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Linking supplier development to supplier segmentation using Best Worst Method

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ABSTRACT

The strategic supplier-related activity of supplier segmentation focuses on the evaluation of suppliers, identifying different approaches, identifying the most suitable criteria and proper methods to segment the suppliers. The main aim of the evaluation *of* suppliers is to form different groups from the selected suppliers to create different supplier management strategies for segments involved. Supplier development is another strategic supplier-related activity designed to upgrade the performance level of suppliers in order to create and maintain a network of competent suppliers, which has a major influence on the competitive advantages of a buying company. To allocate scarce resources more efficiently, we should design different supplier development strategies for different supplier segments. This is where we actually use the evaluation *for* suppliers. This paper proposes an integrative approach that includes capabilities and willingness as two dimensions for evaluating and subsequently segmenting suppliers. The results of that segmentation are then used as the main basis for supplier development. The integrative approach proposed in this paper is of significant importance, as it helps companies apportion their managerial resources more efficiently. We use a new multi-criteria decision-making method called Best Worst Method (BWM) to segment suppliers. A supplier development conceptual model is proposed to develop the suppliers in the different segments. The proposed framework is further applied to a medium-sized high-tech company as input to validate the model.

1. Introduction

With an increasing impact of suppliers on cost, quality, time and responsiveness of buying firms, supply chain management can be considered as a strategic tool which is used by firms to improve quality, customer service and competitive advantage (Tan, Lyman, & Wisner, 2002). One of the main business processes of supply chain management is supplier relationship management which is focused on the development and maintaining the relationships with suppliers (Lambert & Schwieterman, 2012). Supplier relationship management usually contains three steps: supplier selection, supplier segmentation and supplier development. Generally speaking, a number of qualitative and quantitative criteria are identified by the company to choose the most suitable suppliers (to see the methods and the criteria of supplier selection we refer to the review papers (Chai, Liu, & Ngai, 2013; De Boer, Labro, & Morlacchi, 2001; Ho, Xu, & Dey, 2010); for a sample of recent studies, see (Azadi, Mirhedayatian, & Saen, 2013; Deng, Aydin, Kwong, & Huang, 2014; Ekici, 2013; Rezaei, Fahim, & Tavasszy, 2014; You, You, Liu, & Zhen, 2015). When firms have a large number of suppliers, it is difficult to manage all the suppliers individually. For example, IKEA has 1026 suppliers in 53 countries (IKEA, 2011). Even though some companies like Philips has centralized its spending by reducing its number of active suppliers, there are still 2000 suppliers (Philips, 2007). Therefore, after the suppliers are selected, the buyer should further classify the selected suppliers in the step of supplier segmentation. Subsequently, in the step of supplier development, most suitable strategies can be formulated to deal with different segments of the selected suppliers (Dyer, Cho, & Chu, 1998). Effective supplier development helps suppliers to improve their capability and performance, which in return helps the buying company realize cost reduction, productivity improvement, quality improvement and optimal resource utilization (Krause & Ellram, 1997a; Sako, 2004; Talluri, Narasimhan, & Chung, 2010; Wouters, van Jarwaarde, & Groen, 2007; Humphreys, Cadden, Wen-Li, & McHugh, 2011). Supplier development activities require the buying company to spend considerable time, manpower, and financial and technical resources, which are scarce commodity in any company and should be allocated more efficiently and strategically (Dyer et al., 1998). This implies that for different groups of suppliers, different supplier development strategies should be formulated. To optimize purchasing

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effectiveness, supplier segmentation is introduced as a means to deal with different suppliers in a systematic way. However, there is no single systematic investigation on linking supplier development to supplier segmentation. The supplier development strategies we find in existing literature are not tailored to different types of suppliers, but treat all suppliers in the same way (Krause & Ellram, 1997a; 1997b).

Moreover, existing supplier development programs focus mostly on improving supplier capabilities. However, a strong and close buyer-supplier relationship, to a great extent depending on a supplier's willingness to collaborate, is also crucial to the buying company in achieving a lead position in the marketplace (Rezaei & Ortt, 2012). A high level of willingness on the part of both the supplier and the buyer creates mutual trust and increases the duration of the relationship (Krause, Handfield, & Tyler, 2007), which has a major impact on the buying firms' competitive advantages. Therefore, a supplier's willingness to engage in a relationship with a buyer also serves an important purpose, which should be taken into consideration. However, in existing literature, this aspect is not taken into account during the supplier development.

In order to find solution for these practical problems, the following research question is formulated:

> *How can the buying company segment its suppliers into different segments based on supplier capabilities and willingness, and develop different types of suppliers to improve their capabilities and/or willingness?*

By answering this main research question, we contribute to the relevant research areas in the following ways.

Firstly, while existing studies on supplier development focus solely on supplier capabilities, we also look at supplier willingness, as a key dimension of supplier development. Secondly, while existing literature considers the two strategic activities (supplier segmentation and supplier development) separately, this study links the two by systematically classifying suppliers according to their capabilities and willingness, and by formulating different supplier development strategies for different supplier segments. In fact, this paper shows how supplier evaluation, which is traditionally used for the purpose of supplier selection (for the benefit of the buying company), can be of great help to suppliers as well. Thirdly, while most supplier segmentation approaches do not provide the buyer with a practical tool to implement the segmentation, we apply an efficient multi-criteria decision-making method, which is among a few applications in supplier segmentation and development fields.

This paper is organized as follows. In Section 2, a literature review on supplier segmentation and development is presented. Section 3, presents a conceptual framework to link supplier development to supplier segmentation. In Section 4, the proposed multi-criteria decision-making method (Best Worst Method: BWM) is presented. In Section 5, the proposed methodology and supplier development conceptual model are applied to a real-world case. Section 6 describes what the case company does in practice for supplier development, which is used as a validation for our conceptual framework proposed in Section 3. Finally, the conclusions and future research are discussed in Section 7.

2. Literature review

In this section we review the relevant literature on supplier segmentation, and supplier development.

2.1. Supplier segmentation

In 1983, Kraljic proposed the purchasing portfolio model in order to determine the differentiated purchasing strategies (Kraljic, 1983). With the purpose of minimizing supply risk and making the most of buying power, Kraljic, considering two dimensions supply risk and profit impact, classifies the materials that a company purchased into four categories: bottleneck (supply risk: high; profit impact: low); non-critical (supply risk: low; profit impact: low); leverage (profit impact: high; supply risk: low); and strategic (supply risk: high; profit impact: high). Kraljic's portfolio approach has been adopted by several large companies, including Shell, Alcatel, Philips and Siemens (Gelderman & Van Weele, 2002). Later, many other researchers have made extensions or modifications to Kraljic's approach. Some researchers focused on the applications of Kraljic's approach. Gelderman and Semeijn (2006) use Kraljic's purchasing portfolio approach for managing global supply base in addition to strategies formulation. Gelderman and Van Weele (2003) deal with the measurement issues and strategic directions in Kraljic's purchasing portfolio model by investigating which measurement methods are possible and which supplier strategies are feasible, including additional strategic movements of commodities within the matrix. Gelderman and Van Weele (2005)'s study also addresses the question of whether or not the use of purchasing portfolio models is considered as a sign of purchasing sophistication. They discover that the purchasing's sophistication is a two-dimension construct: purchasing's professionalism and purchasing's position within the organization. Both of the position and the professionalism of purchasing are positively related to the greater use of purchasing portfolio models. Additionally, based on Kraljic's model, Pagell, Wu, and Wasserman (2010) developed a modified sustainable purchasing portfolio model that is suitable for sustainable supply chain management (SSCM). Caniëls and Gelderman (2007) investigated power and interdependence in each quadrant of the Kraljic portfolio matrix. According to their research, the bottleneck quadrant of Kraljic matrix is characterized by supplier dominance, while the leverage quadrant is buyer dominance. The non-critical quadrant is characterized by balanced power. The total interdependence is highest in the strategic quadrant and lowest in non-critical quadrant. Therefore the power and interdependence in different quadrants are different, which should be taken into consideration when doing purchasing and relationship management.

Some researchers focus on the evolution of supplier evaluation dimensions. Supplier segmentation is identified to have effect of leading to more effective supplier involvement in product development. Wynstra and Ten Pierick (2000)'s research classified suppliers based on two dimensions: development risk and degree of development responsibility held by the supplier. Development risk refers to the importance, newness and complexity of development of the part concerned and gives an indication of the time and effort required developing a specific part. Different communication and collaboration strategies are proposed to deal with different types of suppliers. The classification of purchase proposed by Olsen and Ellram (1997) is based on two dimensions: difficulty of managing the purchase situation and strategic importance of the purchase. Aiming at allocating different levels of resources to each group, Dyer et al. (1998) proposed a strategic supplier typology by segmenting suppliers into two primary categories: strategic partners and durable arm's-length suppliers. The inputs provided by strategic partners are high in value and closely related to buying company's core competence, while durable arm's-length suppliers only provide non-crucial products. Kaufman, Wood, and Theyel (2000) suggested to segment suppliers according to two dimensions technology and collaboration. Suppliers can therefore be categorized into four groups: commodity suppliers, collaboration specialists, technology specialists, problem-solving suppliers. Masella and Rangone (2000) proposed to segment suppliers according to the time horizon involved and on the content of relationship. The length of reference time is related to long-term relationship and short-term relationship, which depend on factors like the level of transaction-specific investments and switching costs. The content of relationship refers to logistic or strategic goals. The logistic integration contains arrangements on performance such as quality, and

service support. Strategic integration refers to arrangement beyond performance, like supplier know-how.

To sum up, the existing portfolios all have the drawback that each of the proposed approaches contains limited variables, and is not able to cover other important variables. In order to deal with the problem that there is no integrated approach for supplier segmentation, and also to overcome the inefficacy of the previous approaches in operationalization of the dimensions (Gelderman & Van Weele, 2005) this research will adopt a new approach to supplier segmentation (supplier potential matrix: SPM) (Rezaei & Ortt, 2012), which groups variables in existing literature under two main dimensions: (1) capabilities: supplier knowledge and skills; (2) willingness: supplier motivation to collaborate with the buying company. However, SPM does not provide a classification of the criteria, which is done in this paper as follows.

2.1.1. Classifying the evaluation criteria

In our view, the resource-based view of the firm provides an excellent basis for classifying the criteria related to capabilities. According to existing literature on the resource-based view of the firm, there are six major categories of resource: financial resources, physical resources, human resources, technological resources, reputation and organizational resources (Grant, 1991; Mahoney & Pandian, 1992). A key ingredient in the relationship between resources and capabilities is the ability of an organization to achieve cooperation and coordination within teams (Mahoney & Pandian, 1992), which means that a company's human resources and organizational resources can be reflected by organizational capability. Product quality capability can serve as a reflection of physical resources.

Influenced by the Just-In-Time principles, buying companies increasingly paying attention to the delivery capability of the suppliers. In addition, service performance criteria should always be included in the supplier evaluation criteria, because all purchases involve some degree of service (Kilincci & Onal, 2011). Since the aim is to evaluate suppliers, delivery capability and service capability are crucial criteria, in addition to the major categories mentioned above. In recent years, sustainability has also become an important issue among companies and their supply chains. As a result, sustainability can serve as another important main criterion for evaluating suppliers.

To summarize, capabilities variables can be classified into the following eight categories:

1. Technical capability, e.g. capability with regard to design, production improvement
2. Product quality capability, e.g. quality assurance
3. Delivery capability, e.g. capacity level, order entry system
4. Intangible capability, e.g. reputation, brand recognition
5. Service capability, e.g. follow-up, technical support
6. Financial/cost capability, e.g. cost reduction program, price
7. Sustainable capability, e.g. pollution reduction
8. Organizational capability, e.g. human resources management

Due to its relative newness in this area, we found no classification for supplier willingness to collaborate. According to the definition of willingness proposed by Rezaei and Ortt (2012), it should reflect not only a willingness to improve, but also a willingness to maintain and develop the relationship with the buyer. Reviewing the relevant literature, here, we propose the following classification for willingness:

1. Willingness to improve performance
2. Willingness to share information
3. Willingness to rely on each other
4. Willingness to become involved in a long-term relationship

"Willingness to improve performance" can refer to as the supplier's efforts regarding self-improvement. By providing better products or services, suppliers show their commitment to engage in a long-term relationship. "Willingness to share information" is an important indicator of a supplier's willingness to maintain and develop the relationship. Besides, according to Morgan and Hunt (1994), a successful relationship requires trust and commitment. "Trust is defined as a willingness to rely on an exchange partner in whom one has confidence" (Rotter, 1967). Confidence results from the firm belief that the other party is reliable and has a high level of integrity, which are associated with such qualities as consistency, honesty, fairness, responsibility, etc. (Morgan & Hunt, 1994). Willingness is a critical aspect of trust's conceptualization, because "if one believes that a partner is trustworthy without being willing to rely on that partner, trust is limited" (Moorman, Deshpande, & Zaltman, 1993). "Commitment to relationship is defined as an enduring desire to maintain a valued relationship" (Moorman et al., 1993). For a supplier, believing that an ongoing relationship with the buyer is so important as to warrant maximum efforts to maintain it (Morgan & Hunt, 1994) creates a willingness to become involved in a long-term relationship with the buying company.

The variables regarding willingness and capabilities, as well as their classification, are summarized in Table 1.

2.2. Supplier development

Krause, Handfield, and Scannell (1998) define supplier development as "an effort of a buying firm with a supplier to increase the performance and/or capabilities of a supplier and to meet the buying firm's long-term and/or short-term needs". Krause, Scannell, and Calantone (2000) recognized that supplier development is a collaboration between buying and supplying firms designed to enhance the supplier's performance and/or capabilities for the sake of buying company. Moreover, Krause et al. (2000) proposed several supplier development strategies that are categorized as internalized or externalized activities, which include competitive pressure, supplier assessment efforts and supplier incentives. On the contrary, internalized supplier development strategies need the buying firm to become directly involved in the supplier development, entail investments in supplier through activities such as training and education of supplier's personnel. It is found that buying firms that are satisfied with their supplier development efforts tend to communicate more effectively with their suppliers, make greater efforts into such activities as supplier evaluation, supplier training and supplier award programs (Krause & Ellram, 1997b). Besides, Krause and Ellram (1997a) reported that "the majority of buying firms involved in supplier development will also perceive their suppliers as partners" and place a greater emphasis on some critical elements than those elements not involved in supplier development. Other researchers also thoroughly examined supplier development. In Table 2, we summarize all the strategies reported in existing literature.

3. Linking supplier development to supplier segmentation

In this study, we use SPM by applying capabilities and willingness as the two overarching dimensions. The suppliers are then classified into four categories: low willingness, low capabilities; high willingness, low capabilities; low willingness, high capabilities; high willingness, high capabilities. The resulting matrix is much more inclusive than the ones used in other supplier segmentation models, because the dimensions are based on multiple criteria (Rezaei & Ortt, 2013a; b). Based on the established supplier segmentation, the ultimate goal is to move the suppliers to a better quadrant. Hence, for the purpose of mapping the existing strategies related to this segmentation, the supplier development strategies are divided into three groups:

- Designed strategies to improve supplier willingness;
- Designed strategies to improve supplier capabilities;

Table 1
A classification of supplier evaluation criteria.

Dimension	Main criteria	Sub-criteria
Capabilities	Technical capability	Industry knowledge
		Design capability
		Supplier process capability
		Technology monitoring
		Technology development
		Innovation
		Production, manufacturing/transformation facilities and capacity
		R&D expenditure
	Product quality capability	Quality
		Reliability of product
		Ease of maintenance design
		Ease of operation
		Contribution to the production
	Delivery capability	Geographic location/proximity
		Delivery
		Reserve capability
		Profit impact of supplier
		Packaging ability
		Lead time
	Intangible capability	Reputation and position in industry
		Labor relations record
		Amount of past business
		Performance awards
		Performance history
	Service capability	Repair services
		After sales support
		Training aids
		Follow-up
		Supplier's order entry and invoicing system including EDI
	Financial/Cost capability	Financial position
		Price/cost
		Cost reduction program
		Cost control
	Sustainable capability	Hazardous air emissions management
		Hazardous waste management
		Environmentally friendly product packaging
		Recycling and reverse logistics program
		Pollution reduction capability
		Availability of clean technologies
		Public disclosure of environmental record
		ISO 14000 and 14001 certification
		Environmental health and safety
		Impact on energy utilization
	Organizational capability	Management and organization
		Human resource management
		Market sensing
		Operational controls
		Customer linking
		Communication system
		Desire for business
		Warranties and claims
Willingness	willingness to improve performance	Commitment to continuous improvement in product and process
		Supplier's effort in eliminating waste
		Supplier's effort in promoting JIT principles
		Willingness to integrate supply chain management relationship
	Willingness to share information	Honest and frequent communications/ communication openness
		Openness
		Willingness to share information, ideas, technology, and cost savings
		Open to site evaluation
	Willingness to rely on each other	Mutual respect and honesty
		Ethical standards
		Impression
		Dependency
	Willingness to get involved in long-term relationship	Long-term relationship
		Commitment to quality
		Relationship closeness
		Willingness to invest in specific equipment
		Prior experience with supplier
		Reciprocal arrangements
		Willingness to co-design and participate in new product development
		Bidding procedural compliance
		Consistency and follow-through

Table 2
Strategies for supplier development.

Strategies	Description
Supplier assessment and feedback	With the intention of putting pressure on suppliers, stimulating learning by experience, and providing assistance for making improvements, buyers should evaluate their suppliers regularly (Wouters et al., 2007) and provide evaluation feedback to suppliers (Wagner, 2006).
Competitive pressure	A buying company can apply competitive pressure to its suppliers, when it uses multiple suppliers for a purchased item or service, or is willing and able to switch to other alternate suppliers (Krause et al., 2000).
Knowledge transfer	The buying company could transfer specialized knowledge to suppliers in order to increase supplier capabilities (Lorenzoni & Lipparini, 1999).
Joint action	Some activities are carried out by both buyer and suppliers in a cooperative or coordinated way, which improves the performance of both parties (Humphreys, Li, & Chan, 2004).
Plant visits to suppliers	Plant visits to suppliers helps to evaluate specific areas of the suppliers (Sánchez-Rodríguez, 2009), stimulate the knowledge flowing between two parities, as well as build and enhance understanding and inter-firm relationship (Cousins, Lamming, Lawson, & Squire, 2007).
Making investment	Many companies invest in equipment for the suppliers or give financial support as a means for supplier development (Wagner, 2006, Wouters et al., 2007).
Two-way communication	Communication helps to develop a common understanding of the message from both the supplier's and buyer's perspectives, making both the buyer's needs, expectations and the supplier's facilities, capabilities well known.
Long-term commitment	Long-term commitment helps to reduce transaction costs and risk (Abdullah and Maharjan, 2003), and saves time and cost in investigating and screening the new supplier candidate (Abdullah and Maharjan, 2003).
Supplier incentives	Offering incentives is an effective way to motivate suppliers, which includes giving consideration for increased volumes, the sharing of achieved cost savings, future business, an opportunity for worldwide purchase contracts, increased access to technical insight at the buyer, and recognizing supplier improvements through awards (Krause et al., 2000, Modi & Mabert, 2007, Monczka et al., 1993b).
Emphasis on factors other than price	Putting emphasis on other factors other than price helps the supplier development efforts to focus on developing supplier future capabilities in technology and product development (Humphreys et al., 2004).
Purchasing a large percentage of suppliers' annual sales	The higher the percentage of supplier's output purchased by any buying firm, the more important the buyer is to the supplier, the more the buying company can expect acquiescence to its needs (Krause & Ellram, 1997a).
Establishing higher supplier performance expectations	Increasing supplier performance expectations is an efficient way to motivate suppliers since suppliers are reluctant to initiate programs to enhance their performance and capabilities (Humphreys et al., 2004).
Trust building	Trust makes buyer and suppliers become more willing to rely on each other (Moorman et al., 1993) and safeguard both parties against the hazards of opportunism while making transaction-specific investments (Johnsen, 2009, Li et al., 2012).

- Designed strategies to improve supplier willingness as well as capabilities.

3.1. Strategies to improve supplier's willingness

According to Mortensen, Freytag, and Arlbjørn (2008), companies can manage their business relationship through attractiveness (voluntary motivation and commitment between the relationship partners), which works better than using power as a traditional approach of managing relations. Therefore, to improve a supplier's willingness to cooperate with the buyer, the buying firm should make itself more attractive to its suppliers. Attraction has been defined by Halinen (1996) as "a company's interest in exchange with another, based on the economic and social reward-cost outcomes expected from the relationship overtime". Later, Morgan (2000) suggested that the basis for relational exchange should be expanded to include access to resources, since parties in a relationship need access to resources that they do not have to improve their competitiveness. According to Harris, O'Malley, and Patterson (2003) and Mortensen et al. (2008) three drivers of attractiveness between two companies are:

1. *Economical attractiveness* refers to the business volume offered, the level of profit, and the stability of the business of the buyer.
2. *Resource-based attractiveness* refers to the possibility of knowledge and resource transferring from the buyer, and the market and information access provided by the buyers.
3. *Socially based attractiveness* refers to the personal relationship between the individual buyer and supplier, the familiarity between the two parties and the ease of the dyadic interaction.

According to the framework proposed by Harris et al. (2003), and considering the supplier development literature, we propose the following strategies to improve supplier willingness.

- Two-way communication: a two-way communication enables both parties to collaborate. This facilitates discussing their common interests, which enhances trust in a business relationship (Coote, Forrest, & Tam, 2003). Two parties become familiar with each other by sharing information and culture. Therefore, effective communication could increase the socially based attractiveness of the buying company and further improve the supplier's willingness to work with the buyer.
- Joint action: by carrying out joint action, both companies can increase their resource-based attractiveness, since both parties can bring complementary skills/resources to the alliance to ensure that their needs will be profitably fulfilled by coalition (Harris et al., 2003). Besides, joint action is a type of socialization mechanism, playing a positive role in establishing and enhancing the relationship (Cousins & Menguc, 2006). As the extent and scope of joint activities increase, the firms move toward closer relationship. Therefore, both parties have increased their socially based attractiveness.
- Plant visits to suppliers: supplier visits serve as an important aspect of supply chain socialization, which offers a good opportunity for both parties to improve communication, share culture, and understand more about each other's business (Cousins & Menguc, 2006). This strategy helps increases the buyer's socially based attractiveness.
- Long-term commitment: a long-term relationship orientation increases communication between firms (Modi & Mabert, 2007) and leads to the establishment of trust between trading partners (Bensaou & Venkatraman, 1995), proving the stability of the business between both parties, and increases the economic attractiveness of the buying firm. Through long-term relationships buyer and supplier become more familiar with each other, hence the companies' socially based attractiveness will be improved.
- Purchase large percentage of suppliers' annual sales: purchasing a large percentage of the supplier's annual sales can definitely make the buying company an important customer to the supplier and increase the buying company's economic attractiveness. This strategy has a positive influence on the supplier's willingness to engage in the relationship.

- Trust building: previous studies have found that trust can increase the duration of the relationship between buyers and suppliers (Krause et al., 2007). A long-term relationship allows both parties to become familiar with each other and guarantee the stability of the business, which increases the buying companies, socially based attractiveness and economic attractiveness. Trust is the most efficient way of safeguarding both parties against the hazards of opportunism when the transaction-specific investments expose them to greater risks and uncertainties (Johnsen, 2009; Li, Humphreys, Yeung, & Cheng, 2012). Hence, trust also helps to increase the company's resource-based attractiveness, and furthermore stimulates the supplier willingness.

3.2. Strategies to improve capabilities

After reviewing existing literature, we summarize the main strategies that can be used to improve a supplier's capabilities.

- Competitive pressure: when the buying company uses multiple suppliers for a purchased item or service, the competitive pressure force the suppliers to improve their capabilities, and stay competitive in terms of quality, delivery, or whatever supplier performance characteristics the buying firm deems important (Modi & Mabert, 2007). Otherwise, suppliers with poor capabilities would be replaced by alternative suppliers or receive a reduced business volume. Thus, competitive pressure is an effective strategy to improve a supplier's capabilities.
- Emphasis on factors other than price: putting emphasis on factors other than price motivates the suppliers to develop other capabilities, like technical and product quality capabilities (Krause & Ellram, 1997a), and prevent the suppliers from blindly lowering the costs and quality of their products.
- Raising expectations regarding supplier performance: since the buying company only maintains relationship with suppliers who are capable to meet the higher expectations (Monczka, Trent, & Callanhan, 1993), the suppliers are encouraged to increase their capabilities continuously. This is an efficient strategy for the buying company to enhance its competitiveness, through the continuous improvement of the supplier's capabilities.

3.3. Strategies to improve both capabilities and willingness simultaneously

Although the above-mentioned strategies may improve the suppliers' willingness and capabilities, based on our literature review, we discuss strategies that could simultaneously improve both aspects.

- Supplier assessment and feedback: by regularly evaluating existing suppliers, the buying company is well aware of the levels of the suppliers' capabilities and willingness (Krause et al., 2000; Wouters et al., 2007). In the next step, good performance can be rewarded to furthermore promote supplier willingness (Wagner, 2010), and competitive pressure can be exerted to poorly performing suppliers to encourage them to improve their capabilities or willingness (Krause et al., 2000). By providing feedback to suppliers, the buying company clarifies its expectation and provides the suppliers with direction for improvement (Wagner, 2006). Additionally, from the perspective of the attractiveness framework (Harris et al., 2003; Mortensen et al., 2008), feedback helps both parties to communicate their issues and expectations, and furthermore improves the buying company's socially based attractiveness, making it an effective way to improve the suppliers' willingness and capabilities.
- Financial and physical investments: by investing in equipment for suppliers or providing financial support, the supplier's capabilities could be increased in terms of production and innovation. Relation-specific investment could lead to the increase of a buying company's resource-based attractiveness. Besides, such investments show the buying company's loyalty and willingness to be involved in a long-term relationship with the supplier (Monczka, Petersen, Handfield, & Ragatz, 1998). The stability of the business is a critical part of 'economic attractiveness' (Harris et al., 2003; Mortensen et al., 2008). As such, this also helps the buying company increase its economic attractiveness. Due to transaction-specific investments, organizational boundaries between supplier and buyer begin to blur (Dyer et al., 1998). The partners' destinies become tightly intertwined, giving both parties strong incentives to help each other as much as possible, because each party has made co-specialized investments that are of little value outside of the relationship (Dyer et al., 1998).
- Knowledge transfer: Wagner and Krause (2009) have demonstrated that there is a positive relationship between a supplier's capabilities improvement and the knowledge transfer from the buyer to the supplier. In addition, knowledge transfer is considered a human resource transaction-specific investment (Dyer et al., 1998), serving as another type of transaction-specific investment made by the buying company. This kind of investment will also result in the increase of the resource-based attractiveness and economic attractiveness of the buying firm. Both parties may rely more on each other, since the relation-based investments have little value outside the relationship. Moreover, tacit knowledge is usually transferred by bringing together individuals from buying firm and its suppliers. Therefore, knowledge transfer also has the ability to increase the buying company's socially based attractiveness.
- Supplier incentives: the incentives provided to the outstanding suppliers may include giving consideration to increased volumes, the sharing of achieved cost savings, future business, and recognition/rewards for improved performance (Krause & Scannell, 2002; Krause et al., 2000; Modi & Mabert, 2007). According to the attractiveness framework, business volume is a major aspect of a buying company's economic attractiveness (Harris et al., 2003; Mortensen et al., 2008). Thus, by offering the supplier incentives, the buying company increases its economic attractiveness. Moreover, offering supplier incentives is also an important approach to drive supplier capability improvement (Monczka et al., 1993). The incentives can be used by the customer firms that succeed in increasing suppliers' performance and capabilities to recognize suppliers' achievements with 'certified' or 'preferred' status (Krause & Ellram, 1997a). Therefore, this action could motivate suppliers to make improve their capabilities.

Based on the classification of strategies, they can be easily mapped onto the supplier segmentation. That is to say, the buying company could use these strategies to develop supplies from each segment.

4. Methodology

Multi-criteria decision-making methods deal with the process of making decisions in presence of multiple criteria. Supplier segmentation depends on a wide range of criteria which involve both quantitative and qualitative. Hence, in order to calculate the aggregated scores of capabilities and willingness for each supplier, multi-criteria decision making methods can be employed. In this research, a new multi-criteria decision-making method which is called Best Worst Method (BWM) is applied to determine the weights of respective willingness and capabilities criteria. Below is a description of the steps of BWM to derive the weight of the criteria (Rezaei, 2015a):

Step 1. The decision-maker (DM) determines a set of decision criteria $\{c_1, c_2, \ldots, c_n\}$.

Step 2. The DM chooses the *best* and the *worst* criteria.

In this step, the DM chooses the best and the worst criteria among the set of criteria identified in Step 1 from his/her own perspective.

Fig. 1. The five-stage research process model (Stuart et al., 2002).

The best criterion represents the most desirable or the most important criterion and the worst criterion is the least desirable or the least important criterion to the decision.

Step 3 . The DM conducts pairwise comparison between the best criterion and the other criteria.

The aim of this step is to determine the preference of the most important criterion to the other criteria, which is determined by the DM using a number from 1 to 9 (1: equally important, 9: extremely more important). The comparison result is expressed by a "Best-to-Others" vector as follows:

$$A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn}),$$

Where a_{Bj} represents the preference of the best criterion B over the criterion j, and $a_{BB} = 1$.

Step 4 . The DM conducts pairwise comparison between the other criteria and the worst criterion.

In this step, the relative importance of the other criteria over the worst criterion is determined by the DM using a number from 1 to 9. The comparison result can be expressed by a "Others-to-Worst" vector as follows:

$$A_W = (a_{1W}, a_{2W}, \ldots, a_{nW})^T,$$

where a_{jW} indicates the preference of the criterion j over the worst criterion W, and $a_{WW} = 1$.

Step 5 . Calculating the optimal weights $(w_1^*, w_2^*, \ldots, w_n^*)$

For each pair of w_B/w_j and w_j/w_W, the optimal weight should meet the requirement that $w_B/w_j = a_{Bj}$ and $w_j/w_W = a_{jW}$. To satisfy the conditions, the maximum absolute differences $|\frac{w_B}{w_j} - a_{Bj}|$ and $|\frac{w_j}{w_W} - a_{jW}|$ for all j is minimized. Also taking into consideration the non-negativity characteristic and sum condition of the weights, the following problem can be formulated:

$$\begin{aligned} &\min \max_j \left\{ \left| \frac{w_B}{w_j} - a_{Bj} \right|, \left| \frac{w_j}{w_W} - a_{jW} \right| \right\} \\ &\text{s.t.} \\ &\textstyle\sum_j w_j = 1 \\ &w_j \geq 0, \text{ for all } j \end{aligned} \tag{1}$$

Hence, problem (1) can be transferred to the following problem:

$$\begin{aligned} &\min \xi \\ &\text{s.t.} \\ &\left| \frac{w_B}{w_j} - a_{Bj} \right| \leq \xi, \text{ for all } j \\ &\left| \frac{w_j}{w_W} - a_{jW} \right| \leq \xi, \text{ for all } j \\ &\sum_j w_j = 1 \\ &w_j \geq 0, \text{ for all } j \end{aligned} \tag{2}$$

By solving the optimization problem (2), the optimal weights $(w_1^*, w_2^*, \ldots, w_n^*)$ and ξ^* can be obtained. For not-fully consistent problems with more than three criteria there might be more than one optimal solution. As such, the following two models are used to calculate the lower and upper bounds of the weight of criterion j. These models are solved after solving model (2) and finding ξ^* (Rezaei, 2015b).

$$\begin{aligned} &\min w_j \\ &\text{s.t.} \\ &\left| \frac{w_B}{w_j} - a_{Bj} \right| \leq \xi^*, \text{ for all } j \\ &\left| \frac{w_j}{w_W} - a_{jW} \right| \leq \xi^*, \text{ for all } j \\ &\sum_j w_j = 1 \\ &w_j \geq 0, \text{ for all } j. \end{aligned} \tag{3}$$

$$\begin{aligned} &\max w_j \\ &\text{s.t.} \\ &\left| \frac{w_B}{w_j} - a_{Bj} \right| \leq \xi^*, \text{ for all } j \\ &\left| \frac{w_j}{w_W} - a_{jW} \right| \leq \xi^*, \text{ for all } j \\ &\sum_j w_j = 1 \\ &w_j \geq 0, \text{ for all } j \end{aligned} \tag{4}$$

Solving these two models for all the criteria we can find the upper and lower bounds of the weights of the criteria. So we have an optimal weight interval for each criterion, one way is to calculate the center of the interval as a representative weight of criterion j as follows:

$$w_j^* = (\min w_j + \max w_j)/2 \tag{5}$$

After finding the final results we should calculate the consistency level of the comparisons. The consistency is defined as follows (Rezaei, 2015a).

Definition 1. A comparison is fully consistent when $a_{Bj} \times a_{jW} = a_{BW}$, for all j, where a_{Bj}, a_{jW} and a_{BW} are respectively the preference of the best criterion over the criterion j, the preference of criterion j over the worst criterion, and the preference of the best criterion over the worst criterion.

The consistency ratio of BWM can be expressed by using ξ^* and the corresponding consistency index (Table 3), as follows:

$$\textit{Consistency Ratio} = \frac{\xi^*}{\textit{Consistency Index}} \tag{6}$$

It can be seen that the smaller the ξ^*, the smaller the 'consistency ratio', and the more consistent the vectors are.

Table 3
Consistency index.

a_{BW}	1	2	3	4	5	6	7	8	9
Consistency Index	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23

5. A real-world case study

As mentioned before, this paper presents the first study that links supplier development to supplier segmentation. A lack of prior empirical evidence suggests the suitability of conducting in-depth case study for this research. For the purpose of this study, we follow the five-stage research process model proposed by Stuart, McCutcheon, Handfield, McLachlin, and Samson (2002) as shown in Fig. 1.

Table 4
Main criteria and sub-criteria considered to evaluate willingness.

Selected main willingness criteria	Selected willingness sub-criteria
Willingness to improve performance (C_1^W)	Commitment to continuous improvement in product and process (C_{11}^W)
	Supplier's effort in promoting JIT principles (C_{12}^W)
Willingness to share information (C_2^W)	Honest and frequent communications/ communication openness (C_{21}^W)
	Open to site evaluation (C_{22}^W)
Willingness to rely on each other (C_3^W)	Ethical standards (C_{31}^W)
Willingness to get involved in long-term relationship (C_4^W)	Long-term relationship (C_{41}^W)
	Commitment to quality (C_{42}^W)

Table 5
Main criteria and sub-criteria considered to evaluate capabilities.

Main capability criteria	Selected capability sub-criteria
Technical capability (C_1^C)	Process capability (C_{11}^C)
Product quality capability (C_2^C)	Quality (C_{21}^C)
	Product reliability (C_{22}^C)
Delivery capability (C_3^C)	Delivery (C_{31}^C)
	Reserve capability (C_{32}^C)
	Lead time (C_{33}^C)
Intangible capability (C_4^C)	Amount of past business (C_{41}^C)
Service capability (C_5^C)	After sales support (C_{51}^C)
Financial/cost capability (C_6^C)	Price/cost (C_{61}^C)
Sustainable capability (C_7^C)	Availability of clean technologies (C_{71}^C)
Organizational capability (C_8^C)	Management and organization (C_{81}^C)

As the first stage, we have defined the following research question:

"How can the buying company segment the suppliers into different segments based on supplier capabilities and willingness, and develop different types of suppliers to improve their capabilities and/or willingness?"

As the second stage, a research instrument needed to be developed, and an appropriate field site needed to be selected. As mentioned by Stuart et al. (2002), case-based research depends on investigative observation. For this study, a medium-sized high-tech Chinese company, which is specialized in testing instruments, is chosen. The buying company changed its supply chain mode, from depending on inventory to serve the market, to its current 'just-in-time' strategy to improve return on investment. This leads to higher expectations regarding supplier performance. Moreover, more challenges with respect to exports, like local safety regulations and environmental friendliness, also make supplier management and development a critical activity in achieving a stronger market position. The company works with a relatively high number of diverse suppliers, making it suitable for our study. The next step is to gather data, which we did by interviewing the DMs of the company. The CEO and vice-president first selected a number of criteria from the list of capabilities and willingness. The interviews with the CEO and the vice-president took place over a period of one month, in two meetings of about 90 min each. At the end, they selected eleven sub-criteria for capabilities dimension and seven sub-criteria for willingness dimension. The selected sub-criteria are shown in Tables 4 and 5.

The problem is formulated as two hierarchies depicted in Figs. 2 and 3, each of which includes three levels: identified goal, criteria, and sub-criteria.

All the 87 suppliers of the company which were considered for this study were evaluated with respect to their capabilities and willingness criteria. To this end, we used a 5-point Likert scale (1: very low to 5: very high). We arranged a joint meeting of two hours for four DMs of the company. The DMs were selected with the consultation with the CEO, and such that various opinions are taken into account. We selected four DMs from three departments: purchasing, manufacturing, and quality management. During the meeting, they were encouraged to discuss the scale, in order to ensure that they have the same understanding of the used scale, and the main criteria, and sub-criteria. Each expert was asked to evaluate the suppliers that he knows more about it compared to their colleagues. Each supplier is evaluated in regard to seven willingness criteria and eleven capabilities criteria, also implying that each supplier is evaluated by one expert. The meetings were organized over a period of two months, in total four meetings, each about 90 min.

Table 6
Best-to-Others vector (main willingness criteria).

Willingness criteria	C_1^W	C_2^W	C_3^W	C_4^W
The most important criterion: C_1^W	1	6	3	2

Table 7
Others-to-Worst vector (main willingness criteria).

Willingness criteria	The least important criterion: C_2^W
C_1^W	6
C_2^W	1
C_3^W	5
C_4^W	4

Table 8
Best-to-Others vector (main capabilities criteria).

Capabilities criteria	C_1^C	C_2^C	C_3^C	C_4^C	C_5^C	C_6^C	C_7^C	C_8^C
The most important criterion: C_2^C	6	1	2	8	5	3	4	9

Table 9
Others-to-Worst vector (main capabilities criteria).

Capabilities criteria	The least important criterion: C_8^C
C_1^C	2
C_2^C	9
C_3^C	8
C_4^C	2
C_5^C	3
C_6^C	5
C_7^C	4
C_8^C	1

In line with BWM's steps, in a two-hour meeting, the purchasing manager and CEO were asked to select the most important and the least important criteria respectively for each level. Then pairwise comparisons were conducted between the best criterion and the other criteria, and between the other criteria and the worst criterion for the two levels. Here we report the comparison vectors for the main willingness criteria (Tables 6 and 7), and comparison vectors for the main capabilities criteria (Tables 8 and 9) (the comparisons for the sub-criteria have been conducted similarly).

Stage four is about data analysis. While, for a case-based research, the data are generally qualitative in nature, which takes a great deal of time and effort, our analysis is relatively simple. That is to say, by solving the programming problems (2–4) for each pair of vectors, the

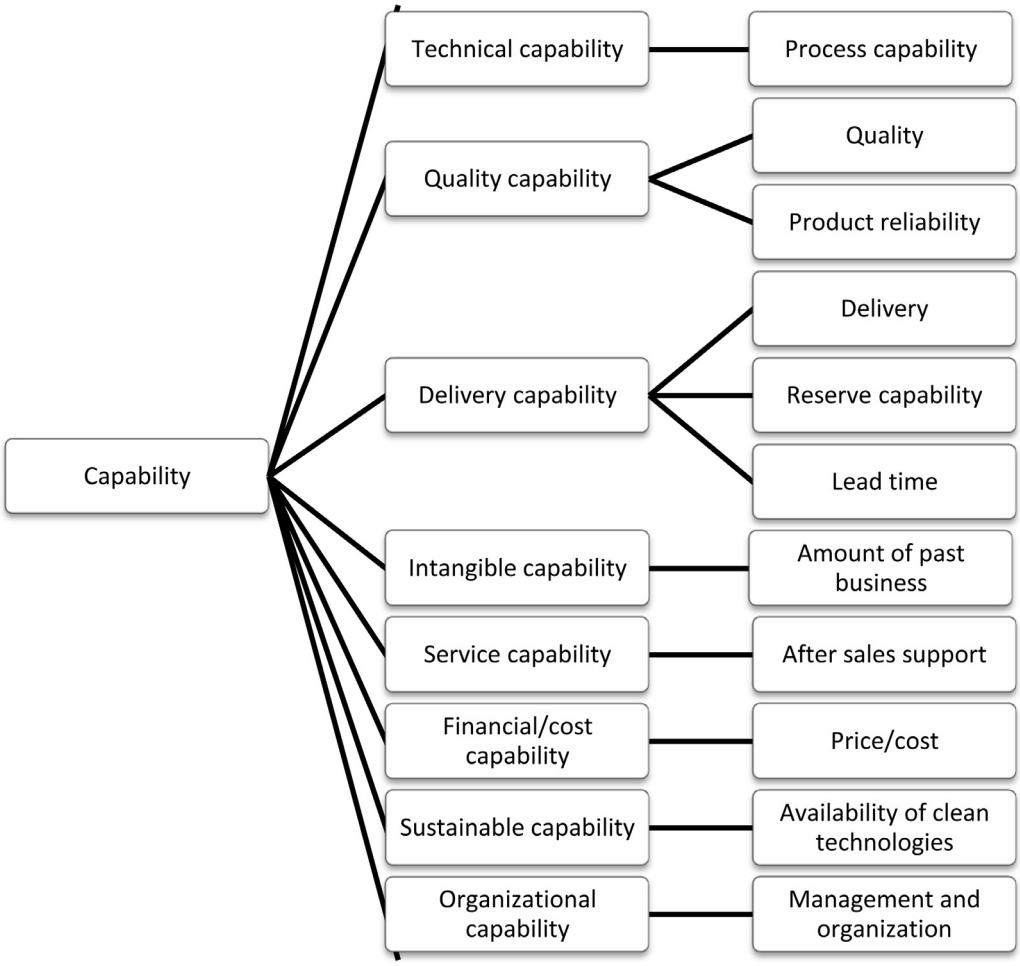

Fig. 2. Hierarchy of supplier capabilities.

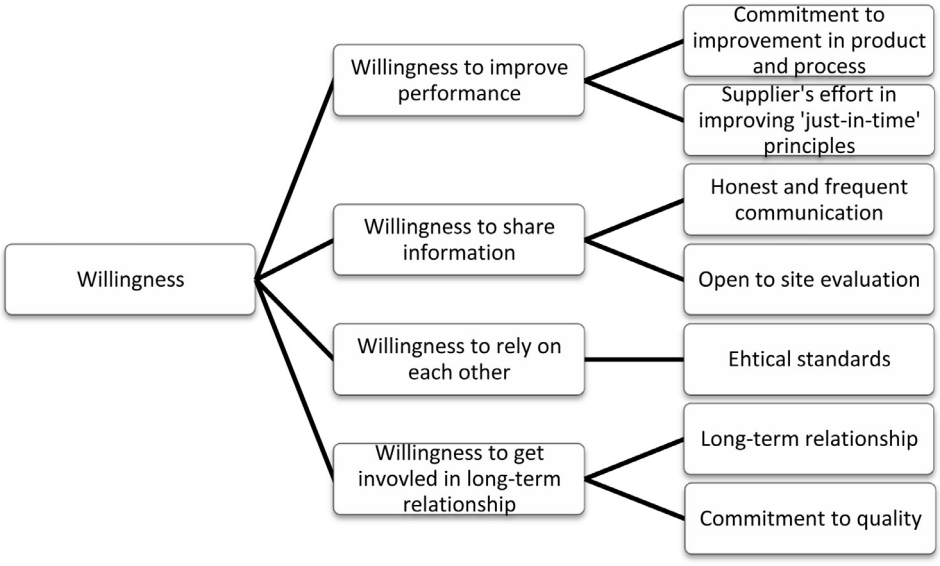

Fig. 3. Hierarchy of supplier willingness.

weights of criteria and sub-criteria can be obtained. Eq. 5 is then used to find the final weights of the criteria (see Tables 10 and 11). To obtain their global weights, their relative weights were multiplied by the weights of the main criteria (see column 5 in Tables 10 and 11).

The consistency ratios for the main comparisons willingness and capabilities are 1.146/3 = 0.382 and 0.86/5.23 = 0.164 respectively, which imply very consistent comparisons. All the consistency ratios for the comparisons made for the sub-criteria (both for willingness and for capabilities) are zero which imply for full consistency.

From Tables 10 and 11, it can be seen that based on the CEO and vice-president's comparisons, 'willingness to improve performance' is the most important dimension for supplier willingness. The high

Table 10
Results of BWM—weights of criteria and sub-criteria (willingness).

Main willingness criteria	Criteria weights	Willingness sub-criteria	Sub-criteria weights	Global weights
Willingness to improve performance (C_1^W)	0.449	Commitment to continuous improvement in product and process (C_{11}^W)	0.250	0.112
		Supplier's effort in promoting JIT principles (C_{12}^W)	0.750	0.337
Willingness to share information (C_2^W)	0.063	Honest and frequent communications/ communication openness (C_{21}^W)	0.750	0.047
		Open to site evaluation (C_{22}^W)	0.250	0.016
Willingness to rely on each other (C_3^W)	0.242	Ethical standards (C_{31}^W)	1.000	0.242
Willingness to get involved in long-term relationship (C_4^W)	0.246	Long-term relationship (C_{41}^W)	0.167	0.041
		Commitment to quality (C_{42}^W)	0.833	0.205

Table 11
Results of BWM—weights of criteria and sub-criteria (capabilities).

Main capabilities criteria	Criteria weights	Capabilities sub-criteria	Sub-criteria weights	Global weights
Technical capability (C_1^C)	0.054	Process capability (C_{11}^C)	1.000	0.054
Product quality capability (C_2^C)	0.314	Quality (C_{21}^C)	0.750	0.236
		Product reliability (C_{22}^C)	0.250	0.078
Delivery capability (C_3^C)	0.251	Delivery (C_{31}^C)	0.141	0.035
		Reserve capability (C_{32}^C)	0.100	0.025
		Lead time (C_{33}^C)	0.759	0.191
Intangible capability (C_4^C)	0.040	Amount of past business (C_{41}^C)	1.000	0.040
Service capability (C_5^C)	0.072	After sales support (C_{51}^C)	1.000	0.072
Financial/cost capability (C_6^C)	0.139	Price/cost (C_{61}^C)	1.000	0.139
Sustainable capability (C_7^C)	0.100	Availability of clean technologies (C_{71}^C)	1.000	0.100
Organizational capability (C_8^C)	0.032	Management and organization (C_{81}^C)	1.000	0.032

importance of 'willingness to improve performance' is mainly due to the fact that the buying company is a high-tech company which works in a very competitive environment and needs to work with very high quality suppliers that are improving their performance constantly. Buying companies expect continuous performance improvement of suppliers with respect to product quality, and lead-time reduction (Monczka et al., 1993). Continuous supplier performance improvement makes manufacturing firms more competitive in downstream markets (Joshi, 2009). The criteria of willingness to rely on each other and willingness to engage in long-term relationship are the next important criteria. It is however surprising that willingness to share information is not that important for the buying company ranked as the last criterion. We think that because the buying company is facing a low level of demand fluctuation, information sharing does not have an important role for the company. For the capabilities dimension, quality capability, and delivery are the most significant criteria. The results for this dimension are also supported by previous studies. Several studies have found that according to the managers quality is the most important criterion for supplier selection (Chen, Chen, & Li, 2005; Kannan & Tan, 2002; Petroni & Braglia, 2000). Delivery has also been found as one of the most important criteria by the managers (Chen et al., 2005; Kannan & Choon Tan, 2004). These two criteria together account for more than 56%, and the remaining six criteria account for less than 44%.

To compare the actual weights of all sub-criteria, it is important to consider both the weights of the main criteria and the relative weights of the sub-criteria. The fifth column of Tables 10 and 11 shows the global weights of all the sub-criteria. The difference in actual weights is now obvious: "supplier's effort in promoting JIT principles" serves as the most crucial factor for supplier willingness and the least important criterion is "open to site evaluation"; "quality" has the biggest weight for evaluating supplier capabilities, "reserve capability" is of the lowest importance.

The final aggregate scores of capabilities for supplier i, Cap^i are calculated as:

$$Cap^i = \sum_{n=1}^{N} w_n^C C_{in}^C, \ \forall i \tag{7}$$

where w_n^C is the global weight of capabilities sub-criterion n, C_{in}^C is the assigned score to supplier i with respect to capabilities sub-criterion n and N is the number of capabilities sub-criteria. The final aggregate scores of willingness for supplier i, Wil^i are calculated similarly as:

$$Wil^i = \sum_{j=1}^{J} w_j^W C_{ij}^W, \ \forall i \tag{8}$$

where w_j^W is the global weight of willingness sub-criterion j, C_{ij}^W is the assigned score to supplier i with respect to willingness sub-criterion j and J is the number of willingness sub-criteria.

In order to effectively classify the suppliers, the suppliers' relative levels of willingness and capabilities are considered. To obtain the relative level of supplier capabilities and willingness, the final scores have been normalized through the following normalizations.

$$Normalized\ Score\ Supplier_k^W = \frac{Wil_k - \min\{Wil_i\}}{\max\{Wil_i\} - \min\{Wil_i\}} \tag{9}$$

$$Normalized\ Score\ Supplier_k^C = \frac{Cap_k - \min\{Cap_i\}}{\max\{Cap_i\} - \min\{Cap_i\}} \tag{10}$$

Considering the suppliers normalized scores we make four segments, which can be seen in Fig. 4.

From Fig. 4, it can be seen the suppliers are segmented as follows:

- Type 1 (low capabilities and low willingness): 9 suppliers;
- Type 2 (low capabilities and high willingness): 4 suppliers;
- Type 3 (high capabilities and low willingness): 18 suppliers;
- Type 4 (high capabilities and high willingness): 56 suppliers.

6. Validation

This section is devoted to the final stage of the five-stage research process model presented in Section 5. In our research, suppliers are evaluated and classified based on the dimensions of willingness and capabilities. After reviewing existing literature extensively, we also proposed different sets of strategies to develop different supplier segments. In order to validate our conceptual framework, we conducted two interviews, each about 90 min, with the CEO of the company.

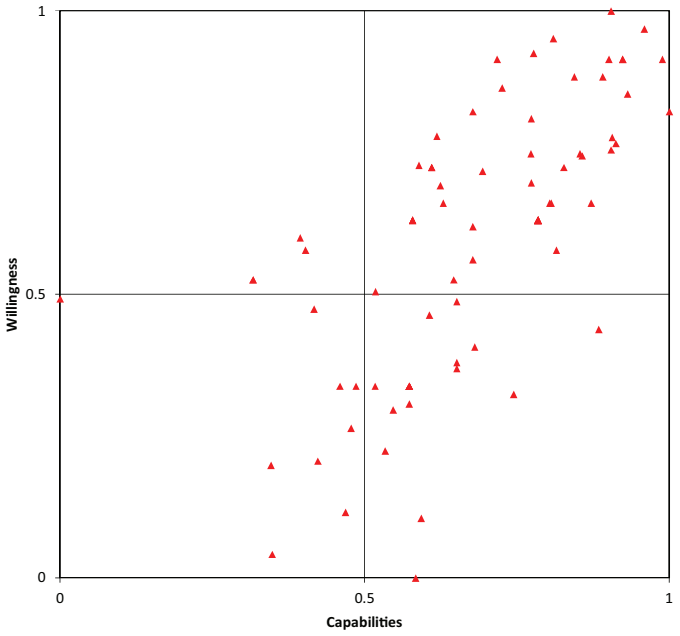

Fig. 4. Supplier segmentation based on BWM (some points are overlapped).

We first discussed our results of supplier segmentation with the CEO, and then we have particularly asked the CEO "what are they doing to improve suppliers of each segment?". The following sub-sections describe what the company does in practice to improve suppliers in each segment. The main aim is to see whether the proposed conceptual framework in this study which is grounded in theory, has real-world value, and the extent to which it matches reality.

6.1. Main strategies to develop Type 1 suppliers (low willingness, low capabilities)

The CEO indicated that, in order to develop suppliers of Type 1, "it is advisable to improve their willingness before improving their capabilities". "Willingness to improve performance" serves as the most important willingness criterion for the company to evaluate its suppliers' willingness. If a supplier is unwilling to make a change, the company prefers to replace this supplier by other suppliers. The reasons behind supplier behavior are various, mostly because of the location and business. For example, one plastic mold company is located in the city of Zhuhai, south of China, which is around 2300 km away from Beijing, where BTHT (the case buying company) is located. Because of that, this supplier does not have a high level of willingness to collaborate with companies in far the North. Another stainless steel company has a low level of willingness because the business volume with BTHT only accounts for a small percentage of their annual sales. Moreover, the buying company orders a wide range of stainless steel products, which makes the supplier's production process even more complex and less profitable.

To improve supplier willingness, the CEO said that "currently they adopt strategies including supplier visits, information exchange and long-term commitment. For example, we send our employees on supplier site visits, explaining the buyer's expectation, providing assistance in solving production issues that the suppliers come across, and transferring knowledge to the suppliers if necessary".

In order to develop the capabilities of Type 1 suppliers, the buying company sets clear goals to the suppliers, representing the buying company's expectations. Suppliers that fail to reach the goal will be replaced by other alternative companies. Such competitive pressures are mainly focusing on cost capabilities and delivery capabilities, which the buying company values most. Besides, the buying company also invites competitive bids from multiple suppliers, to achieve a low purchasing price through bidding specifications and short-term contracts. Moreover, the buying company provides necessary assistance for product quality improvement, such as offering fixtures and sealed samples. Finally, the buying company will ask the suppliers to continuously increase their capabilities.

6.2. Main strategies to develop Type 2 suppliers (high willingness, low capabilities)

According to the CEO, "to develop this type of suppliers, first of all we identify the specific shortcomings of each supplier and then adopt specific measures for improvement".

There are only a few suppliers that fall in this segment, which provide magnet-related products and hardware molds, respectively. One of the suppliers is a small-scale company, while the other one is geographically isolated. These suppliers are highly willing to collaborate with the company, which implies the company could think of developing this type of suppliers. Therefore, in order to help these two suppliers to develop their capabilities, the CEO pointed out that the buying company may offer assistance for quality improvement as what it does to improve Type 1 suppliers.

In addition, knowledge transfer is also necessary. The engineers at BTHT will be sent to the suppliers' production sites to give technical advice, and to communicate with the suppliers about customer requirements. Moreover, the buying company can co-construct a laboratory with the suppliers, so that they can each access complementary knowledge and resources from the other. Additionally, the buying company may invite Type 2 suppliers to join BTHT for plant visits to other suppliers. During this process, the Type 2 suppliers can gain useful knowledge and information.

6.3. Main strategies to develop Type 3 suppliers (low willingness, high capabilities)

Most of these suppliers are large-scale enterprises in leading industry position. Compared to other competitors, they are strong in terms of their capabilities. Since they are experienced in operation and have complete management system, this type of companies tends to be more independent. They are reluctant to accept the intervention from other parties in terms of external investment or knowledge transfer.

For these particular Type 3 suppliers, the CEO indicated that, "first of all, the buying company will show its loyalty and collaboration by making long-term commitments. Afterwards, the company may adopt the communication strategies to improve supplier willingness, especially focusing on the communication with the suppliers' top management personnel". Through effective communication, shared values and goals are expected to be achieved. Additionally, increasing the purchasing amount will also help improve willingness. One example within this group is a supplier in England. The distance leads to time zone differences and communication inconvenience. The language barrier and cultural differences result in a lack of effective communication or sometimes even misunderstandings. As a result, the relationship between the two parties is never close. To solve this, the CEO suggested that the purchasing department should get help from the international trade department for a better communication with this supplier, since employees working in international trade department are skilled in English, resulting in a more efficient and effective communication, which in turn has a positive influence on the overall relationship.

6.4. Main strategies to develop Type 4 suppliers (high willingness, high capabilities)

These suppliers are excellent suppliers in terms of their capabilities and willingness. To maintain a close relationship with this type of suppliers, the CEO mentioned that the buying company mainly uses incentive strategies. For example, the buying company holds an annual awards ceremony to recognize outstanding suppliers, which allows suppliers to attract other customers. When designing a new product, the buyer would consider outstanding suppliers' products to be incorporated in the product design phase with a high priority level. In addition, vice-presidents of the buying company visit the outstanding suppliers in person to improve communication and achieve a long-term commitment with the suppliers. The outstanding suppliers will be introduced to each other, allowing them to exchange information, experience and knowledge.

Investigating what the company is doing to develop its suppliers provides a basis to confront the results with our conceptual model proposed in this research, it can be found that the conceptual model is greatly supported by the experience of the company, which also shows the validity of the conceptual framework.

7. Conclusion and future research

This paper proposed a novel and effective approach for developing suppliers, by integrating supplier segmentation as an important input factor to the design of supplier development strategies. By applying the proposed conceptual model, limited resources can be allocated more efficiently to deal with different types of suppliers. Additionally, supplier willingness is considered as an important dimension of supplier development, in addition to supplier capabilities, for the first time.

The proposed supplier development consists of two phases. First, the suppliers are evaluated and segmented considering their overall level with respect to their capabilities and willingness to collaborate. Best Worst Method (BWM) is applied to find the relative weight of the criteria. Simple formulas are used to find the overall scores of the suppliers' capabilities and willingness. A scatter plot is then used to segment the suppliers, where the horizontal and vertical axes are capabilities and willingness, respectively. Dividing each dimension to two equal parts, suppliers are segmented to four segments. BWM has several salient features that make it a robust and user-friendly method compared to most multi-criteria decision-making methods. It requires less data; results in more reliable results and, because it does not use fractional numbers, it is easier to understand by the decision-makers.

In the supplier development phase, the strategies mentioned in existing literature have been reviewed and classified into three categories: strategies to improve capabilities, strategies to improve willingness and strategies to improve both capabilities and willingness simultaneously.

The proposed supplier segmentation and development methodology was applied in a high-tech test instruments manufacturing company. The interview with the CEO of the company mostly complies with our conceptual model. In real application, the adoption of strategies designed to develop different supplier segments depends on the specific situation. So, for future research, we suggest collecting data from more companies to better validate the proposed conceptual framework. This study was devoted to the segmentation and development parts of supplier-related activities, but studying the other connection parts could be interesting as well. For example, it would be interesting to examine which criteria companies use in supplier selection, and which criteria in supplier segmentation. In addition, we suggest using other decision-making methods to segment suppliers, so that the performance of different methodologies can be compared and the suitability of each particular method for different situations can be identified.

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