levels of consumers' confusions can lead to an absolute loss of preference share for one brand.

Figure 5.7: Results for scenario 5-4 (different confusion parameters)



However, the ideal situation does not exist (i.e., the amount of expansion is always positive) in Figure 5.7C (when $\gamma_B^{y,b} \geq 0.8$). In that case, *Bio*'s customers have a relatively small confusion about the attribute beliefs of the *Appetite-Bio* pizza and this causes *Bio*'s absolute loss in terms of preference share[11] even if *Appetite*'s customers have a complete negative belief revision of *Appetite* (i.e., $\gamma_A^{x,a} = 1$). Finally, *Bio* has to bring more consumers from outside the alliance to maintain its initial share. Such a situation is not appealing to *Bio*. Although the parameter setting in Fig. 5.7C is not supported by the experiment result of Geylani et al. (2008) (i.e., the standard deviation of confusion is 3.92 when $\delta^b = 0.2$ and this is out of the reasonable range), our results can still be a benchmark for *Appetite* and *Bio*.

[11] In that case, a smaller level of confusion about the attribute levels of *Appetite-Bio* leads to a larger shift-in ratio and therefore causes an absolute loss of preference share.

In short, we suggest that the customers of *Appetite* and *Bio* are better to have the same level of confusions about the attribute beliefs of *Appetite-Bio* because an equal level of "confusions" prevents the case where one of the brands is always the loser in the alliance.

5.3 Summary and Limitation

Summing up, the current chapter provides an ex-ante measure for the allying brands (i.e., the two firms, *Appetite* and *Bio*) to predict the success of their partnership. We found that the ideal situation can occur when both brands (firms) are similar with respect to the magnitude of customers' belief revision (scenario 5-1), brand reputation (scenario 5-2), customer loyalty (scenario 5-3), and confusions about the co-branding beliefs (scenario 5-4). In particular, we would like to emphasize the importance of a compatible "reputation" because it is related to a "free-riding" problem – a less-reputed brand may contribute less but gain more from its partner (e.g., Rao et al., 1999). In order to avoid this problem, brand managers should carefully check the quantity of loyal customers before initiating or entering a co-branding alliance. In addition, in order to achieve the same level of customer loyalty (μ), brand managers can use persuasive advertisements (Mackenzie, 1986) to advocate the benefits reaped by a specific attribute where one brand excels (e.g., *Appetite*'s good-taste or *Bio*'s low-calories).

Our results might be useful in the following context: *Bio* knows some customer updating characteristics but has no idea of the negative updating weight of *Appetite*'s customers on *Appetite*. For example, *Bio* can go ahead for the partnership when *Appetite*'s segment size is only half of *Bio*'s (Fig. 5.5B), and *Bio*'s customers have a modest negative revision on itself (i.e., $\gamma_B^{y,b} \leq 0.5$). In this case, the ideal situation can occur. However, in the same condition, *Bio* can make a retreat from this alliance when its customers have a larger negative revision on itself (i.e., $\gamma_B^{y,b} \geq 0.6$) because it has no chances to earn more or at

least an equal level of preference share (revenue) from this partnership. Hence, it is difficult for *Bio* to agree to join this alliance.

There are two critical limitations in our numerical experiment. First, the ideal situation presented in this chapter is only valid when we analyze co-branding success from the perspective of inter-organizational exchange, and assume (1) the aggregated market size remains fixed over time and (2) the brands (firms) use the share of consumer preferences to split the sales revenue of the co-branded products. In other cases, some amounts of market expansion should exist to ensure that the co-branded products attract new customers from the competing brands (firms).

The other limitation in our numerical experiment is that the values of parameters are in a known set of numbers. In other words, our numerical experiment is in a deterministic setting (as compared to a stochastic setting, see Gibb et al., 2002). There are two main reasons for choosing the deterministic approach. First, in this dissertation, our experiment is just an add-on part for visualizing the results of our propositions in section 4.3. The full control of parameter values and the subsequent unique set of outputs are better for us to briefly demonstrate the scenario analyses in section 5-2. Secondly, Nawrocki (2001) has inferred that a single point estimate (i.e., a deterministic approach) may be sufficient if the analytical result can be obtained and the observed equations are not complex.

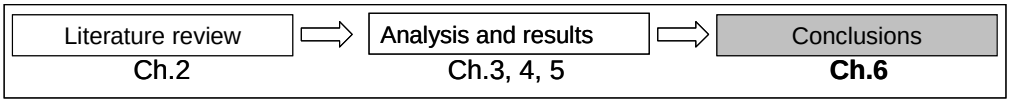
Of course, from a scientific point of view, the stochastic method may be more rigorous. Hence, one can challenge our arguments by proposing a Monte Carlo numerical experiment, which follows a random sampling procedure. In that case, the steps are listed in the following. First we should generate the random inputs for the parameters μ and δ (i.e., assigning the lower and upper bounds). Then we should assume that these two parameters follow a specific probability distribution (e.g., Gaussian distribution) and are independently distributed from

each other. Besides we treat $M_{A(l)}$, D, and $\gamma_B^{y,a}$ as constants. We operate $\gamma_A^{x,a}$ as the only variable and evaluate Eq. (4.35) for at least ten thousand times. Finally we save the results of shift-in ratio, $S_{AB(l)}^a$, and plot the results as a histogram in order to visualize the uncertainties of the shift-in ratios and required expansions.

Chapter 6
Conclusions and Outlook

The current chapter provides the answers to the research questions listed in section 1.3, concludes the success factors of a co-branding alliance (strategy), and discusses some directions for further research on this topic. The position of this chapter in this dissertation is presented in Fig. 6.1.

Figure 6.1: The position of chapter 6



This study applies the “top-down” approach to connect the necessary condition of a successful co-branding with the components of consumer evaluations. We briefly review the answers to the research questions of this study in the following. It should be noted that some of our findings are not universally valid and are only effective under specific assumptions – especially the arrangement of profit-sharing (cf. Venkatesh et al., 2000).

The first question(s) investigates the classification as well as the success factors of co-branding and can be answered as follows. The specific type of co-branding analyzed in this study is defined as a short-to-mid-term cooperation by two brands to release several joint products of the same product category as

the partnering brands. This partnership is thought of as one type of brand extension and thus it can be categorized in the “co-branding line extension” (Hadjicharalambous, 2006). Furthermore, the nature of this type of alliance is close to “co-marketing” since it is developed at the same level in the value-added chain. The purpose of this alliance is to offer a “complementary product”, which provides a better performance by combining the salient attributes of each of the allying brands. The success factors of co-branding are involved with a number of previous studies and are thus summarized in section 6.1.

The second question(s) explores the process of consumer evaluations of co-branding on the attitude and belief level. We find that the theories of information integration (Anderson, 1981), attitude accessibility (Fazio et al., 1989), contrast effect (Lynch et al., 1991), and the model of accommodation (Park et al., 1993; Thorbjørnsen, 2005) provide the grounds for the respective preference change in co-branding. We conclude with a conceptual model to show that the post-exposure attitudes toward the allying brands are influenced by three important effects, namely the extension effect, the mutual effect, and the reciprocal effect. We find that the relative strength of these effects can determine preference change. We claim that the co-branding beliefs are merged and transferred from the pre-alliance beliefs, and that finally a reciprocal effect on the belief level can exist (i.e., belief revisions).

Finally, the third question(s) concerns how belief revision influences the success of co-branding, and when (under which circumstances) an ideal situation can occur. We argue that the attribute complementarity, although representing a better product fit, can cause belief revision of the allying brands. We find that the relative magnitude of belief revisions on each of the allying brands may affect the brands (firms)’ intentions of joining the partnership (Prop. 4.1a(b) and 4.2a(b)). In addition we support the argument that the attribute-levels of the allying brands should be perceived as only “moderately apart” (cf. Rule 4.2 and Example 4.1), because the respective preference shifts can occur and thus create

mutual benefits, which are at the heart of dynamic alliances (p.272, Seno and Lukas, 2007).

The results of a numerical experiment recommend that the allying brands (or the partnering firms) should preferably be equivalent in terms of their resource endowments, namely brand reputation (scenario 5-2), customer loyalty (scenario 5-3), and customers' confusions (scenario 5-4). In doing so, the partners have a larger possibility to achieve an ideal situation whereby their alliance can be easily established without additional expansions.

6.1 The Success Factors of Co-branding

Table 6.1 summarizes the success factors of a co-branding alliance (strategy) from this dissertation as well as from the explicit findings of previous studies (cf. Table 2.4).

Table 6.1: The success factors of co-branding

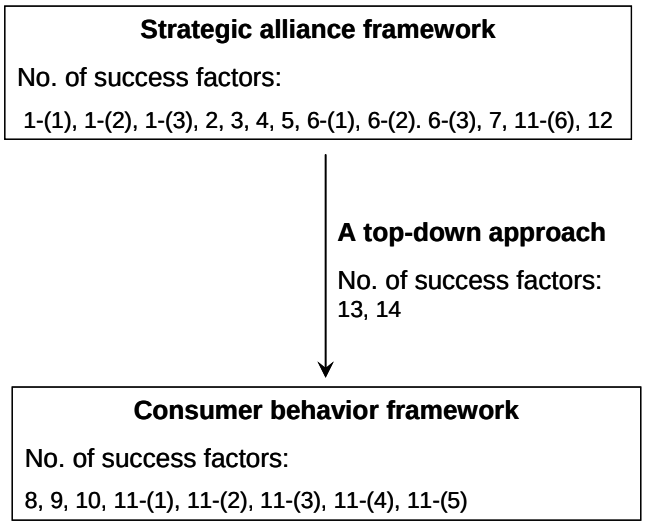
No. of success factors from existing studies		Arguments	Authors
1. Attributes of partnership	(1) Commitment	A high level of commitment is positively related to alliance success.	Angle and Perry (1981)
	(2) Coordination	A high level of coordination is positively related to alliance success.	Pfeffer and Salancik (1978)
	(3) Trust	The existence of trust is positively related to alliance success.	Mohr and Spekman (1994)
2. Communication behavior		A higher level of communication quality, more information sharing between partners, and more participation in planning and goal setting are positively related to alliance success.	Devlin and Bleackley (1988); Mohr and Spekman (1994)
3. Conflict and its resolution		The less conflict, the greater the alliance success.	Bucklin and Sengupta (1993)
		The joint-problem solving and persuasion skills are the constructive techniques to solve conflicts and are positively related to alliance success.	Mohr and Spekman (1994)
4. Power and managerial imbalances		The imbalance of power and managerial resource are negatively related to alliance success.	Bucklin and Sengupta (1993)
5. Profit scanning		Well-identified market opportunity and low-cost are positively related to alliance success.	Bucklin and Sengupta (1993)
6. Similarity	(1) Endowment	The similar endowments in terms of resource, market positions, and competitive capabilities are positively related to alliance success.	Bucklin and Sengupta (1993); Venkatesh et al. (2000)
	(2) Management style	The similar management style is positively related to alliance success.	Bucklin and Sengupta (1993)
	(3) Corporate culture	The similar corporate culture is positively related to alliance success.	Bucklin and Sengupta (1993)
7. Brand name		A good match in terms of brand name (i.e., lower-status with higher status) can signal an enhancement of perceived quality of the joint products and the allying brands.	Rao et al. (1999)
8. Brand associations		That the existing associations remain positive in the co-brand is positively related to co-branding's success.	James (2005)
		Co-branding will be successful if both brands are perceived to have competencies by consumers.	Helmig et al. (2008)
9. Brand orientations		A higher level of brand orientations has positive impacts on the consumer evaluations of co-brand.	Huber (2005)
10. Product involvements		A higher degree of product involvements has positive impacts on the consumer evaluations of co-brand.	Huber (2005)

11. Fit/Congruence	(1) Product fit	A better product fit (attribute complementarity or relatedness of product categories) is positively related a favorable evaluation of co-brand.	Park et al. (1996)
	(2) Brand fit	A better brand fit (consistent brand image) is positively related to a favorable evaluation of the co-brand.	Baumgarth (2004)
	(3) Fit between the co-brand and the joint product	A higher fit between the brand images of the allying brands and the joint product is positively related to a favorable evaluation of co-brand.	Bouten (2006)
	(4) Fit of brand personality	A similarity of brand personalities of both brands contributes the success of co-branding.	James et al. (2006)
	(5) Between-partner congruence	A (moderate) between-partner congruence leads to a favorable evaluation of the co-brand.	Walchli (2007); Hao (2008)
	(6) Organizational fit	The organizational fit is an important factor determining the success of co-branding.	Decker and Schlifter (2001)
12. Value creations		A Successful co-branding occurs when two brands add value to the partnership.	Leuthesser et al. (2003)
		The shift-in preference motivates the alliance formation and the equal shift-in ratio assures alliance success.	Venkatesh et al. (2000)
No. of success factors from current study[1]		Arguments	Example/Prop./Scenario
13. Product fit		It is optimal for one allying brand to find a complementary brand (partner) with only a moderately higher attribute level.	Example 4.1
14. Similarity		The equal level of the belief revisions of each brand's customers on that brand, ceteris paribus, assures the success of co-branding.	Prop. 4.1a(b) and 4.2a(b), Scenario 5-1
		The equal level of reputation, customer loyalty, and customers' confusions about the co-brand, ceteris paribus, assures the success of co-branding.	Scenario 5-2, 5-3, 5-4

[1] Please note that the success factors No. 13 and 14 are concluded for the "functional co-branding alliances" (cf. section 2.2.3), and are only valid under the respective assumptions in chapter 4.

As can be seen from Table 6.1, the major contribution of this study is to address the importance of two success factors, namely the “fit” and the “similarity”, among others. Our findings are robust because, starting from the theoretical foundation of the strategic alliance framework, we not only make a connection from the underlying reasons behind a successful alliance to the “elements” of consumer evaluations (i.e., factor No. 14 in Table 6.1), but also echo the results of the existing studies, which are conducted purely from the field of consumer behavior (i.e., the “moderate fit” in factor No. 13 echoes factor No. 11-(5) in Table 6.1). Fig. 6.2 separates the success factors into three sub-groups by different research frameworks.

Figure 6.2: The success factors of co-branding in different frameworks



In addition to the above contribution, we make another two contributions to the academic researchers in co-branding field. First, as the belief revision has been found in brand extension field (e.g., Loken and Roedder John, 1993; Roedder John et al., 1998; Milberg, 2001), we are the first to utilize the expectancy-value model (Bass and Talarzyk, 1972; Fishbein and Ajzen, 1975) to show quantitatively the existence of the “belief revision” in co-branding.

Secondly, to our knowledge, we are the first to offer a comprehensive and chronological review regarding the effectiveness of co-branding (cf. Table 2.4 and Table 6.1).

6.2 Future Research Directions

Some of the limitations in this dissertation provide avenues for future research opportunities. First of all, the specific alliance analyzed in this dissertation does not include one popular strategy in corporate branding, namely the ingredient branding. Ingredient branding concerns a physical combination of the brands at different stages in the value-added chain and hence it becomes more difficult to find a common product-related attribute for both brands. In that case, the fit of different product categories of the allying brands is important because it may affect the perceived quality of the joint products (Simonin and Ruth, 1998). Future research may formulate the attribute nature, the respective fit, and the cooperation/competition behaviors between the firms by adapting the Hotelling's model (1929) (e.g., Ansari et al., 1994).

Further, as illustrated in section 2.4.1, future research can utilize the bottom-up approach to examine the effectiveness of co-branding. Starting from the setting of market structure (e.g., Oligopoly), the bottom-up approach can offset an intrinsic limitation of our model – allowing the customers of each brand shift their preference to the third player and allowing the customers of the third player change their preference to one of the allying brands. In particular, one can apply the three-brand scenario (see section 3.3.3) to investigate how the belief revisions affect preference changes and the subsequent brand choice behaviors on the market level.

Thirdly, we do not measure the change of the customer-based brand equities of the partnering brands. The high customer-based brand equity indicates the strong brand associations, a better brand/product evaluation, and a better brand reputation (Keller, 1993; Washburn et al., 2000). Since the reputation is

measured by consumer preferences in our model, one can further investigate the pre- and post-equity by sizing the loyal customers before and after co-branding. For example, one may use the mechanism of belief updating (see section 4.2.3) to conduct an experiment (cf. Park et al., 1996; Washburn et al., 2000; Geylani et al., 2008) to show how the respective belief revisions influence the brand equities.

6.2.1 Potential Empirical Investigation

A critical limitation of this dissertation is the lack of empirical validations. According to Panda (2002), Leuthesser et al. (2003) and Helmig et al. (2008), existing empirical research on co-branding is still limited. To fill this gap, we feel a need to discuss the possible empirical investigations derived from each chapter of this dissertation in this subsection.

In section 2.2.2, we argued that co-branding is one type of brand extension. Hence future research can empirically test whether part of the determinants of extension success can be applied in the field of co-branding. Besides, Table 6.1 has concluded the success factors of co-branding and, based on these factors, one can develop several theoretical hypotheses and build up a conceptual framework. Then, for every hypothesis, we can gather empirical data and use structure equation modeling (e.g., by using LISREL or AMOS) to analyze the causal relationships between the factors and the success of co-branding (cf. Voelckner and Sattler, 2006). Because little is known about the factors determining the success of co-branding (Hadjicharalambous, 2006), the empirical results can be useful for brand managers to judge whether co-branding would be an appropriate strategy.

In section 3.3, we have offered the underlying reasons of “routes” of preference change in co-branding. Indeed, an experiment is needed to complete the “route” analysis. The experiment can be conducted by integrating the measure of fit (e.g., by using semantic differential scale, cf. Simonin and Ruth,

1998), and consumer preferences can be collected by rank order scaling (cf. Venkatesh et al., 2000). In chapter 4, we adapted the multi-attribute model to show the mechanism of belief revisions and to relate the link between belief revisions and the success of co-branding. To conduct a corresponding empirical study several parameters should be measured. First, for the composition of preference score ($\Phi^{G}_{R(i)}$), we can use the constant sum scaling (cf. Mackenzie, 1986) to measure the importance of relative weights ($w^{K,G}$). For the pre- and post-alliance beliefs ($P^{K,G}_{R(i)}$), we can use semantic differential scale scored either on a 1 to 7 scale (cf. Park et al., 1996) or on a 1 to 100 scale (cf. Geylani et al., 2008). Secondly, for the level of familiarity and the degree of confusions (δ), the semantic differential scales can be employed again (cf. Simonin and Ruth, 1998). The examples of measurement and scaling technique can be found in Appendix A.14.

Indeed the constant-sum approach for measuring relative attribute importance has been criticized in the field of preference measurement (e.g., Srinivasan, 1988). The scholars in preference measurement have provided a more rigorous examination of the attribute importance and the attribute levels. There are mainly four popular methods used by the researchers in preference measurement, namely (traditional) Conjoint Analysis (CA), Adaptive Conjoint Analysis (ACA), Computer-assisted Self-explication of Multi-attributed Preferences (CASEMAP), and Analytical Hierarchy Process (AHP). Since the 70's, CA, among others, remains the most widely accepted tool for decompositing consumer preferences (Carroll and Green, 1995). CA investigates how consumers make trade-offs among various products (Green et al., 2001) by analyzing the buyers' part-worth utilities. However, this traditional CA has been criticized for its information-overload problem (i.e., full-profile characteristic of products, see Srinivasan, 1988).

For solving that problem, Srinivasan (1988) developed the CASEMAP (Computer-assisted Self-explication of Multi-attributed Preferences) procedure,

which collects self-explicated data of attribute level and importance in an interval or ratio scale. CASEMAP in particular does not use the traditional way to measure attribute importance (e.g., how important is attribute *x*). Instead, this method utilizes the critical attribute as the anchor and compares it with other attributes. Although the self-explicated method avoids the information-overload problem, the difficulties of estimating unacceptable attribute levels and the lack of trade-off perspective (Meissner et al., 2008) are its weaknesses.

Another popular and commonly-accepted solution for solving the information-overload problem is ACA (Johnson, 1987a). ACA is a hybrid approach in the sense that it consists of the elements from the self-explicit and the conjoint parts simultaneously. That is, at the beginning of the survey, the respondents are asked to elicit levels of attributes that they consider totally unacceptable. Then ACA presents a series of pairwise questionnaires for the respondents to declare their preferences from each pair of designed products. All in all, ACA is famous for its robustness but is sometimes criticized due to the nature of partial-profile.

AHP (Saaty, 1977) is also an effective method in measuring attribute-based preferences and in analyzing complex decision problems (Meissner et al., 2008). AHP breaks down the preference with a hierarchic structure. In contrast to ACA, AHP is empirically proved to have a higher accuracy regarding choice prediction under a complex-product setting (Meissner et al., 2008). Recently a modified version of AHP, Paired Comparison-based Preference Measurement (PCPM) is empirically proved to have better results with respect to interview length, individual hit rates and aggregate choice share (Scholz et al., forthcoming). In short, there is no denying that preference measurement has been an important topic in developing new brands and products (Helm et al., 2004). To our knowledge, there is no application of preference measurement in the field of co-branding. Since co-branding is often viewed as a new product development strategy, future research in this field can use the above methods to design the

characteristics (positioning) of the joint products and predict corresponding market shares.

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Appendix A.1: Necessary Condition of Alliance Formation (1)

According to Venkatesh et al. (p.25, 2000), the proof of necessary condition for a successful co-branding is listed below.

Proof.

Let the sales (per period) of product $J_{R(.)}$ of brand *R* (*R=A*, *B*) in the steady state be $fM_{R(I)}$, where "*f*" is a constant multiple of the market size and related to the number of units of the product that consumers buy per period in the steady state. For example, in the baseline situation, if *A*'s loyal customer base is 100 and if it sells 200 units of different generations of the products, then *f* is 2.

For product $J_{AB(.)}$, in the steady state, the share of sales due to *A* (or *B*) being the primary reason

$$= \frac{S_{BA}}{S_{AB} + S_{BA}} \left(\frac{S_{AB}}{S_{AB} + S_{BA}} \right). \tag{A.1.1}$$

Assuming *A* will either break off or not enter the alliance if the equilibrium unit sales of $J_{AB(.)}$ due to *A* being the primary reason is less than the equilibrium sales of $J_{R(.)}$. That is to say, for *A*, the necessary condition of forming the alliance is

$$fM_{A(I)} \le f\left(\frac{S_{BA}}{S_{AB} + S_{BA}} \right)\left(M_{A(I)} + M_{B(I)} + \Delta M_A \right). \tag{A.1.2}$$

After making suitable algebraic manipulation, Eq. (A.1.2) can be written as

$$\Delta M_A \ge M_{A(I)}\left(S_{AB}/S_{BA} \right) - M_{B(I)}. \tag{A.1.3}$$

Similarly, for *B*, the necessary condition can be expressed as

$$\Delta M_B \ge M_{B(I)}\left(S_{BA}/S_{AB} \right) - M_{A(I)}. \tag{A.1.4}$$

Hence, the necessary condition for alliance formation is

$$\Delta M \ge Max\left\{ M_{A(I)}\left(\frac{S_{AB}}{S_{BA}} \right) - M_{B(I)}, M_{B(I)}\left(\frac{S_{BA}}{S_{AB}} \right) - M_{A(I)} \right\} \text{ for } S_{AB,}\, S_{BA} \ne 0. \tag{A.1.5}$$

Appendix A.2: The Setting of Attribute-level Difference

The setting of equal attribute-level difference between brand *A* and *B* (Eq. (4.7)) is inspired from Geylani et al. (p.736, 2008). In their experiment setting, durability and style are the product attributes of the luggage (*L*) and clothes (*C*) brands. Sixteen experimental conditions are designed for further validations. Table A.1 replicates parts of their experimental conditions.

Table A.1: Experimental conditions of Geylani et al. (2008)

Cell	Mean (*L*'s durability)	Mean (*C*'s durability)	Mean (*L*'s style)	Mean (*C*'s style)
a	80	60	60	80
b	80	30	60	80
c	80	60	30	80
d	80	30	30	80
e	80	60	60	80
f	80	60	60	80
g	80	60	60	80
h	80	30	60	80
i	80	30	60	80
j	80	30	60	80
k	80	60	30	80
l	80	60	30	80
m	80	60	30	80
n	80	30	30	80
o	80	30	30	80
p	80	30	30	80

Note: the scores are out of 100.

The beliefs about durability and style are normally distributed in their study and, from the above table, one can easily check difference of the mean values of durability (style) between *L* and *C* is assumed to be equal in some cells (e.g., the differences of durability and style are both equal to 20 in cell a). This motivates our setting of an equal attribute-level difference in Eq. (4.7).

Appendix A.3: Necessary Condition of Alliance Formation (2)

By adapting the Venkatesh et al. (p.25, 2000) model, the proof of necessary condition for a successful co-branding in our model is shown as follows.

Proof.

Let the sales (per period) of product $J_{R(.)}$ of brand R ($R = A, B$) in the steady state be $fM_{R(1)}$, where "f" is a constant multiple of the market size and related to the number of units of the product that consumers buy per period in the steady state.

As mentioned in section 4.2.5, for product $J_{AB(.)}$, in the steady state, the share of sales due to brand A (B) being the primary reason

$$= \left(1 - S^{a}_{AB(1)} + S^{b}_{BA(1)}\right)/2 \quad \left(\left(1 + S^{a}_{AB(1)} - S^{b}_{BA(1)}\right)/2\right). \tag{A.3.1}$$

Assuming A will either break off or not enter the alliance if the equilibrium unit sales of $J_{AB(.)}$ due to A being the primary reason is less than the equilibrium sales of $J_{R(.)}$. That is, for A, the necessary condition of forming the alliance is

$$fM \le f\left[\left(1 - S^{a}_{AB(1)} + S^{b}_{BA(1)}\right)/2\right] \times \left(2M + \Delta M_{A}\right). \tag{A.3.2}$$

After making suitable algebraic manipulation, Eq. (A.3.2) can be written as

$$\Delta M_{A} \ge \left[2/\left(1 - S^{a}_{AB(1)} + S^{b}_{BA(1)}\right) - 2\right]M. \tag{A.3.3}$$

Following the same logic, the necessary condition for B can be expressed as

$$\Delta M_{B} \ge \left[2/\left(1 + S^{a}_{AB(1)} - S^{b}_{BA(1)}\right) - 2\right]M. \tag{A.3.4}$$

Hence, the necessary condition for alliance formation is

$$\Delta M \ge Max\left\{\Delta M_{A}, \Delta M_{B}\right\}. \tag{A.3.5}$$

Appendix A.4: Proof of Proposition 4.1b

By using Eqs. (4.30) and (4.33), Eq. (4.29) can be rearranged as:

$$S^{b}_{BA(1)} = Pr\left[\frac{w^{x,b}D\left(1-\frac{1}{2}\gamma^{x,b}_{A}-\frac{1}{2}\gamma^{x,b}_{B}-\mu+\frac{1}{2}\mu\gamma^{y,b}_{A}+\frac{1}{2}\mu\gamma^{y,b}_{B}\right)}{w^{x,b}\left(\gamma^{x,b}_{B}-\gamma^{x,b}_{A}+\mu\gamma^{y,b}_{B}-\mu\gamma^{y,b}_{A}\right)}>\varepsilon\right]. \quad \text{(A.4.1)}$$

By canceling out $w^{x,b}$ and assuming $1\geq\gamma^{x,b}_{B}>\gamma^{y,b}_{B}>\gamma^{x,b}_{A}>\gamma^{y,b}_{A}>0$ and $\gamma^{x,b}_{B}=\mu\gamma^{y,b}_{A}$, Eq. (A.4.1) can be given by

$$S^{b}_{BA(1)} = Pr\left[D\left(\frac{1-\mu}{\mu\gamma^{y,b}_{B}-\gamma^{x,b}_{A}}+\frac{1}{2}\right)>\varepsilon\right]. \quad \text{(A.4.2)}$$

If we use η to represent $\left(\gamma^{y,b}_{B}-\gamma^{x,b}_{A}\right)$, Eq. (A.4.2) can be written as follows:

$$S^{b}_{BA(1)} = Pr\left\{D\left[\frac{1-\mu}{(\mu-1)\left(\eta+\gamma^{x,b}_{A}\right)+\eta}+\frac{1}{2}\right]>\varepsilon\right\}. \quad \text{(A.4.3)}$$

Let Q be the term $D\left[\frac{(1-\mu)}{(\mu-1)\left(\eta+\gamma^{x,b}_{A}\right)+\eta}+\frac{1}{2}\right]$,

$$S^{b}_{BA(1)} = Pr(Q>\varepsilon). \quad \text{(A.4.4)}$$

Because ε is uniformly distributed on the interval $[-\theta,\theta]$,

$$S^{b}_{BA(1)} = \frac{Q+\theta}{2\theta}, \text{ if } -\theta < Q < \theta. \quad \text{(A.4.5)}$$

Since $\frac{\partial S^{b}_{BA(1)}}{\partial Q}>0$ and $\frac{\partial Q}{\partial\eta}>0$

$$\frac{\partial S^{b}_{BA(1)}}{\partial\eta}>0. \quad \text{(A.4.6)}$$

Moreover, the required expansion (necessary condition) for *B* to forge the

alliance is at least

$$\left[\frac{2}{1+S^{a}_{AB(1)}-S^{b}_{BA(1)}}-2\right]M\ . \qquad \text{(A.4.7)}$$

If assuming all the other variables being the same in Eq. (A.4.7), one can easily confirm that the volume of required expansion for *B* will increase as $\eta=\left(\gamma_{B}^{y,b}-\gamma_{A}^{x,b}\right)$ increases. Q.E.D.

Appendix A.5: Proof of Proposition 4.2b

Followed by Eqs. (4.30) and (4.42) and substituting $w^{y,b}$ from Eq. (4.29) by $\mu w^{x,b}$, Eq. (4.29) can be rearranged as:

$$S^{b}_{BA(1)} = Pr\left[\frac{D\left(1-\frac{1}{2}\gamma^{x,b}_{A}-\frac{1}{2}\gamma^{x,b}_{B}-\mu+\frac{1}{2}\mu\gamma^{y,b}_{A}+\frac{1}{2}\mu\gamma^{y,b}_{B}\right)}{\left(\gamma^{x,b}_{B}-\gamma^{x,b}_{A}+\mu\gamma^{y,b}_{B}-\mu\gamma^{y,b}_{A}\right)}<\varepsilon\right]. \qquad \text{(A.5.1)}$$

Assuming $1 \geq \gamma^{x,b}_{A} > \gamma^{y,b}_{A} > \gamma^{x,b}_{B} > \gamma^{y,b}_{B} > 0$ and $\gamma^{x,b}_{A} = \mu\gamma^{y,b}_{B}$, Eq. (A.5.1) can be given by

$$S^{b}_{BA(1)} = Pr\left[D\left(\frac{1-\mu}{-\mu\gamma^{y,b}_{A}+\gamma^{x,b}_{B}}-\frac{1}{2}\right)<\varepsilon\right]. \qquad \text{(A.5.2)}$$

If we use ω to represent $\left(\gamma^{y,b}_{A}-\gamma^{x,b}_{B}\right)$, Eq. (A.5.2) can be written as follows:

$$S^{b}_{BA(1)} = Pr\left\{D\left[\frac{1-\mu}{-(\mu-1)(\omega+\gamma^{x,b}_{B})-\omega}-\frac{1}{2}\right]<\varepsilon\right\}. \qquad \text{(A.5.3)}$$

Let Z be the term $D\left[\frac{(1-\mu)}{-(\mu-1)(\omega+\gamma^{x,b}_{B})-\omega}-\frac{1}{2}\right]$, we obtain

$$S^{b}_{BA(1)} = Pr(Z<\varepsilon) = 1 - Pr(Z>\varepsilon). \qquad \text{(A.5.4)}$$

Since ε is uniformly distributed on the interval: $[-\theta,\theta]$,

$$S^{b}_{BA(1)} = 1-\frac{(Z+\theta)}{2\theta} = \frac{\theta-Z}{2\theta}, \text{ if } -\theta < Z < \theta. \qquad \text{(A.5.5)}$$

Since $\frac{\partial S^{b}_{BA(1)}}{\partial Z} < 0$ and $\frac{\partial Z}{\partial \omega} < 0$, we get

$$\frac{\partial S^{b}_{BA(1)}}{\partial \omega} > 0. \qquad \text{(A.5.6)}$$

Moreover, the required expansion for B to establish the alliance is at least

$$\left[\frac{2}{1+S^{a}_{AB(1)}-S^{b}_{BA(1)}}-2\right]M\ . \tag{A.5.7}$$

If assuming all the other variables being the same in Eq. (A.5.7), one can easily confirm that the volume of required expansion for B will increase as $\omega=\left(\gamma^{y,b}_{A}-\gamma^{x,b}_{B}\right)$ increases. Q.E.D.

Appendix A.6: The Details of Experiment Codes

We use different English letters and numbers to represent the value of parameters of each code (from the left-hand side): *A* denotes 1.1, *B* denotes 1.2, *C* denotes 1.3, *D* denotes 1.4; *a* represents 0.333, *b* represents 0.367; *1* denotes 0.1, *2* denotes 0.2, *3* denotes 0.3, *4* denotes 0.4. Table A.2 demonstrates the details of parameters in 48 different codes.

Table A.2: The details of codes

Code	μ	δ	$\gamma_B^{y,a}$
A31	1.1	0.3	0.1
A32	1.1	0.3	0.2
A33	1.1	0.3	0.3
Aa1	1.1	0.333	0.1
Aa2	1.1	0.333	0.2
Aa3	1.1	0.333	0.3
Ab1	1.1	0.367	0.1
Ab2	1.1	0.367	0.2
Ab3	1.1	0.367	0.3
A41	1.1	0.4	0.1
A42	1.1	0.4	0.2
A43	1.1	0.4	0.3
B31	1.2	0.3	0.1
B32	1.2	0.3	0.2
B33	1.2	0.3	0.3
Ba1	1.2	0.333	0.1
Ba2	1.2	0.333	0.2
Ba3	1.2	0.333	0.3
Bb1	1.2	0.367	0.1
Bb2	1.2	0.367	0.2
Bb3	1.2	0.367	0.3
B41	1.2	0.4	0.1
B42	1.2	0.4	0.2
B43	1.2	0.4	0.3
C31	1.3	0.3	0.1
C32	1.3	0.3	0.2
C33	1.3	0.3	0.3
Ca1	1.3	0.333	0.1
Ca2	1.3	0.333	0.2
Ca3	1.3	0.333	0.3
Cb1	1.3	0.367	0.1
Cb2	1.3	0.367	0.2
Cb3	1.3	0.367	0.3
C41	1.3	0.4	0.1
C42	1.3	0.4	0.2
C43	1.3	0.4	0.3
D31	1.4	0.3	0.1
D32	1.4	0.3	0.2
D33	1.4	0.3	0.3
Da1	1.4	0.333	0.1
Da2	1.4	0.333	0.2
Da3	1.4	0.333	0.3
Db1	1.4	0.367	0.1
Db2	1.4	0.367	0.2
Db3	1.4	0.367	0.3
D41	1.4	0.4	0.1
D42	1.4	0.4	0.2
D43	1.4	0.4	0.3

Appendix A.7: The Details of Variables in Fig. 5.2

One can easily check the details of variables $S^{a}_{AB(I)}$ and ΔM_{A} in Table A.3 by Eqs. (4.35) and (4.40).

Table A.3: The details of variables in Fig. 5.2

Variable / Code	$\gamma_{A}^{x,a}$	$S^{a}_{AB(I)}$	ΔM_{A}	$\frac{\Delta M_{A}}{M_{A}}\times 100(\%)$
A41	0.1	0	-33.33333333	-33.33333333
	0.15	0	-33.33333333	-33.33333333
	0.2	0.083333333	-20.89552239	-20.89552239
	0.25	0.410714286	53.39366516	53.39366516
	0.3	0.581521739	123.3743409	123.3743409
	0.35	0.686403509	189.41076	189.41076
	0.4	0.757352941	251.8272425	251.8272425
	0.45	0.808544304	310.9135004	310.9135004
	0.5	0.847222222	366.9291339	366.9291339
	0.55	0.877475248	420.1074444	420.1074444
	0.6	0.901785714	470.6586826	470.6586826
	0.65	0.921747967	518.7728269	518.7728269
	0.7	0.938432836	564.6219686	564.6219686
	0.75	0.952586207	608.3623693	608.3623693
	0.8	0.96474359	650.1362398	650.1362398
	0.85	0.975299401	690.0732845	690.0732845
	0.9	0.984550562	728.2920469	728.2920469
	0.95	0.992724868	764.9010849	764.9010849
	1	1	800	800
Ba1	0.1	0	-33.33333333	-33.33333333
	0.15	0	-33.33333333	-33.33333333
	0.2	0	-33.33333333	-33.33333333
	0.25	0	-33.33333333	-33.33333333
	0.3	0.095749596	-18.88166015	-18.88166015
	0.35	0.312312312	25.30446549	25.30446549
	0.4	0.460486803	70.44818227	70.44818227
	0.45	0.568250068	116.5809602	116.5809602
	0.5	0.65015015	163.7356636	163.7356636
	0.55	0.714500215	211.946629	211.946629
	0.6	0.766395428	261.2497487	261.2497487
	0.65	0.809132662	311.6825598	311.6825598
	0.7	0.844939534	363.2843395	363.2843395
	0.75	0.875375375	416.0962072	416.0962072
	0.8	0.901564355	470.1612337	470.1612337
	0.85	0.924337381	525.5245583	525.5245583
	0.9	0.944321873	582.2335147	582.2335147
	0.95	0.962000462	640.3377657	640.3377657
	1	0.977750478	699.8894485	699.8894485
D41	0.1	0	-33.33333333	-33.33333333
	0.15	0	-33.33333333	-33.33333333
	0.2	0	-33.33333333	-33.33333333
	0.25	0	-33.33333333	-33.33333333
	0.3	0	-33.33333333	-33.33333333

	0.35	0	-33.33333333	-33.33333333
	0.4	0.038043478	-27.87652011	-27.87652011
	0.45	0.181603774	-3.612783696	-3.612783696
	0.5	0.291666667	20.18348624	20.18348624
	0.55	0.378731343	43.52567015	43.52567015
	0.6	0.449324324	66.42664266	66.42664266
	0.65	0.507716049	88.89879626	88.89879626
	0.7	0.556818182	110.9540636	110.9540636
	0.75	0.598684211	132.6039387	132.6039387
	0.8	0.634803922	153.859497	153.859497
	0.85	0.666284404	174.7314138	174.7314138
	0.9	0.693965517	195.229983	195.229983
	0.95	0.718495935	215.365133	215.365133
	1	0.740384615	235.1464435	235.1464435

Appendix A.8: The Details of Variables in Fig. 5.3

Table A.4: The details of variables in Fig. 5.3

$S_{AB(1)}$	$S_{BA(1)}$	ΔM_A	ΔM_B	$\frac{\Delta M}{2M}\times 100(\%)^*$
0.1	0.2	-50	100	50
0.2	0.2	0	0	0
0.3	0.2	50	-33.33333333	25
0.4	0.2	100	-50	50
0.5	0.2	150	-60	75
0.6	0.2	200	-66.66666667	100
0.7	0.2	250	-71.42857143	125
0.8	0.2	300	-75	150
0.9	0.2	350	-77.77777778	175
0.1	0.4	-75	300	150
0.2	0.4	-50	100	50
0.3	0.4	-25	33.33333333	16.66666667
0.4	0.4	0	0	0
0.5	0.4	25	-20	12.5
0.6	0.4	50	-33.33333333	25
0.7	0.4	75	-42.85714286	37.5
0.8	0.4	100	-50	50
0.9	0.4	125	-55.55555556	62.5
0.1	0.6	-83.33333333	500	250
0.2	0.6	-66.66666667	200	100
0.3	0.6	-50	100	50
0.4	0.6	-33.33333333	50	25
0.5	0.6	-16.66666667	20	10
0.6	0.6	0	0	0
0.7	0.6	16.66666667	-14.28571429	8.333333333
0.8	0.6	33.33333333	-25	16.66666667
0.9	0.6	50	-33.33333333	25
0.1	0.8	-87.5	700	350
0.2	0.8	-75	300	150
0.3	0.8	-62.5	166.6666667	83.33333333
0.4	0.8	-50	100	50
0.5	0.8	-37.5	60	30
0.6	0.8	-25	33.33333333	16.66666667
0.7	0.8	-12.5	14.28571429	7.142857143
0.8	0.8	0	0	0
0.9	0.8	12.5	-11.11111111	6.25

* $\Delta M = Max\left[\Delta M_A, \Delta M_B\right]$

In Fig. 5.3, the amount of required expansion is expressed as a percentage of the initial aggregated sizes of *Appetite* and *Bio* (i.e., $(\Delta M/2M)\times 100$ (%) and M denotes the initial customer size of each brand). One can easily check the details of variables ΔM_A and ΔM_B in Table A.4 by Eqs. (A.1.3) and (A.1.4).

Appendix A.9: The Details of Variables in Fig. 5.4

Table A.5: The details of variables in Fig. 5.4

$\gamma_A^{x,a}$	$\gamma_B^{y,b}$	$S_{AB(I)}^{a}$	$S_{BA(I)}^{b}$	ΔM_A	ΔM_B	$\frac{\Delta M}{2M}\times 100(\%)^*$
0.38	0.4	0	0.038043	-7.3298429	7.90960452	3.95480226
0.4	0.4	0.03804347	0.038043	0	0	0
0.45	0.4	0.18160377	0.038043	33.5249042	-25.107604	16.7624521
0.5	0.4	0.29166666	0.038043	67.9611650	-40.462427	33.9805825
0.55	0.4	0.37873134	0.038043	103.346456	-50.822846	51.6732283
0.6	0.4	0.44932432	0.038043	139.720558	-58.284762	69.8602794
0.65	0.4	0.50771604	0.038043	177.125506	-63.915266	88.5627530
0.7	0.4	0.55681818	0.038043	215.605749	-68.314899	107.802874
0.75	0.4	0.59868421	0.038043	255.208333	-71.847507	127.604166
0.8	0.4	0.63480392	0.038043	295.983086	-74.746396	147.991543
0.85	0.4	0.66628440	0.038043	337.982832	-77.168054	168.991416
0.9	0.4	0.69396551	0.038043	381.263616	-79.221367	190.631808
0.95	0.4	0.71849593	0.038043	425.884955	-80.984434	212.942477
1	0.4	0.74038461	0.038043	471.910112	-82.514734	235.955056
0.38	0.5	0	0.29166666	-45.161290	82.3529411	41.17647059
0.4	0.5	0.03804347	0.29166666	-40.462427	67.9611650	33.98058252
0.45	0.5	0.18160377	0.29166666	-19.830028	24.7349823	12.36749117
0.5	0.5	0.29166666	0.29166666	0	0	0
0.55	0.5	0.37873134	0.29166666	19.0735694	-16.018306	9.536784741
0.6	0.5	0.44932432	0.29166666	37.4331550	-27.237354	18.71657754
0.65	0.5	0.50771604	0.29166666	55.1181102	-35.532994	27.55905512
0.7	0.5	0.55681818	0.29166666	72.1649484	-41.916167	36.08247423
0.75	0.5	0.59868421	0.29166666	88.6075949	-46.979865	44.30379747
0.8	0.5	0.63480392	0.29166666	104.477611	-51.094890	52.23880597
0.85	0.5	0.66628440	0.29166666	119.804401	-54.505005	59.90220049
0.9	0.5	0.69396551	0.29166666	134.615384	-57.377049	67.30769231
0.95	0.5	0.71849593	0.29166666	148.936170	-59.829059	74.46808511
1	0.5	0.74038461	0.29166666	162.790697	-61.946902	81.39534884
0.38	0.6	0	0.44932432	-62.004662	163.190184	81.59509202
0.4	0.6	0.03804347	0.44932432	-58.284762	139.720558	69.86027944
0.45	0.6	0.18160377	0.44932432	-42.236524	73.1197771	36.55988858
0.5	0.6	0.29166666	0.44932432	-27.237354	37.4331550	18.71657754
0.55	0.6	0.37873134	0.44932432	-13.187641	15.1909722	7.595486111
0.6	0.6	0.44932432	0.44932432	0	0	0
0.65	0.6	0.50771604	0.44932432	12.4025513	-11.034047	6.201275691
0.7	0.6	0.55681818	0.44932432	24.0880936	-19.412090	12.0440468
0.75	0.6	0.59868421	0.44932432	35.1170568	-25.990099	17.55852843
0.8	0.6	0.63480392	0.44932432	45.5432661	-31.291908	22.77163305
0.85	0.6	0.66628440	0.44932432	55.4148195	-35.656071	27.70740975
0.9	0.6	0.69396551	0.44932432	64.7748303	-39.311119	32.38741518
0.95	0.6	0.71849593	0.44932432	73.6620565	-42.416897	36.83102826
1	0.6	0.74038461	0.44932432	82.1114369	-45.088566	41.05571848
0.38	0.7	0	0.55681818	-71.532846	251.282051	125.6410256
0.4	0.7	0.03804347	0.55681818	-68.314899	215.605749	107.8028747
0.45	0.7	0.18160377	0.55681818	-54.568132	120.109814	60.05490734
0.5	0.7	0.29166666	0.55681818	-41.916167	72.1649484	36.08247423
0.55	0.7	0.37873134	0.55681818	-30.233227	43.3347090	21.66735452
0.6	0.7	0.44932432	0.55681818	-19.412090	24.0880936	12.0440468
0.65	0.7	0.50771604	0.55681818	-9.3607916	10.3275302	5.163765122

0.7	0.7	0.55681818	0.55681818	0	0	0
0.75	0.7	0.59868421	0.55681818	8.73907615	-8.0367393	4.369538077
0.8	0.7	0.63480392	0.55681818	16.9163847	-14.468788	8.458192363
0.85	0.7	0.66628440	0.55681818	24.5844064	-19.733132	12.29220323
0.9	0.7	0.69396551	0.55681818	31.7892824	-24.121295	15.89464124
0.95	0.7	0.71849593	0.55681818	38.5717434	-27.835215	19.28587172
1	0.7	0.74038461	0.55681818	44.9678800	-31.019202	22.48394004
0.38	0.8	0	0.63480392	-77.661169	347.651006	173.8255034
0.4	0.8	0.03804347	0.63480392	-74.746396	295.983086	147.9915433
0.45	0.8	0.18160377	0.63480392	-62.372708	165.764546	82.88227334
0.5	0.8	0.29166666	0.63480392	-51.094890	104.477611	52.23880597
0.55	0.8	0.37873134	0.63480392	-40.773532	68.8434303	34.42171518
0.6	0.8	0.44932432	0.63480392	-31.291908	45.5432661	22.77163305
0.65	0.8	0.50771604	0.63480392	-22.551546	29.1181364	14.55906822
0.7	0.8	0.55681818	0.63480392	-14.468788	16.9163847	8.458192363
0.75	0.8	0.59868421	0.63480392	-6.9721115	7.49464668	3.74732334
0.8	0.8	0.63480392	0.63480392	0	0	0
0.85	0.8	0.66628440	0.63480392	6.50074294	-6.1039414	3.250371471
0.9	0.8	0.69396551	0.63480392	12.5763564	-11.171401	6.288178225
0.95	0.8	0.71849593	0.63480392	18.2672233	-15.445719	9.133611691
1	0.8	0.74038461	0.63480392	23.6087689	-19.099590	11.80438449

* $\Delta M = Max\left[\Delta M_A, \Delta M_B\right]$

In Fig. 5.4, the amount of required expansion is expressed as a percentage of the initial aggregated sizes of *Appetite* and *Bio* (i.e., $\left(\Delta M/2M\right)\times 100(\%)$). One can easily check the details of variables $S^{a}_{AB(1)}$ and ΔM_A in Table A.5 by Eqs. (4.35), (4.40). Besides, $S^{b}_{BA(1)}$ and ΔM_B can be checked by Eqs. (A.4.4), and (A.4.7).

Appendix A.10: The Details of Variables in Fig. 5.5

The formula of required expansion of each brand in scenario 5-2 varies in different conditions where the segment sizes of both brands are different. Table A.6 lists the conditions, the algebra expressions of the required expansion, and the corresponding figure numbers. Table A.7, A.8, and A.9 demonstrate the values in the experiment and one can check the values of $S^{a}_{AB(1)}$ and $S^{b}_{BA(1)}$ by Eqs. (4.35) and (A.4.4), respectively.

Table A.6: The amounts of required expansion for different segment sizes

Condition*	ΔM_A	ΔM_B	No. of Figure
$M_A = 0.75M_B$	$\Delta M_A \geq \left[\frac{7\left(3S^{a}_{AB(1)} - 4S^{b}_{BA(1)}\right)}{4\left(3 - 3S^{a}_{AB(1)} + 4S^{b}_{BA(1)}\right)}\right]M$	$\Delta M_B \geq \left[\frac{7\left(-3S^{a}_{AB(1)} + 4S^{b}_{BA(1)}\right)}{4\left(4 + 3S^{a}_{AB(1)} - 4S^{b}_{BA(1)}\right)}\right]M$	Fig. 5.5A
$M_A = 0.5M_B$	$\Delta M_A \geq \left[\frac{3\left(S^{a}_{AB(1)} - 2S^{b}_{BA(1)}\right)}{2\left(1 - S^{a}_{AB(1)} + 2S^{b}_{BA(1)}\right)}\right]M$	$\Delta M_B \geq \left[\frac{3\left(-S^{a}_{AB(1)} + 2S^{b}_{BA(1)}\right)}{2\left(2 + S^{a}_{AB(1)} - 2S^{b}_{BA(1)}\right)}\right]M$	Fig. 5.5B
$M_A = 0.25M_B$	$\Delta M_A \geq \left[\frac{5\left(S^{a}_{AB(1)} - 4S^{b}_{BA(1)}\right)}{4\left(1 - S^{a}_{AB(1)} + 4S^{b}_{BA(1)}\right)}\right]M$	$\Delta M_B \geq \left[\frac{5\left(-S^{a}_{AB(1)} + 4S^{b}_{BA(1)}\right)}{4\left(4 + S^{a}_{AB(1)} - 4S^{b}_{BA(1)}\right)}\right]M$	Fig. 5.5C

*We assume $M_B = M$.

Table A.7: The details of variables in Fig. 5.5A

$\gamma^{x,a}_{A}$	$\gamma^{y,b}_{B}$	$S^{a}_{AB(1)}$	$S^{b}_{BA(1)}$	ΔM_A	ΔM_B	$\frac{\Delta M}{M_A + M_B} \times 100(\%)$ *
0.38	0.4	0	0.03804347	-8.4482758	6.92090395	3.95480226
0.4	0.4	0.03804347	0.03804347	-2.1914132	1.68038408	0.960219479
0.45	0.4	0.18160377	0.03804347	26.3528925	-15.642435	15.05879577
0.5	0.4	0.29166666	0.03804347	55.5489260	-26.783659	31.74224344
0.55	0.4	0.37873134	0.03804347	85.4192652	-34.551128	48.81100873
0.6	0.4	0.44932432	0.03804347	115.987543	-40.275775	66.27859643
0.65	0.4	0.50771604	0.03804347	147.278512	-44.669827	84.15914988
0.7	0.4	0.55681818	0.03804347	179.318106	-48.148894	102.4674892
0.75	0.4	0.59868421	0.03804347	212.133516	-50.971820	121.2191521
0.8	0.4	0.63480392	0.03804347	245.753266	-53.308230	140.4304381
0.85	0.4	0.66628440	0.03804347	280.207297	-55.273918	160.1184558
0.9	0.4	0.69396551	0.03804347	315.527053	-56.950633	180.3011732
0.95	0.4	0.71849593	0.03804347	351.745577	-58.397734	200.9974731
1	0.4	0.74038461	0.03804347	388.897620	-59.659364	222.2272115

0.38	0.5	0	0.29166666	-49	72.0588235	41.17647059
0.4	0.5	0.03804347	0.29166666	-45.451497	62.4923171	35.70989551
0.45	0.5	0.18160377	0.29166666	-30.046668	32.2143355	18.40819176
0.5	0.5	0.29166666	0.29166666	-15.506329	13.7640449	7.865168539
0.55	0.5	0.37873134	0.29166666	-1.7596962	1.34341218	0.767664108
0.6	0.5	0.44932432	0.29166666	11.2564922	-7.5882036	6.432281262
0.65	0.5	0.50771604	0.29166666	23.5989492	-14.319872	13.48511384
0.7	0.5	0.55681818	0.29166666	35.3186646	-19.575273	20.18209408
0.75	0.5	0.59868421	0.29166666	46.4616096	-23.792041	26.54949121
0.8	0.5	0.63480392	0.29166666	57.0693391	-27.250388	32.61105092
0.85	0.5	0.66628440	0.29166666	67.1795097	-30.138042	38.38829131
0.9	0.5	0.69396551	0.29166666	76.8263266	-32.585501	43.9007581
0.95	0.5	0.71849593	0.29166666	86.0409297	-34.686290	49.16624558
1	0.5	0.74038461	0.29166666	94.8517298	-36.509194	54.20098847
0.38	0.6	0	0.44932432	-65.563380	142.791411	81.59509202
0.4	0.6	0.03804347	0.44932432	-62.896371	127.136562	72.64946427
0.45	0.6	0.18160377	0.44932432	-51.542802	79.7757696	45.5861541
0.5	0.6	0.29166666	0.44932432	-41.149870	52.4423710	29.96706915
0.55	0.6	0.37873134	0.44932432	-31.600603	34.6500898	19.80005135
0.6	0.6	0.44932432	0.44932432	-22.796278	22.1455756	12.65461465
0.65	0.6	0.50771604	0.44932432	-14.652998	12.8765490	7.358028008
0.7	0.6	0.55681818	0.44932432	-7.0990079	5.73110776	3.274918722
0.75	0.6	0.59868421	0.44932432	-0.0725753	0.05447107	0.031126328
0.8	0.6	0.63480392	0.44932432	6.47970048	-4.5640392	3.702685993
0.85	0.6	0.66628440	0.44932432	12.6042485	-8.3950530	7.20242776
0.9	0.6	0.69396551	0.44932432	18.3416277	-11.624160	10.48093011
0.95	0.6	0.71849593	0.44932432	23.7274258	-14.382881	13.55852905
1	0.6	0.74038461	0.44932432	28.7929990	-16.767021	16.45314234
0.38	0.7	0	0.55681818	-74.565217	219.871794	125.6410256
0.4	0.7	0.03804347	0.55681818	-72.323412	195.987169	111.9926682
0.45	0.7	0.18160377	0.55681818	-62.879481	127.044592	72.59690998
0.5	0.7	0.29166666	0.55681818	-54.373368	89.3776824	51.07296137
0.55	0.7	0.37873134	0.55681818	-46.671987	65.6390297	37.50801703
0.6	0.7	0.44932432	0.55681818	-39.666297	49.3086310	28.17636059
0.65	0.7	0.50771604	0.55681818	-33.266106	37.3866683	21.3638105
0.7	0.7	0.55681818	0.55681818	-27.396166	28.3003300	16.17161716
0.75	0.7	0.59868421	0.55681818	-21.993202	21.1454667	12.08312385
0.8	0.7	0.63480392	0.55681818	-17.003621	15.3653881	8.780221778
0.85	0.7	0.66628440	0.55681818	-12.381728	10.5985847	6.056334135
0.9	0.7	0.69396551	0.55681818	-8.0883268	6.60008132	3.771475043
0.95	0.7	0.71849593	0.55681818	-4.0895966	3.19798207	1.827418331
1	0.7	0.74038461	0.55681818	-0.3562082	0.26811118	0.153206391
0.38	0.8	0	0.63480392	-80.221238	304.194631	173.8255034
0.4	0.8	0.03804347	0.63480392	-78.227327	269.468503	153.9820015
0.45	0.8	0.18160377	0.63480392	-69.882360	174.023496	99.44199774
0.5	0.8	0.29166666	0.63480392	-62.440882	124.685205	71.24868835
0.55	0.8	0.37873134	0.63480392	-55.763702	94.5440267	54.02515812
0.6	0.8	0.44932432	0.63480392	-49.738821	74.2205373	42.41173557
0.65	0.8	0.50771604	0.63480392	-44.275106	59.58976	34.05129141
0.7	0.8	0.55681818	0.63480392	-39.297644	48.5536896	27.74496549
0.75	0.8	0.59868421	0.63480392	-34.744287	39.9324672	22.8185527
0.8	0.8	0.63480392	0.63480392	-30.563047	33.0116533	18.86380189
0.85	0.8	0.66628440	0.63480392	-26.710099	27.3333355	15.61904886
0.9	0.8	0.69396551	0.63480392	-23.148238	22.5904764	12.90884367
0.95	0.8	0.71849593	0.63480392	-19.845679	18.5695039	10.61114509
1	0.8	0.74038461	0.63480392	-16.775100	15.1172615	8.638435148

* $\Delta M = Max\left[\Delta M_A, \Delta M_B\right]$

Table A.8: The details of variables in Fig. 5.5B

$\gamma_A^{x,a}$	$\gamma_B^{y,b}$	$S_{AB(I)}^{a}$	$S_{BA(I)}^{b}$	ΔM_A	ΔM_B	$\frac{\Delta M}{M_A + M_B} \times 100(\%)^*$
0.38	0.4	0	0.03804347	-10.606060	5.93220339	3.95480226
0.4	0.4	0.03804347	0.03804347	-5.4973821	2.90858725	1.939058172
0.45	0.4	0.18160377	0.03804347	17.6946004	-7.5171674	11.79640032
0.5	0.4	0.29166666	0.03804347	41.2240184	-14.595257	27.48267898
0.55	0.4	0.37873134	0.03804347	65.0982901	-19.715010	43.39886007
0.6	0.4	0.44932432	0.03804347	89.3250527	-23.590394	59.55003515
0.65	0.4	0.50771604	0.03804347	113.912170	-26.625920	75.94144729
0.7	0.4	0.55681818	0.03804347	138.867745	-29.067914	92.57849667
0.75	0.4	0.59868421	0.03804347	164.200119	-31.074951	109.4667466
0.8	0.4	0.63480392	0.03804347	189.917894	-32.753737	126.6119295
0.85	0.4	0.66628440	0.03804347	216.029930	-34.178713	144.0199538
0.9	0.4	0.69396551	0.03804347	242.545365	-35.403393	161.6969103
0.95	0.4	0.71849593	0.03804347	269.473619	-36.467234	179.6490795
1	0.4	0.74038461	0.03804347	296.824408	-37.399968	197.882939
0.38	0.5	0	0.29166666	-55.263157	61.7647058	41.17647059
0.4	0.5	0.03804347	0.29166666	-52.930832	56.2266500	37.48443337
0.45	0.5	0.18160377	0.29166666	-42.989343	37.7029021	25.13526808
0.5	0.5	0.29166666	0.29166666	-33.870967	25.6097561	17.07317073
0.55	0.5	0.37873134	0.29166666	-25.477542	17.0938690	11.39591271
0.6	0.5	0.44932432	0.29166666	-17.725918	10.7724803	7.181653591
0.65	0.5	0.50771604	0.29166666	-10.545193	5.89414595	3.929430634
0.7	0.5	0.55681818	0.29166666	-3.8745387	2.01535508	1.343570058
0.75	0.5	0.59868421	0.29166666	2.33853006	-1.1425462	1.559020045
0.8	0.5	0.63480392	0.29166666	8.13953488	-3.7634408	5.426356589
0.85	0.5	0.66628440	0.29166666	13.5681534	-5.9735731	9.045435598
0.9	0.5	0.69396551	0.29166666	18.6591276	-7.8624914	12.43941842
0.95	0.5	0.71849593	0.29166666	23.4430082	-9.4954783	15.62867215
1	0.5	0.74038461	0.29166666	27.9467680	-10.921248	18.63117871
0.38	0.6	0	0.44932432	-70.996441	122.392638	81.59509202
0.4	0.6	0.03804347	0.44932432	-69.381068	113.297666	75.53177775
0.45	0.6	0.18160377	0.44932432	-62.640605	83.8351468	55.89009788
0.5	0.6	0.29166666	0.44932432	-56.657323	65.3597413	43.57316087
0.55	0.6	0.37873134	0.44932432	-51.310420	52.6913773	35.12758491
0.6	0.6	0.44932432	0.44932432	-46.503496	43.4640522	28.97603486
0.65	0.6	0.50771604	0.44932432	-42.158685	36.4434018	24.29560123
0.7	0.6	0.55681818	0.44932432	-38.212405	30.9223930	20.61492869
0.75	0.6	0.59868421	0.44932432	-34.612228	26.4668967	17.64459785
0.8	0.6	0.63480392	0.44932432	-31.314534	22.7956045	15.19706971
0.85	0.6	0.66628440	0.44932432	-28.282739	19.7182234	13.14548228
0.9	0.6	0.69396551	0.44932432	-25.485929	17.1014210	11.40094738
0.95	0.6	0.71849593	0.44932432	-22.897805	14.8489970	9.899331391
1	0.6	0.74038461	0.44932432	-20.495849	12.8897982	8.593198815
0.38	0.7	0	0.55681818	-79.032258	188.461538	125.6410256
0.4	0.7	0.03804347	0.55681818	-77.731492	174.532335	116.3548904
0.45	0.7	0.18160377	0.55681818	-72.361558	130.907448	87.2716322
0.5	0.7	0.29166666	0.55681818	-67.671517	104.662379	69.77491961
0.55	0.7	0.37873134	0.55681818	-63.539935	87.1363453	58.0908969
0.6	0.7	0.44932432	0.55681818	-59.872670	74.6033570	49.7355714
0.65	0.7	0.50771604	0.55681818	-56.595614	65.1957331	43.46382208
0.7	0.7	0.55681818	0.55681818	-53.649635	57.8740157	38.58267717
0.75	0.7	0.59868421	0.55681818	-50.986971	52.0136931	34.67579541
0.8	0.7	0.63480392	0.55681818	-48.568630	47.2169327	31.47795518

0.85	0.7	0.66628440	0.55681818	-46.362457	43.2182904	28.81219365
0.9	0.7	0.69396551	0.55681818	-44.341705	39.8338705	26.55591371
0.95	0.7	0.71849593	0.55681818	-42.483941	36.9322433	24.6214956
1	0.7	0.74038461	0.55681818	-40.770210	34.4169801	22.94465341
0.38	0.8	0	0.63480392	-83.909287	260.738255	173.8255034
0.4	0.8	0.03804347	0.63480392	-82.782579	240.403550	160.2690334
0.45	0.8	0.18160377	0.63480392	-78.161059	178.948836	119.2992242
0.5	0.8	0.29166666	0.63480392	-74.163568	143.525179	95.68345324
0.55	0.8	0.37873134	0.63480392	-70.671709	120.483855	80.32257001
0.6	0.8	0.44932432	0.63480392	-67.595254	104.298388	69.53225897
0.65	0.8	0.50771604	0.63480392	-64.864238	92.3051543	61.53676956
0.7	0.8	0.55681818	0.63480392	-62.423572	83.0621429	55.37476199
0.75	0.8	0.59868421	0.63480392	-60.229290	75.7206638	50.48044259
0.8	0.8	0.63480392	0.63480392	-58.245877	69.7486535	46.49910233
0.85	0.8	0.66628440	0.63480392	-56.444329	64.7956144	43.1970763
0.9	0.8	0.69396551	0.63480392	-54.800729	60.6212543	40.41416958
0.95	0.8	0.71849593	0.63480392	-53.295178	57.0553286	38.03688575
1	0.8	0.74038461	0.63480392	-51.910985	53.9738495	35.98256634

* $\Delta M = Max\left[\Delta M_A, \Delta M_B\right]$

Table A.9: The details of variables in Fig. 5.5C

$\gamma_A^{x,a}$	$\gamma_B^{y,b}$	$S_{AB(I)}^{a}$	$S_{BA(I)}^{b}$	ΔM_A	ΔM_B	$\frac{\Delta M}{M_A + M_B} \times 100(\%)^*$
0.38	0.4	0	0.03804347	-16.509433	4.94350282	3.95480226
0.4	0.4	0.03804347	0.03804347	-12.804878	3.67132867	2.937062937
0.45	0.4	0.18160377	0.03804347	3.79027997	-0.9129660	3.032223983
0.5	0.4	0.29166666	0.03804347	20.2631578	-4.2122538	16.21052632
0.55	0.4	0.37873134	0.03804347	36.6151022	-6.7004126	29.2920818
0.6	0.4	0.44932432	0.03804347	52.8474399	-8.6438215	42.27795193
0.65	0.4	0.50771604	0.03804347	68.9614784	-10.203727	55.16918272
0.7	0.4	0.55681818	0.03804347	84.9585062	-11.483454	67.96680498
0.75	0.4	0.59868421	0.03804347	100.839793	-12.552267	80.67183463
0.8	0.4	0.63480392	0.03804347	116.606591	-13.458338	93.28527291
0.85	0.4	0.66628440	0.03804347	132.260133	-14.236206	105.8081067
0.9	0.4	0.69396551	0.03804347	147.801636	-14.911285	118.2413088
0.95	0.4	0.71849593	0.03804347	163.232297	-15.502685	130.585838
1	0.4	0.74038461	0.03804347	178.553299	-16.025056	142.8426396
0.38	0.5	0	0.29166666	-67.307692	51.4705882	41.17647059
0.4	0.5	0.03804347	0.29166666	-66.276595	49.1324921	39.30599369
0.45	0.5	0.18160377	0.29166666	-62.029702	40.8409387	32.67275098
0.5	0.5	0.29166666	0.29166666	-58.333333	35	28
0.55	0.5	0.37873134	0.29166666	-55.086956	30.6631171	24.53049371
0.6	0.5	0.44932432	0.29166666	-52.213114	27.3156089	21.85248714
0.65	0.5	0.50771604	0.29166666	-49.651162	24.6535796	19.72286374
0.7	0.5	0.55681818	0.29166666	-47.352941	22.4860335	17.98882682
0.75	0.5	0.59868421	0.29166666	-45.279720	20.6869009	16.54952077
0.8	0.5	0.63480392	0.29166666	-43.4	19.1696113	15.33568905
0.85	0.5	0.66628440	0.29166666	-41.687898	17.8727471	14.29819771
0.9	0.5	0.69396551	0.29166666	-40.121951	16.7515274	13.401222
0.95	0.5	0.71849593	0.29166666	-38.684210	15.7725321	12.61802575
1	0.5	0.74038461	0.29166666	-37.359550	14.9103139	11.92825112

0.38	0.6	0	0.44932432	-80.314009	101.993865	81.59509202
0.4	0.6	0.03804347	0.44932432	-79.697897	98.1399541	78.51196329
0.45	0.6	0.18160377	0.44932432	-77.211526	84.7045849	67.76366796
0.5	0.6	0.29166666	0.44932432	-75.112359	75.4514672	60.36117381
0.55	0.6	0.37873134	0.44932432	-73.316480	68.6907901	54.95263209
0.6	0.6	0.44932432	0.44932432	-71.762589	63.5350318	50.82802548
0.65	0.6	0.50771604	0.44932432	-70.404863	59.47334	47.578672
0.7	0.6	0.55681818	0.44932432	-69.208361	56.1908736	44.95269894
0.75	0.6	0.59868421	0.44932432	-68.145976	53.4830212	42.78641701
0.8	0.6	0.63480392	0.44932432	-67.196354	51.2110423	40.9688339
0.85	0.6	0.66628440	0.44932432	-66.342447	49.2775347	39.42202776
0.9	0.6	0.69396551	0.44932432	-65.570479	47.6121053	38.0896843
0.95	0.6	0.71849593	0.44932432	-64.869194	46.1626157	36.93009261
1	0.6	0.74038461	0.44932432	-64.229311	44.8896247	35.91169978
0.38	0.7	0	0.55681818	-86.267605	157.051282	125.6410256
0.4	0.7	0.03804347	0.55681818	-85.805577	151.125511	120.9004093
0.45	0.7	0.18160377	0.55681818	-83.958113	130.842018	104.6736149
0.5	0.7	0.29166666	0.55681818	-82.419354	117.201834	93.76146789
0.55	0.7	0.37873134	0.55681818	-81.117892	107.400473	85.9203784
0.6	0.7	0.44932432	0.55681818	-80.002763	100.017277	80.0138217
0.65	0.7	0.50771604	0.55681818	-79.036626	94.2556136	75.40449093
0.7	0.7	0.55681818	0.55681818	-78.191489	89.6341463	71.70731707
0.75	0.7	0.59868421	0.55681818	-77.445961	85.8448928	68.67591425
0.8	0.7	0.63480392	0.55681818	-76.783412	82.6816288	66.1453031
0.85	0.7	0.66628440	0.55681818	-76.190718	80.0010686	64.00085488
0.9	0.7	0.69396551	0.55681818	-75.657385	77.700556	62.1604448
0.95	0.7	0.71849593	0.55681818	-75.174921	75.7046171	60.56369368
1	0.7	0.74038461	0.55681818	-74.736379	73.9565217	59.16521739
0.38	0.8	0	0.63480392	-89.681440	217.281879	173.8255034
0.4	0.8	0.03804347	0.63480392	-89.297671	208.594027	166.8752222
0.45	0.8	0.18160377	0.63480392	-87.771159	179.434745	143.5477967
0.5	0.8	0.29166666	0.63480392	-86.509433	160.314685	128.2517483
0.55	0.8	0.37873134	0.63480392	-85.449100	146.810679	117.4485433
0.6	0.8	0.44932432	0.63480392	-84.545503	136.765215	109.4121727
0.65	0.8	0.50771604	0.63480392	-83.766282	129.000461	103.2003689
0.7	0.8	0.55681818	0.63480392	-83.087411	122.818884	98.25510768
0.75	0.8	0.59868421	0.63480392	-82.490677	117.781083	94.2248669
0.8	0.8	0.63480392	0.63480392	-81.962025	113.596491	90.87719298
0.85	0.8	0.66628440	0.63480392	-81.490431	110.065278	88.05222263
0.9	0.8	0.69396551	0.63480392	-81.067132	107.045499	85.63639929
0.95	0.8	0.71849593	0.63480392	-80.685069	104.433548	83.54683857
1	0.8	0.74038461	0.63480392	-80.338497	102.152034	81.72162741

* $\Delta M = Max\left[\Delta M_A, \Delta M_B\right]$

Appendix A.11: The Details of Variables in Fig. 5.6

One can easily check the details of variables $S^{a}_{AB(1)}$ and ΔM_A in Table A.10, A.11, and A.12 by Eqs. (4.35) and (4.40). Besides, $S^{b}_{BA(1)}$ and ΔM_B can be checked by Eqs. (A.4.4) and (A.4.7).

Table A.10: The details of variables in Fig. 5.6A

$\gamma_A^{x,a}$	$\gamma_B^{y,b}$	$S^{a}_{AB(1)}$	$S^{b}_{BA(1)}$	ΔM_A	ΔM_B	$\frac{\Delta M}{2M}\times 100(\%)^{*}$
0.38	0.4	0	0.23214285	-37.681159	60.4651162	30.23255814
0.4	0.4	0.03804347	0.23214285	-32.509752	48.1695568	24.08477842
0.45	0.4	0.18160377	0.23214285	-9.6215522	10.6458481	5.32292406
0.5	0.4	0.29166666	0.23214285	12.6582278	-11.235955	6.329113924
0.55	0.4	0.37873134	0.23214285	34.3535290	-25.569502	17.17676452
0.6	0.4	0.44932432	0.23214285	55.4870530	-35.685963	27.74352651
0.65	0.4	0.50771604	0.23214285	76.0803408	-43.207742	38.04017042
0.7	0.4	0.55681818	0.23214285	96.1538461	-49.019607	48.07692308
0.75	0.4	0.59868421	0.23214285	115.727003	-53.645116	57.86350148
0.8	0.4	0.63480392	0.23214285	134.818288	-57.413879	67.4091442
0.85	0.4	0.66628440	0.23214285	153.445280	-60.543751	76.72264042
0.9	0.4	0.69396551	0.23214285	171.624714	-63.184498	85.81235698
0.95	0.4	0.71849593	0.23214285	189.372526	-65.442469	94.68626343
1	0.4	0.74038461	0.23214285	206.703910	-67.395264	103.3519553
0.38	0.5	0	0.44318181	-61.417322	159.183673	79.59183673
0.4	0.5	0.03804347	0.44318181	-57.665260	136.212624	68.10631229
0.45	0.5	0.18160377	0.44318181	-41.468388	70.8478513	35.42392567
0.5	0.5	0.29166666	0.44318181	-26.315789	35.7142857	17.85714286
0.55	0.5	0.37873134	0.44318181	-12.109623	13.7781000	6.889050036
0.6	0.5	0.44932432	0.44318181	1.23609394	-1.2210012	0.618046972
0.65	0.5	0.50771604	0.44318181	13.7972405	-12.124406	6.898620276
0.7	0.5	0.55681818	0.44318181	25.6410256	-20.408163	12.82051282
0.75	0.5	0.59868421	0.44318181	36.8271954	-26.915113	18.41359773
0.8	0.5	0.63480392	0.44318181	47.4090407	-32.161555	23.7045204
0.85	0.5	0.66628440	0.44318181	57.4342458	-36.481418	28.71712292
0.9	0.5	0.69396551	0.44318181	66.9456066	-40.100250	33.47280335
0.95	0.5	0.71849593	0.44318181	75.9816420	-43.175891	37.99082101
1	0.5	0.74038461	0.44318181	84.5771144	-45.822102	42.28855721
0.38	0.6	0	0.57352941	-72.897196	268.965517	134.4827586
0.4	0.6	0.03804347	0.57352941	-69.748074	230.557467	115.2787337
0.45	0.6	0.18160377	0.57352941	-56.314163	128.907141	64.45357061
0.5	0.6	0.29166666	0.57352941	-43.977055	78.4982935	39.24914676
0.55	0.6	0.37873134	0.57352941	-32.607697	48.3848984	24.19244923
0.6	0.6	0.44932432	0.57352941	-22.096517	28.3639664	14.18198321
0.65	0.6	0.50771604	0.57352941	-12.349885	14.0899815	7.044990769
0.7	0.6	0.55681818	0.57352941	-3.2873109	3.39904826	1.699524133
0.75	0.6	0.59868421	0.57352941	5.16077808	-4.9075122	2.580389043
0.8	0.6	0.63480392	0.57352941	13.0548302	-11.547344	6.527415144
0.85	0.6	0.66628440	0.57352941	20.4476169	-16.976356	10.22380846
0.9	0.6	0.69396551	0.57352941	27.3854136	-21.498076	13.69270683

0.95	0.6	0.71849593	0.57352941	33.9089701	-25.322403	16.95448507
1	0.6	0.74038461	0.57352941	40.0543109	-28.599127	20.02715547
0.38	0.7	0	0.66203703	-79.665738	391.780821	195.890411
0.4	0.7	0.03804347	0.66203703	-76.846802	331.905781	165.9528908
0.45	0.7	0.18160377	0.66203703	-64.904413	184.936113	92.46805649
0.5	0.7	0.29166666	0.66203703	-54.054054	117.647058	58.82352941
0.55	0.7	0.37873134	0.66203703	-44.152487	79.0590050	39.52950251
0.6	0.7	0.44932432	0.66203703	-35.080478	54.0368722	27.01843611
0.65	0.7	0.50771604	0.66203703	-26.737967	36.4963503	18.24817518
0.7	0.7	0.55681818	0.66203703	-19.040365	23.5183443	11.75917215
0.75	0.7	0.59868421	0.66203703	-11.915673	13.5275754	6.763787721
0.8	0.7	0.63480392	0.66203703	-5.3022269	5.59910414	2.799552072
0.85	0.7	0.66628440	0.66203703	0.85309674	-0.8458805	0.426548371
0.9	0.7	0.69396551	0.66203703	6.59630606	-6.1881188	3.298153034
0.95	0.7	0.71849593	0.66203703	11.9674485	-10.688328	5.98372427
1	0.7	0.74038461	0.66203703	17.0015456	-14.531043	8.500772798
0.38	0.8	0	0.72606383	-84.129429	530.097087	265.0485437
0.4	0.8	0.03804347	0.72606383	-81.518016	441.067457	220.5337287
0.45	0.8	0.18160377	0.72606383	-70.504906	239.039436	119.519718
0.5	0.8	0.29166666	0.72606383	-60.568603	153.605015	76.80250784
0.55	0.8	0.37873134	0.72606383	-51.558541	106.434740	53.21737015
0.6	0.8	0.44932432	0.72606383	-43.350973	76.5255416	38.26277082
0.65	0.8	0.50771604	0.72606383	-35.843259	55.8682685	27.93413425
0.7	0.8	0.55681818	0.72606383	-28.949545	40.7450523	20.37252619
0.75	0.8	0.59868421	0.72606383	-22.597467	29.1947385	14.59736927
0.8	0.8	0.63480392	0.72606383	-16.725604	20.0849305	10.04246528
0.85	0.8	0.66628440	0.72606383	-11.281484	12.7160429	6.358021488
0.9	0.8	0.69396551	0.72606383	-6.2200106	6.63255637	3.316278188
0.95	0.8	0.71849593	0.72606383	-1.5022103	1.52512092	0.76256046
1	0.8	0.74038461	0.72606383	2.90577002	-2.8237192	1.452885015

* $\Delta M = Max\left[\Delta M_A, \Delta M_B\right]$

Table A.11: The details of variables in Fig. 5.6B

$\gamma_A^{x,a}$	$\gamma_B^{y,b}$	$S^a_{AB(1)}$	$S^b_{BA(1)}$	ΔM_A	ΔM_B	$\frac{\Delta M}{2M}\times 100(\%)^*$
0.38	0.4	0	0.46710526	-63.677130	175.308642	87.65432099
0.4	0.4	0.03804347	0.46710526	-60.048038	150.300601	75.1503006
0.45	0.4	0.18160377	0.46710526	-44.418694	79.9166087	39.95830438
0.5	0.4	0.29166666	0.46710526	-29.850746	42.5531914	21.27659574
0.55	0.4	0.37873134	0.46710526	-16.239624	19.3881947	9.694097372
0.6	0.4	0.44932432	0.46710526	-3.4940600	3.62056480	1.810282404
0.65	0.4	0.50771604	0.46710526	8.46596681	-7.8051826	4.232983407
0.7	0.4	0.55681818	0.46710526	19.7109067	-16.465422	9.855453351
0.75	0.4	0.59868421	0.46710526	30.3030303	-23.255813	15.15151515
0.8	0.4	0.63480392	0.46710526	40.2975821	-28.722934	20.14879107
0.85	0.4	0.66628440	0.46710526	49.7437443	-33.219247	24.87187217
0.9	0.4	0.69396551	0.46710526	58.6854460	-36.982248	29.342723
0.95	0.4	0.71849593	0.46710526	67.1620463	-40.177808	33.58102315
1	0.4	0.74038461	0.46710526	75.2089136	-42.925278	37.60445682
0.38	0.5	0	0.625	-76.923076	333.333333	166.6666667
0.4	0.5	0.03804347	0.625	-73.972602	284.210526	142.1052632

0.45	0.5	0.18160377	0.625	-61.437908	159.322033	79.66101695
0.5	0.5	0.29166666	0.625	-50	100	50
0.55	0.5	0.37873134	0.625	-39.520958	65.3465346	32.67326733
0.6	0.5	0.44932432	0.625	-29.885057	42.6229508	21.31147541
0.65	0.5	0.50771604	0.625	-20.994475	26.5734265	13.28671329
0.7	0.5	0.55681818	0.625	-12.765957	14.6341463	7.317073171
0.75	0.5	0.59868421	0.625	-5.1282051	5.40540540	2.702702703
0.8	0.5	0.63480392	0.625	1.98019802	-1.9417475	0.99009901
0.85	0.5	0.66628440	0.625	8.61244019	-7.9295154	4.306220096
0.9	0.5	0.69396551	0.625	14.8148148	-12.903225	7.407407407
0.95	0.5	0.71849593	0.625	20.6278026	-17.100371	10.31390135
1	0.5	0.74038461	0.625	26.0869565	-20.689655	13.04347826
0.38	0.6	0	0.72177419	-83.840749	518.840579	259.4202899
0.4	0.6	0.03804347	0.72177419	-81.216159	432.372505	216.1862528
0.45	0.6	0.18160377	0.72177419	-70.144240	234.943745	117.4718729
0.5	0.6	0.29166666	0.72177419	-60.150375	150.943396	75.47169811
0.55	0.6	0.37873134	0.72177419	-51.084423	104.433858	52.21692928
0.6	0.6	0.44932432	0.72177419	-42.822884	74.8951467	37.4475734
0.65	0.6	0.50771604	0.72177419	-35.263244	54.4717507	27.23587535
0.7	0.6	0.55681818	0.72177419	-28.319697	39.5083406	19.75417032
0.75	0.6	0.59868421	0.72177419	-21.919879	28.0735721	14.03678606
0.8	0.6	0.63480392	0.72177419	-16.002327	19.0509179	9.525458954
0.85	0.6	0.66628440	0.72177419	-10.514510	11.7499608	5.874980417
0.9	0.6	0.69396551	0.72177419	-5.4112554	5.72082379	2.860411899
0.95	0.6	0.71849593	0.72177419	-0.6535093	0.65780818	0.328904092
1	0.6	0.74038461	0.72177419	3.79266750	-3.6540803	1.896333755
0.38	0.7	0	0.78716216	-88.090737	739.682539	369.8412698
0.4	0.7	0.03804347	0.78716216	-85.656701	597.189695	298.5948478
0.45	0.7	0.18160377	0.78716216	-75.432745	307.045895	153.5229476
0.5	0.7	0.29166666	0.78716216	-66.265060	196.428571	98.21428571
0.55	0.7	0.37873134	0.78716216	-57.997995	138.083873	69.04193658
0.6	0.7	0.44932432	0.78716216	-50.505050	102.040816	51.02040816
0.65	0.7	0.50771604	0.78716216	-43.682357	77.5642509	38.78212549
0.7	0.7	0.55681818	0.78716216	-37.443834	59.8563447	29.92817239
0.75	0.7	0.59868421	0.78716216	-31.717534	46.4504820	23.22524102
0.8	0.7	0.63480392	0.78716216	-26.442860	35.9487339	17.97436699
0.85	0.7	0.66628440	0.78716216	-21.568410	27.4996474	13.74982372
0.9	0.7	0.69396551	0.78716216	-17.050298	20.5549845	10.27749229
0.95	0.7	0.71849593	0.78716216	-12.850827	14.7457827	7.372891353
1	0.7	0.74038461	0.78716216	-8.9374379	9.81461286	4.907306434
0.38	0.8	0	0.83430232	-90.966719	1007.01754	503.5087719
0.4	0.8	0.03804347	0.83430232	-88.657472	781.637717	390.8188586
0.45	0.8	0.18160377	0.83430232	-78.985795	375.868603	187.934302
0.5	0.8	0.29166666	0.83430232	-70.351758	237.288135	118.6440678
0.55	0.8	0.37873134	0.83430232	-62.596876	167.357347	83.67867389
0.6	0.8	0.44932432	0.83430232	-55.593374	125.191619	62.59580991
0.65	0.8	0.50771604	0.83430232	-49.237095	96.9942443	48.49712215
0.7	0.8	0.55681818	0.83430232	-43.442283	76.8105340	38.40526701
0.75	0.8	0.59868421	0.83430232	-38.137691	61.6493194	30.82465973
0.8	0.8	0.63480392	0.83430232	-33.263638	49.8433494	24.92167474
0.85	0.8	0.66628440	0.83430232	-28.769750	40.3897935	20.19489678
0.9	0.8	0.69396551	0.83430232	-24.613220	32.6492537	16.32462687
0.95	0.8	0.71849593	0.83430232	-20.757434	26.1948038	13.0974019
1	0.8	0.74038461	0.83430232	-17.170891	20.7305034	10.36525173

* $\Delta M = Max\left[\Delta M_A, \Delta M_B\right]$

Table A.12: The details of variables in Fig. 5.6C

$\gamma_A^{x,a}$	$\gamma_B^{y,b}$	$S_{AB(I)}^{a}$	$S_{BA(I)}^{b}$	ΔM_A	ΔM_B	$\frac{\Delta M}{2M}\times 100(\%)^{*}$
0.38	0.4	0	0.75735294	-86.192468	624.242424	312.1212121
0.4	0.4	0.03804347	0.75735294	-83.674228	512.528473	256.2642369
0.45	0.4	0.18160377	0.75735294	-73.076245	271.419228	135.7096141
0.5	0.4	0.29166666	0.75735294	-63.545150	174.311926	87.1559633
0.55	0.4	0.37873134	0.75735294	-54.927559	121.865065	60.93253267
0.6	0.4	0.44932432	0.75735294	-47.098146	89.0292935	44.51464675
0.65	0.4	0.50771604	0.75735294	-39.953508	66.537624	33.268812
0.7	0.4	0.55681818	0.75735294	-33.407572	50.1672240	25.08361204
0.75	0.4	0.59868421	0.75735294	-27.388109	37.7184912	18.85924563
0.8	0.4	0.63480392	0.75735294	-21.834061	27.9329608	13.96648045
0.85	0.4	0.66628440	0.75735294	-16.693458	20.0385928	10.01929642
0.9	0.4	0.69396551	0.75735294	-11.921793	13.5354629	6.767731456
0.95	0.4	0.71849593	0.75735294	-7.4807227	8.08558278	4.042791392
1	0.4	0.74038461	0.75735294	-3.3370411	3.45224395	1.726121979
0.38	0.5	0	0.84722222	-91.729323	1109.09090	554.5454545
0.4	0.5	0.03804347	0.84722222	-89.452603	848.101265	424.0506329
0.45	0.5	0.18160377	0.84722222	-79.924480	398.119122	199.0595611
0.5	0.5	0.29166666	0.84722222	-71.428571	250	125
0.55	0.5	0.37873134	0.84722222	-63.805759	176.287051	88.14352574
0.6	0.5	0.44932432	0.84722222	-56.928034	132.169576	66.08478803
0.65	0.5	0.50771604	0.84722222	-50.691244	102.803738	51.40186916
0.7	0.5	0.55681818	0.84722222	-45.009784	81.8505338	40.9252669
0.75	0.5	0.59868421	0.84722222	-39.812646	66.1478599	33.07392996
0.8	0.5	0.63480392	0.84722222	-35.040431	53.9419087	26.97095436
0.85	0.5	0.66628440	0.84722222	-30.643072	44.1817050	22.09085252
0.9	0.5	0.69396551	0.84722222	-26.578073	36.1990950	18.09954751
0.95	0.5	0.71849593	0.84722222	-22.809123	29.5489891	14.77449456
1	0.5	0.74038461	0.84722222	-19.305019	23.9234449	11.96172249
0.38	0.6	0	0.90178571	-94.835680	1836.36363	918.1818182
0.4	0.6	0.03804347	0.90178571	-92.689023	1267.80626	633.9031339
0.45	0.6	0.18160377	0.90178571	-83.733228	514.750150	257.3750753
0.5	0.6	0.29166666	0.90178571	-75.785582	312.977099	156.4885496
0.55	0.6	0.37873134	0.90178571	-68.684924	219.335009	109.6675049
0.6	0.6	0.44932432	0.90178571	-62.302708	165.271044	82.63552226
0.65	0.6	0.50771604	0.90178571	-56.535146	130.070947	65.03547389
0.7	0.6	0.55681818	0.90178571	-51.297525	105.328376	52.66418835
0.75	0.6	0.59868421	0.90178571	-46.520014	86.9858395	43.49291976
0.8	0.6	0.63480392	0.90178571	-42.144535	72.8445187	36.42225937
0.85	0.6	0.66628440	0.90178571	-38.122389	61.6093431	30.8046716
0.9	0.6	0.69396551	0.90178571	-34.412439	52.4679362	26.23396813
0.95	0.6	0.71849593	0.90178571	-30.979694	44.8848991	22.44244956
1	0.6	0.74038461	0.90178571	-27.794204	38.4930384	19.24651925
0.38	0.7	0	0.93843283	-96.823869	3048.48484	1524.242424
0.4	0.7	0.03804347	0.93843283	-94.758408	1807.81759	903.9087948
0.45	0.7	0.18160377	0.93843283	-86.158531	622.466705	311.2333526
0.5	0.7	0.29166666	0.93843283	-78.549848	366.197183	183.0985915
0.55	0.7	0.37873134	0.93843283	-71.770334	254.237288	127.1186441
0.6	0.7	0.44932432	0.93843283	-65.691453	191.472562	95.73628109
0.65	0.7	0.50771604	0.93843283	-60.209929	151.318983	75.65949183
0.7	0.7	0.55681818	0.93843283	-55.241836	123.422929	61.71146462
0.75	0.7	0.59868421	0.93843283	-50.718264	102.914931	51.45746579
0.8	0.7	0.63480392	0.93843283	-46.582107	87.2031939	43.60159697

0.85	0.7	0.66628440	0.93843283	-42.785641	74.7812999	37.39064999
0.9	0.7	0.69396551	0.93843283	-39.288668	64.7138964	32.35694823
0.95	0.7	0.71849593	0.93843283	-36.057094	56.3895154	28.19475772
1	0.7	0.74038461	0.93843283	-33.061811	49.3915533	24.69577666
0.38	0.8	0	0.96474359	-98.205546	5472.72727	2736.363636
0.4	0.8	0.03804347	0.96474359	-96.195573	2528.51711	1264.258555
0.45	0.8	0.18160377	0.96474359	-87.838296	722.253206	361.1266035
0.5	0.8	0.29166666	0.96474359	-80.459770	411.764705	205.8823529
0.55	0.8	0.37873134	0.96474359	-73.897568	283.106078	141.5530391
0.6	0.8	0.44932432	0.96474359	-68.023322	212.727922	106.3639614
0.65	0.8	0.50771604	0.96474359	-62.734234	168.342807	84.17140359
0.7	0.8	0.55681818	0.96474359	-57.947019	137.795275	68.8976378
0.75	0.8	0.59868421	0.96474359	-53.593479	115.486961	57.74348057
0.8	0.8	0.63480392	0.96474359	-49.617238	98.4805852	49.24029263
0.85	0.8	0.66628440	0.96474359	-45.971284	85.0867633	42.54338167
0.9	0.8	0.69396551	0.96474359	-42.616107	74.2649287	37.13246438
0.95	0.8	0.71849593	0.96474359	-39.518253	65.3391412	32.66957063
1	0.8	0.74038461	0.96474359	-36.649214	57.8512396	28.92561983

* $\Delta M = Max\left[\Delta M_A, \Delta M_B\right]$

Appendix A.12: The Details of Variables in Fig. 5.7

One can easily check the details of variables $S^{a}_{AB(I)}$ and ΔM_{A} in Table A.13, A.14, and A.15 by Eqs. (4.35) and (4.40). Besides, $S^{b}_{BA(I)}$ and ΔM_{B} can be checked by Eqs. (A.4.4) and (A.4.7).

Table A.13: The details of variables in Fig. 5.7A

$\gamma_A^{x,a}$	$\gamma_B^{y,b}$	$S^{a}_{AB(I)}$	$S^{b}_{BA(I)}$	ΔM_{A}	ΔM_{B}	$\frac{\Delta M}{2M}\times 100(\%)^{*}$
0.38	0.5	0	0.27293369	-42.882625	75.0780762	37.5390381
0.4	0.5	0.03804347	0.27293369	-38.042283	61.4003961	30.70019807
0.45	0.5	0.18160377	0.27293369	-16.737362	20.1018885	10.05094427
0.5	0.5	0.29166666	0.27293369	3.81811870	-3.6776997	1.909059354
0.55	0.5	0.37873134	0.27293369	23.6630212	-19.135082	11.83151065
0.6	0.5	0.44932432	0.27293369	42.8335649	-29.988444	21.41678247
0.65	0.5	0.50771604	0.27293369	61.3635489	-38.028135	30.68177447
0.7	0.5	0.55681818	0.27293369	79.2845509	-44.222745	39.64227549
0.75	0.5	0.59868421	0.27293369	96.6261066	-49.142053	48.31305334
0.8	0.5	0.63480392	0.27293369	113.415872	-53.143128	56.70793608
0.85	0.5	0.66628440	0.27293369	129.679771	-56.461119	64.83988551
0.9	0.5	0.69396551	0.27293369	145.442128	-59.257198	72.72106406
0.95	0.5	0.71849593	0.27293369	160.725790	-61.645528	80.36289537
1	0.5	0.74038461	0.27293369	175.552239	-63.709240	87.77611965
0.38	0.6	0	0.44476765	-61.569437	160.209563	80.10478148
0.4	0.6	0.03804347	0.44476765	-57.825717	137.111327	68.55566372
0.45	0.6	0.18160377	0.44476765	-41.667417	71.4307770	35.71538854
0.5	0.6	0.29166666	0.44476765	-26.554654	36.1556661	18.07783305
0.55	0.6	0.37873134	0.44476765	-12.389130	14.1410878	7.070543914
0.6	0.6	0.44932432	0.44476765	0.91550533	-0.9071998	0.457752666
0.65	0.6	0.50771604	0.44476765	13.4354165	-11.844110	6.717708289
0.7	0.6	0.55681818	0.44476765	25.2380409	-20.152056	12.61902047
0.75	0.6	0.59868421	0.44476765	36.3833036	-26.677241	18.19165183
0.8	0.6	0.63480392	0.44476765	46.9246356	-31.937894	23.46231783
0.85	0.6	0.66628440	0.44476765	56.90983	-36.269129	28.454915
0.9	0.6	0.69396551	0.44476765	66.3817665	-39.897260	33.19088325
0.95	0.6	0.71849593	0.44476765	75.3790271	-42.980639	37.6895136
1	0.6	0.74038461	0.44476765	83.9364216	-45.633388	41.96821082
0.38	0.7	0	0.56192717	-71.953056	256.545094	128.2725474
0.4	0.7	0.03804347	0.56192717	-68.756388	220.065429	110.0327148
0.45	0.7	0.18160377	0.56192717	-55.106419	122.748995	61.37449762
0.5	0.7	0.29166666	0.56192717	-42.551981	74.0704072	37.0352036
0.55	0.7	0.37873134	0.56192717	-30.966273	44.8567324	22.42836621
0.6	0.7	0.44932432	0.56192717	-20.241337	25.3782309	12.68911549
0.65	0.7	0.50771604	0.56192717	-10.284680	11.4636840	5.731842026
0.7	0.7	0.55681818	0.56192717	-1.0166045	1.02704553	0.513522766
0.75	0.7	0.59868421	0.56192717	7.63193468	-7.0907716	3.815967341
0.8	0.7	0.63480392	0.56192717	15.7210484	-13.585297	7.860524236
0.85	0.7	0.66628440	0.56192717	23.3033154	-18.899179	11.65165773
0.9	0.7	0.69396551	0.56192717	30.4249254	-23.327539	15.21246274
0.95	0.7	0.71849593	0.56192717	37.1266213	-27.074700	18.56331069
1	0.7	0.74038461	0.56192717	43.4444789	-30.286616	21.72223946

0.38	0.8	0	0.64692525	-78.561580	366.452296	183.2261481
0.4	0.8	0.03804347	0.64692525	-75.690058	311.354337	155.6771689
0.45	0.8	0.18160377	0.64692525	-63.511179	174.056546	87.02827315
0.5	0.8	0.29166666	0.64692525	-52.426686	110.201883	55.10094157
0.55	0.8	0.37873134	0.64692525	-42.295410	73.2964418	36.64822091
0.6	0.8	0.44932432	0.64692525	-32.999461	49.2525324	24.6262662
0.65	0.8	0.50771604	0.64692525	-24.439620	32.3444922	16.17224611
0.7	0.8	0.55681818	0.64692525	-16.531783	19.8060828	9.903041408
0.75	0.8	0.59868421	0.64692525	-9.2041892	10.1372399	5.068619981
0.8	0.8	0.63480392	0.64692525	-2.3952332	2.45401261	1.227006307
0.85	0.8	0.66628440	0.64692525	3.94826475	-3.7982978	1.974132377
0.9	0.8	0.69396551	0.64692525	9.87245531	-8.9853778	4.936227655
0.95	0.8	0.71849593	0.64692525	15.4175828	-13.358088	7.708791428
1	0.8	0.74038461	0.64692525	20.6189013	-17.094254	10.30945069

* $\Delta M = Max\left[\Delta M_A, \Delta M_B\right]$

Table A.14: The details of variables in Fig. 5.7B

$\gamma_A^{x,a}$	$\gamma_B^{y,b}$	$S^a_{AB(I)}$	$S^b_{BA(I)}$	ΔM_A	ΔM_B	$\frac{\Delta M}{2M}\times 100(\%)^*$
0.38	0.5	0	0.22222222	-36.363636	57.1428571	28.57142857
0.4	0.5	0.03804347	0.22222222	-31.106578	45.1517394	22.57586973
0.45	0.5	0.18160377	0.22222222	-7.8065978	8.46763179	4.233815897
0.5	0.5	0.29166666	0.22222222	14.9253731	-12.987012	7.462686567
0.55	0.5	0.37873134	0.22222222	37.109855	-27.065782	18.5549275
0.6	0.5	0.44932432	0.22222222	58.7663914	-37.014377	29.38319573
0.65	0.5	0.50771604	0.22222222	79.9136069	-44.417767	39.95680346
0.7	0.5	0.55681818	0.22222222	100.56926	-50.141911	50.28462998
0.75	0.5	0.59868421	0.22222222	120.750293	-54.699946	60.37514654
0.8	0.5	0.63480392	0.22222222	140.472879	-58.415268	70.2364395
0.85	0.5	0.66628440	0.22222222	159.752463	-61.501808	79.87623195
0.9	0.5	0.69396551	0.22222222	178.603807	-64.106736	89.3019039
0.95	0.5	0.71849593	0.22222222	197.041022	-66.334616	98.5205111
1	0.5	0.74038461	0.22222222	215.077605	-68.261787	107.5388027
0.38	0.6	0	0.43243243	-60.377358	152.380952	76.19047619
0.4	0.6	0.03804347	0.43243243	-56.567997	130.244967	65.12248363
0.45	0.6	0.18160377	0.43243243	-40.105998	66.9616268	33.48081341
0.5	0.6	0.29166666	0.43243243	-24.679170	32.7653997	16.38269987
0.55	0.6	0.37873134	0.43243243	-10.192850	11.3497096	5.674854798
0.6	0.6	0.44932432	0.43243243	3.43642611	-3.3222591	1.718213058
0.65	0.6	0.50771604	0.43243243	16.2825312	-14.002560	8.141265617
0.7	0.6	0.55681818	0.43243243	28.4110838	-22.125102	14.20554192
0.75	0.6	0.59868421	0.43243243	39.8805715	-28.510443	19.94028578
0.8	0.6	0.63480392	0.43243243	50.7432937	-33.662057	25.37164687
0.85	0.6	0.66628440	0.43243243	61.0461588	-37.906001	30.52307941
0.9	0.6	0.69396551	0.43243243	70.8313614	-41.462738	35.41568071
0.95	0.6	0.71849593	0.43243243	80.1369599	-44.486683	40.06847998
1	0.6	0.74038461	0.43243243	88.9973713	-47.089211	44.49868569
0.38	0.7	0	0.57575757	-73.076923	271.428571	135.7142857
0.4	0.7	0.03804347	0.57575757	-69.936810	232.632704	116.316352
0.45	0.7	0.18160377	0.57575757	-56.543804	130.116786	65.0583933
0.5	0.7	0.29166666	0.57575757	-44.247787	79.3650793	39.68253968
0.55	0.7	0.37873134	0.57575757	-32.919283	49.0741392	24.53706963
0.6	0.7	0.44932432	0.57575757	-22.448423	28.9464432	14.47322161
0.65	0.7	0.50771604	0.57575757	-12.741363	14.6018365	7.30091826

0.7	0.7	0.55681818	0.57575757	-3.7174721	3.86100386	1.930501931
0.75	0.7	0.59868421	0.57575757	4.69291981	-4.4825570	2.346459906
0.8	0.7	0.63480392	0.57575757	12.5503196	-11.150852	6.275159839
0.85	0.7	0.66628440	0.57575757	19.9075312	-16.602402	9.953765618
0.9	0.7	0.69396551	0.57575757	26.8108428	-21.142389	13.40542142
0.95	0.7	0.71849593	0.57575757	33.3010022	-24.981809	16.65050113
1	0.7	0.74038461	0.57575757	39.4140216	-28.271203	19.70701081
0.38	0.8	0	0.67973856	-80.933852	424.489795	212.244898
0.4	0.8	0.03804347	0.67973856	-78.174697	358.183800	179.0919005
0.45	0.8	0.18160377	0.67973856	-66.500663	198.513376	99.25668827
0.5	0.8	0.29166666	0.67973856	-55.915244	126.835781	63.41789052
0.55	0.8	0.37873134	0.67973856	-46.272951	86.1259878	43.06299391
0.6	0.8	0.44932432	0.67973856	-37.453116	59.8800677	29.94003386
0.65	0.8	0.50771604	0.67973856	-29.354813	41.5524613	20.77623068
0.7	0.8	0.55681818	0.67973856	-21.892982	28.0294690	14.01473452
0.75	0.8	0.59868421	0.67973856	-14.995425	17.6407280	8.820364045
0.8	0.8	0.63480392	0.67973856	-8.6004691	9.40975192	4.704875962
0.85	0.8	0.66628440	0.67973856	-2.6551094	2.72752828	1.363764141
0.9	0.8	0.69396551	0.67973856	2.88645651	-2.8054776	1.443228259
0.95	0.8	0.71849593	0.67973856	8.06401459	-7.4622570	4.032007297
1	0.8	0.74038461	0.67973856	12.9122900	-11.435681	6.456145046

* $\Delta M = Max\left[\Delta M_A, \Delta M_B\right]$

Table A.15: The details of variables in Fig. 5.7C

$\gamma_A^{x,a}$	$\gamma_B^{y,b}$	$S_{AB(I)}^{a}$	$S_{BA(I)}^{b}$	ΔM_A	ΔM_B	$\frac{\Delta M}{2M}\times 100(\%)^{*}$
0.38	0.5	0	0.08333333	-15.384615	18.1818181	9.090909091
0.4	0.5	0.03804347	0.08333333	-8.6655112	9.48766603	4.743833017
0.45	0.5	0.18160377	0.08333333	21.7959895	-17.895490	10.89799477
0.5	0.5	0.29166666	0.08333333	52.6315789	-34.482758	26.31578947
0.55	0.5	0.37873134	0.08333333	83.8481906	-45.607297	41.92409532
0.6	0.5	0.44932432	0.08333333	115.452930	-53.586150	57.72646536
0.65	0.5	0.50771604	0.08333333	147.453083	-59.588299	73.72654155
0.7	0.5	0.55681818	0.08333333	179.856115	-64.267352	89.92805755
0.75	0.5	0.59868421	0.08333333	212.669683	-68.017366	106.3348416
0.8	0.5	0.63480392	0.08333333	245.901639	-71.090047	122.9508197
0.85	0.5	0.66628440	0.08333333	279.560036	-73.653706	139.7800183
0.9	0.5	0.69396551	0.08333333	313.653136	-75.825156	156.8265683
0.95	0.5	0.71849593	0.08333333	348.189415	-77.688004	174.0947075
1	0.5	0.74038461	0.08333333	383.177570	-79.303675	191.588785
0.38	0.6	0	0.39864864	-57.004830	132.584269	66.29213483
0.4	0.6	0.03804347	0.39864864	-53.006585	112.795773	56.39788652
0.45	0.6	0.18160377	0.39864864	-35.667522	55.4424814	27.72124074
0.5	0.6	0.29166666	0.39864864	-19.328585	23.9596469	11.97982346
0.55	0.6	0.37873134	0.39864864	-3.9056706	4.06441323	2.032206616
0.6	0.6	0.44932432	0.39864864	10.6761565	-9.6463022	5.338078292
0.65	0.6	0.50771604	0.39864864	24.4838724	-19.668308	12.24193624
0.7	0.6	0.55681818	0.39864864	37.5775264	-27.313709	18.78876323
0.75	0.6	0.59868421	0.39864864	50.0111135	-33.338272	25.00555679
0.8	0.6	0.63480392	0.39864864	61.8333188	-38.208027	30.91665944
0.85	0.6	0.66628440	0.39864864	73.0881543	-42.225971	36.54407719

0.9	0.6	0.69396551	0.39864864	83.8155067	-45.597625	41.90775335
0.95	0.6	0.71849593	0.39864864	94.0516092	-48.467317	47.02580463
1	0.6	0.74038461	0.39864864	103.829451	-50.939376	51.91472562
0.38	0.7	0	0.61363636	-76.056338	317.647058	158.8235294
0.4	0.7	0.03804347	0.61363636	-73.063656	271.245634	135.6228172
0.45	0.7	0.18160377	0.61363636	-60.338374	152.132880	76.06644017
0.5	0.7	0.29166666	0.61363636	-48.710601	94.9720670	47.48603352
0.55	0.7	0.37873134	0.61363636	-38.044224	61.4054533	30.70272667
0.6	0.7	0.44932432	0.61363636	-28.224742	39.3237780	19.66188901
0.65	0.7	0.50771604	0.61363636	-19.155143	23.6937078	11.84685391
0.7	0.7	0.55681818	0.61363636	-10.752688	12.0481927	6.024096386
0.75	0.7	0.59868421	0.61363636	-2.9463759	3.03582270	1.517911354
0.8	0.7	0.63480392	0.61363636	4.3250626	-4.1457560	2.1625313
0.85	0.7	0.66628440	0.61363636	11.1147793	-10.002971	5.557389678
0.9	0.7	0.69396551	0.61363636	17.4691095	-14.871236	8.734554751
0.95	0.7	0.71849593	0.61363636	23.4286304	-18.981520	11.7143152
1	0.7	0.74038461	0.61363636	29.0290290	-22.498060	14.51451451
0.38	0.8	0	0.76960784	-86.980609	668.085106	334.0425532
0.4	0.8	0.03804347	0.76960784	-84.497507	545.057562	272.5287813
0.45	0.8	0.18160377	0.76960784	-74.055738	285.441688	142.7208441
0.5	0.8	0.29166666	0.76960784	-64.676616	183.098591	91.54929577
0.55	0.8	0.37873134	0.76960784	-56.205781	128.340640	64.1703201
0.6	0.8	0.44932432	0.76960784	-48.517384	94.2403274	47.12016373
0.65	0.8	0.50771604	0.76960784	-41.507805	70.9629811	35.48149059
0.7	0.8	0.55681818	0.76960784	-35.090942	54.0617039	27.03085197
0.75	0.8	0.59868421	0.76960784	-29.194667	41.2323012	20.61615061
0.8	0.8	0.63480392	0.76960784	-23.758099	31.1614730	15.58073654
0.85	0.8	0.66628440	0.76960784	-18.729492	23.0458660	11.52293302
0.9	0.8	0.69396551	0.76960784	-14.064587	16.3664624	8.183231233
0.95	0.8	0.71849593	0.76960784	-9.7253028	10.7730107	5.386505387
1	0.8	0.74038461	0.76960784	-5.6786957	6.02058652	3.010293261

* $\Delta M = Max\left[\Delta M_A, \Delta M_B\right]$

Appendix A.13: An Example Code of MATLAB

The following code provides the experiment of Fig. 5.3.

```
%% D_Venkatesh (MA=MB=M)

%%First Figure

b=[0.1:0.1:0.9];c1=0.2;m=100

i1=(m*(b/c1)-m); j1=(m*(c1./b)-m); k1=max(i1,j1)/(2*m)*100

%%Second Figure

b=[0.1:0.1:0.9]; c2=0.4;

i2=(m*(b/c2)-m); j2=(m*(c2./b)-m); k2=max(i2,j2)/(2*m)*100

%%Third Figure

b=[0.1:0.1:0.9];c3=0.6;

i3=(m*(b/c3)-m);j3=(m*(c3./b)-m); k3=max(i3,j3)/(2*m)*100

%%Fourth Figure

b=[0.1:0.1:0.9];c4=0.8;

i4=(m*(b/c4)-m); j4=(m*(c4./b)-m); k4=max(i4,j4)/(2*m)*100

plot(b, k1, '-o', b, k2, '-*', b, k3, '-^', b, k4, '-x')

%%title('Anticipated Market Expansion of Alliance');

legend('{\itS}_{\itBA(1)}=0.2', '{\itS}_{\itBA(1)}=0.4',
'{\itS}_{\itBA(1)}=0.6', '{\itS}_{\itBA(1)}=0.8', -1)

xlabel('Shift-in Ratio of {\itA},{\itS}_{\itAB(1)}');

ylabel('Market Expansion Required (% of initial sizes)');

text(0.2, 0, '\bullet'); text(0.4, 0, '\bullet'); text(0.6, 0, '\bullet'); text(0.8, 0,
'\bullet')

axis on; grid on; axis ([0.1 0.9 0 300])
```

Appendix A.14: Examples of Measurement and Scaling

Table A.16 demonstrates two attributes (good-taste and low-calories) of the *Appetite-Bio* pizza and please allocate 100 points between them. The points should reflect the relative importance of each attribute. That is, if an attribute is twice as important as the other, it should count twice as many points.

Table A.16: Importance of two attributes using the constant sum scaling

Attribute	Group *a*	Group *b*
Good-taste	40	60
Low-Calories	60	40
Sum	100	100

Besides, both the Likert scale (Likert, 1932) and the Semantic differential scale are commonly accepted measures for identifying attitudes, preferences, and perceptual phenomena (Menezes and Elbert, 1979). The Likert scale asks the respondents to indicate a degree of agreement or disagreement with each of the statements about the stimulus objects. The semantic differential scale asks the respondents to rate objects on a seven itemized rating scales bounded at each end by one of two bipolar (or contrasting) adjectives. The means and standard deviations derived from a semantic differential scale are usually used as a summary statistic because it can be considered as interval-scale data. Fig. A.1 shows the application of the Likert scale.

Figure A.1: Example of the Likert scale

Please indicate how strongly you agree or disagree with each of the following sentence (by putting * next to your choice) :

1= strongly disagree, 2=disagree, 3= no opinion, 4= agree, 5=strongly agree

Questions	strongly disagree	disagree	no opinion	agree	strongly agree
Brand *A* offers high quality products	1	2	3*	4	5
Brand *B* is a likeable brand	1	2*	3	4	5
Brand *B* has good performance in "low-calories"	1	2	3	4*	5
Brand *A* performs well in "good-taste"	1	2	3	4	5*

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