Reshoring decision-making based on operational capabilities in Swedish apparel supply chains: a fuzzy AHP approach

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Abstract

This paper determines how operational capabilities influence reshoring decision-making based on proximity make-buy alternatives in apparel supply chains in high-cost locations. By drawing operational capabilities from reshoring literature, a hierarchical model is constructed and tested using fuzzy AHP in a workshop with industry and academia. The priority weights for 12 capabilities categorized into three criteria influences the four reshoring alternatives in the order: make-onshore, make-nearshore, buy-onshore, buy-nearshore. Sourcing/production capabilities were the most important criteria followed by value-added products/services. Relationship was least important but its underlining aspects: availability of skilled labor/know-how and flexible supplier relationship were necessary preconditions for reshoring.

Keywords: Reshoring, Make-buy, Fuzzy AHP.

Introduction

The issue of reshoring to high-cost locations is increasingly of interest in both business and research. There are several motivations that have been found for reshoring, including issues with quality or cost of maintaining offshore production, or the presence of interdependencies in the supply chain (Kinkel and Maloca, 2009; Ketokivi et al., 2017). Such reversal of offshore production has even been observed within labor-intensive sectors too, such as apparel (e.g. Gray et al., 2017), which have previously experienced wide-scale offshoring to low cost countries. However, it is likely that in these labor-intensive sectors such as apparel and footwear, only the premium products in smaller numbers are able to be produced competitively, or sourced from, high-cost locations (Martínez-Mora and Merino, 2014; Pal et al., 2017).

With reshoring on the rise, of crucial importance is right decision-making, i.e. to decide where the production should be performed (i.e. location decision) and how shall it be organized or who performs it (i.e. ownership or governance) (Tate and Bals, 2017).

Based upon the location-ownership possibilities, and four reshoring options pointed out in Gray et al. (2013), it is evident that manufacturers located in high-cost locations can fulfill demands by moving manufacturing activities either in wholly owned facility (i.e. make as own label brands), or decide to get it performed by suppliers (i.e. buy as private labels do), in the "local" market. In both cases, the geographical "locality" is crucial as the production can take place on-shore or sometimes in comparatively cheaper near-by locations. In case of the apparel sector in extremely high-cost European locations such as Sweden, cheaper alternatives exist either in the Baltic States or Portugal. To clarify, in this paper, high-cost location is defined by relevant input factor such as wage. Often the wage or labor cost in the apparel sector is determined by hourly compensation rate. Sardar and Lee (2016) present that in developed markets (herein, referred as high-cost location), e.g. Sweden, the labor costs in the apparel sector (in USD) is ~125 times that in Bangladesh and ~4 times that in Portugal.

Of key importance for the manifestation of both make and buy reshoring decisions are requirement of capabilities that can develop firm's competitive advantage (Helfat and Winter, 2011; Sansone et al., 2017). Such capabilities at the operational level, as highlighted in previous studies, include responsiveness, flexibility, control, supplier relationship, among others (e.g. Fratocchi et al., 2016; Martínez-Mora and Merino, 2014; Pal, et al., 2017), and are crucial to facilitate the development and configuration of the reshored supply chains. Suited to the configurational requirement for the supply chain, to competitively produce high value-added products in small-series, these operational capabilities serve as the basis on which decision-makers select the reshoring location-ownership strategy (Gray et al., 2017; Martínez-Mora and Merino, 2014). However considering the early stage of reshoring research, knowledge of how these operational capabilities can enable strategic decisions related to the choice of reshoring strategy, i.e. best choice of location-ownership alternative is sparse. Contextually, such reshoring decision-making is important in EU's apparel supply chains in high-cost locations to decide the suitability and competitiveness to produce small-series, high-value added products. In such supply chains the choice of reshoring strategy largely depends on the operational capabilities of the suppliers and/or manufacturers in proximity to the consumer market – much different from the global ones selected mainly due to low-cost and productivity.

The purpose of this paper is to *determine how operational capabilities influence the reshoring decision-making based on proximity make-buy alternatives in apparel supply chains in high-cost locations.* By drawing upon a list of operational capabilities referred in reshoring literature, and structuring it along supply chain configuration elements, this paper guides the development of a reshoring decision-making hierarchical model which is further tested empirically with responses from both practitioners and academicians related to Swedish textile and apparel sectors.

Conceptual framework for constructing the hierarchical model

To a large extent the choice of reshoring strategy, i.e. location-ownership alternative, is guided by the suitability of supply chain structures and relationships. In this context, Srai and Gregory's (2008) supply chain configuration model lays a logical unified foundation for the selection of the key operational capabilities. Supply chain configuration, is defined *as the particular arrangement of the supply networks' elements including, the "network structure" of the various operations within the supply network and their integrating mechanisms, the flow of materials and information between and within key "unit operations" the "role, inter-relationships, and* *governance" between key network partners, and the "value structure" of the product* or *service delivered"* (Srai and Gregory, 2008, p. 394).

This demonstrates the need for operational capabilities of different supply chain profiles along the key elements of *network-structure, unit operations, network relationship-configuration* and *product-configuration,* that can allow the development of supply chain network reconfigurability through improvement in performance (e.g. cost, quality or flexibility) or development of the product or service. This also brings agility to the supply chain as new business opportunities can be captured by engaging in relationships with innovative supply chain partners (Chandra and Grabis, 2016).

The conceptual framework derived in this paper originates from the findings of a Delphi study (see Pal et al., 2017) conducted to identify the success factors for competitive manufacturing supply chains in high-cost locations. The study initially identified 23 success factors which were later paired down to 12 items for ranking. Additionally 9 challenges that were faced by the manufacturers were also revealed. Starting with these items (12 success factors and 9 challenges), the conceptual framework of key operational capabilities that influence reshoring decisions was structured along the four elements of supply chain configuration as proposed by Srai and Gregory (2008), as shown in Table 1.

Table 1 – Conceptual framework derivation

Srai and Gregory (2008)'s elements	**Success factors and *challenges* (Pal, et al., 2017)**	**References**	**In our AHP model**	
			Sub-criteria	**Criteria**
Product-configuration	Extremely high quality of product and/or service	Ashby (2016), Bals et al. (2016), Fratocchi et al. (2016), Robinson and Hsieh (2016)	High quality and performance *(S_1)*	Value-added products/services *(C_1)*
	High potential for innovation	Ashby (2016), Bals et al. (2016), Fratocchi et al. (2016), Robinson and Hsieh (2016)	Innovative *(S_2)*	
	Commitment to environmental protection	Ashby (2016), Ellram et al. (2013), Gray et al. (2013), Tate et al. (2014)	Sustainable and environmentally-friendly *(S_3)*	
	Customized product and/or service	Ashby (2016), Bals et al. (2016), Fratocchi et al. (2016), Robinson and Hsieh (2016)	Customization *(S_4)*	
Unit operations and Network structure	Available production capacity	Bals et al. (2016), Fratocchi et al. (2016), Wiesmann et al. (2017)	Available capacity to meet quick orders *(S_5)*	Sourcing/ production capabilities *(C_2)*

	High control and efficiency of production or supply chain	Ashby (2016), Bals et al. (2016), Ellram et al. (2013), Fratocchi et al. (2016), Gray et al. (2013), Martínez-Mora and Merino (2014), Robinson and Hsieh (2016), Tate et al. (2014), Wiesmann et al. (2017)	High control and efficiency (S_6)	
	Flexibility to meet short lead times	Fratocchi et al. (2016), Stentoft et al. (2016b), Wiesmann et al. (2017)	Meet short lead times (S_7)	
	Increasingly short lead time expectations and fast changing fashions			
	Flexibility to respond to changes in demand (number and type of products)	Ashby (2016), Bals, et al. (2016), Fratocchi et al. (2016), Martínez-Mora and Merino (2014)	Flexibility to respond to demand changes (S_8)	
	Balancing low inventory with high variety			
	Specialization of production and/or service (to increase productivity)	Tate et al. (2014), Fratocchi et al. (2016), Wiesmann et al. (2017)	Process specialization (S_9)	
Network relationship	Closeness (geographical and cultural distance, close relationship) to customers	Ashby (2016), Fratocchi et al. (2016); Ellram et al. (2013)	Modified to operational capability: Close/ relationship to client/customer (S_{10})	Relational aspects (C_3)
	Lack of consumer awareness of local production and benefits	Ellram et al. (2013), Gray et al. (2013), Tate et al. (2014)	Challenge modified to capability (S_{10})	
	Closeness (geographical distance) to skilled labor and know-how	Fratocchi et al. (2016), Wiesmann et al. (2017)	Not an operational capability. Modified to Skilled labor/know-how: (S_{11})	
	Lack of skilled labor	Fratocchi et al. (2016), Wiesmann et al. (2017)	Challenge converted to capability: (S_{11})	
	Lack of know-how	Fratocchi et al. (2016), Stentoft et al.	Challenge converted to capability: (S_{11})	

		(2016b)		
	Flexibility of purchasing practices (suppliers offering small batch sizes/no minimum orders)	Ashby (2016)	Modified to relational capability: Flexible supplier relations *(S_{12})*	
	Supplier minimums too high	Ashby (2016)	Challenge converted to relational capability: *(S_{12})*	
	High fixed costs with own production	Not a capability. Opted out as it only determines choice for "buy" instead of "make" reshoring strategy.		
	High costs due to strict labor regulations	Not related to manufacturing or sourcing operational capability		

Methodology

The paper adopts a fuzzy AHP (FAHP) technique. Owing to the large number of factors affecting reshoring make-buy decisions in high-cost locations, an orderly sequence of steps is followed. In step 1, the key supply and/or manufacturing operational capabilities are identified through literature review, and subsequently categorized into groups. In step 2, a hierarchical decision-making model is constructed.

The two step process is described below:

- Step 1 – Identification and categorization of the decision variables, critical for selection process (see Table 1)
- Step 2 – Adoption of specific decision-making technique to discuss the alternatives for the selection of reshoring option

Step 1: Reshoring decision-making framework development

The model consists of four levels (see Figure 1): (i) Level 1 is the goal: *reshoring decision-making*, (ii) Level 2 includes three criteria: *value-added products/services, sourcing/production capabilities, and relational aspects*, (iii) Level 3 includes twelve sub-criteria, divided into 4, 5 and 3 and listed under the above criteria respectively, and (iv) Level 4 includes four alternatives adapted from Tate and Bal's (2017) right reshoring decision options in terms of proximity location and governance combination: (i) make onshore, (ii) buy onshore, (iii) make nearshore, and (iv) buy nearshore.

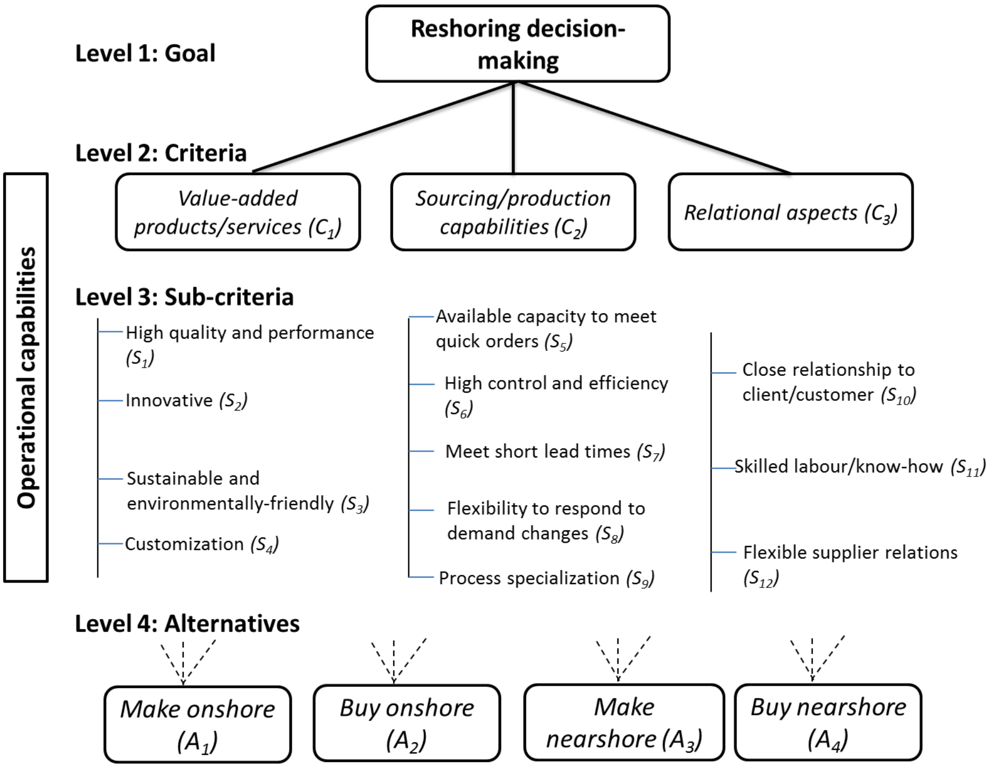

Figure 1 – Hierarchy for right reshoring decision-making based on operational capabilities

Step 2: Adoption of fuzzy AHP technique

Fuzzy-AHP is the fuzzy modified form of AHP. It has the ability to extract the merits of both approaches to efficiently and effectively tackle the multi-criterion decision making problems, like supplier selection (e.g. Chan et al., 2008) or reshoring location-ownership alternative as in this paper. The AHP is one of the extensively used multi-criterion decision making methods but it has been generally criticized because of the use of a discrete scale of 1 to 9 which cannot handle the uncertainty and ambiguity present in deciding the priorities of different attributes. Since basic AHP does not include vagueness for personal judgments, it has been improved by benefiting from fuzzy logic approach. In this paper, decision-making of the respondents in terms of reshoring location-ownership model contracts such vagueness in judgement. In FAHP, the pair wise comparisons of both criteria and the alternatives are performed through the linguistic variables, which are represented by triangular numbers. Buckley (1985) has contributed to the subject by determining the fuzzy priorities of comparison ratios having triangular membership functions.

Data collection

In order to conduct the FAHP, data was collected through a focused workshop involving participants from both industry and academia. Out of 17 participants, 11 were owners, supply chain/production/sourcing managers of Swedish textile and apparel firms, and were either producing or sourcing locally or from near-by high-cost locations. The remaining participants were either consultants or researchers working with the subject matter. In the workshop, two rounds of survey were conducted to determine the preferences of one criterion (C_i) or sub-criterion (S_i) over another (C_j or S_j). Round 1 aimed at calculating the comparison values and different priority weights of each *Ci* or *Si* with respect to (w.r.t) the goal, i.e. between levels 1-2 and 1-3 respectively, while round 2 prioritized each S_i w.r.t. location (onshore or nearshore) and ownership alternatives (make or buy) respectively, i.e. between levels 3 and 4.

After each round, the participants were divided into smaller groups where discussions were initiated around the initial results with the suggested topics of 'thoughts', 'motivations', 'disagreements', and 'regional necessities' in order to gather additional explanations that would support the survey answers. Subsequently, open discussions were held with all participants with documentation of the points that were brought up.

FAHP steps for data analysis

A 7-step FAHP computational procedure using triangular fuzzy numbers was developed in line with Buckley (1985), to determine the normalized priority weights of all decision variables w.r.t. the level above, and finally multiplying them to relate the final priority of the decision alternatives w.r.t. the goal. Aggregated responses were calculated using method prescribed by Rahimianzarif and Moradi (2018) to construct a fuzzy paired comparison matrix. The steps of the procedure are as follows:

Step 1: The survey results from each decision maker was converted first to Saaty's scale such that $\forall\, x\ \in I, |x| = (x + 1)$. Here the scale is such that 1 is equivalent to the linguistic term "equally important" while 9 is equivalent to "absolutely important". On the Saaty's scale if the decision maker states C_i or S_i is more important over another C_j *or* S_j, then in the pairwise comparison if the judgment value is on the left side of 1, it takes a number x, otherwise $\frac{1}{x}$, $\forall\, x\ \in I.$

Step 2: Accordingly, each decision makers' criteria/sub-criteria or alternatives are converted to the corresponding triangular fuzzy numbers. The fuzzy triangular scale used is such that a Saaty number 1 is equivalent to (1, 1, 1) on fuzzy scale, 2 is equivalent to (1, 2, 3), …. 9 is equivalent to (9, 9, 9). If the judgement value was on the right side of 1 then comparison will take the fuzzy triangular scale as$[\frac{1}{(x+1)}, \frac{1}{x}, \frac{1}{(x-1)}]$ except for 9 when the fuzzy number is $[\frac{1}{9}, \frac{1}{9}, \frac{1}{9}]$.

Step 3: A pairwise contribution matrix is generated according to Rahimianzarif and Moradi (2018)'s method such that:

$$\tilde{A} = \begin{matrix} (1,1,1) & (\mathrm{a12}, \mathrm{b12}, \mathrm{c12}) & (\mathrm{a13}, \mathrm{b13}, \mathrm{c13}) \\ (\frac{1}{\mathrm{c12},}, \frac{1}{\mathrm{b12}}, \frac{1}{\mathrm{a12}}) & (1,1,1) & (\mathrm{a23}, \mathrm{b23}, \mathrm{c23}) \\ (\frac{1}{\mathrm{c13}}, \frac{1}{\mathrm{b13}}, \frac{1}{\mathrm{a13}}) & (\frac{1}{\mathrm{c23}}, \frac{1}{\mathrm{b23}}, \frac{1}{\mathrm{a23}}) & (1,1,1) \end{matrix}$$

Where each triangular fuzzy number $\widetilde{\boldsymbol{aij}}$ = (a_{ij}, b_{ij}, c_{ij}), such that:

a_{ij} = Min (β_{ijk}), k = 1, 2, …, n
$b_{ij} = \ (\prod_{k=1}^{n} \beta ijk))^{1/n}$, k = 1, 2, …, n
c_{ij} = Max (β_{ijk}), k = 1, 2, …, n

where, β_{ijk} shows the relative importance of a parameter $_i$ over $_j$ from the viewpoint of kth person/respondent, a_{ij} and c_{ij} are, respectively, lower and upper limits of opinions, and b_{ij} is the geometric mean of them. Each triangular fuzzy number is defined such that

$a_{ij} \leq b_{ij} \leq c_{ij}$, and range $[\frac{1}{9}, 9]$.

Step 4: According to Buckley (1985), the geometric mean of fuzzy comparison values of each criterion/sub-criterion is calculated as shown in below. Here, $\tilde{\boldsymbol{ri}}$ still represents triangular fuzzy values.

$$\tilde{\boldsymbol{ri}} = \left(\prod_{j=1}^{n} \tilde{dij}\right)^{1/n}, \; i = 1, 2, \ldots, n$$

Step 5: Next the relative fuzzy weights of each criterion/sub-criterion is found along 3 sub steps.

Step 5a: The vector summation of each $\tilde{\boldsymbol{ri}}$ is calculated.

Step 5b: The (-1) power of the summation vector was calculated to replace the fuzzy triangular number, and was arranged in an increasing order.

Step 5c: The relative fuzzy weight of each criterion/sub-criterion ($\tilde{\boldsymbol{wi}}$) was calculated, by multiplying each $\tilde{\boldsymbol{ri}}$ with this reverse vector, such that:

$$\tilde{\boldsymbol{wi}} = \tilde{\boldsymbol{ri}} \otimes (\tilde{\boldsymbol{r1}} \oplus \tilde{\boldsymbol{r2}} \oplus \ldots \oplus \tilde{\boldsymbol{rn}})^{-1} = (lw_i, mw_i, uw_i)$$

Step 6: Since $\tilde{\boldsymbol{wi}}$ are still fuzzy triangular numbers, we de-fuzzified them by using center of are method proposed by Chou and Chang [50] by applying:

$$M_i = \frac{(lwi + mwi + uwi)}{3}$$

Step 7: M_i is not a fuzzy number but needs to be normalized by following:

$$N_i = \frac{Mi}{\sum_{i=1}^{n} Mi}$$

These 7 steps were performed to find the normalized relative weights of both *Ci* or *Si* w.r.t goal, and *Si* w.r.t location and ownership decisions. Then by multiplying each normalized relative weights of these decisions the scores for each reshoring alternative (A_1, ... , A_4) was calculated. According to these results, the alternative with the highest score is suggested to the decision maker.

Results

Table 2 presents the results of the FAHP analysis. Column 2 shows the relative weights of each S_i w.r.t C_i, while columns 3-6 shows the relative weights each S_i w.r.t $A_{1\text{-}4}$. Column 7 is the cumulative weight for $C_{1\text{-}3}$.

Table 2 – Aggregated results for each alternative w.r.t. each criterion and overall goal

	Levels 2-3	A_1	A_2	A_3	A_4	
S_1	27,04%	2,46%	2,33%	2,24%	2,12%	
S_2	21,08%	2,13%	1,57%	1,97%	1,45%	
S_3	24,48%	2,32%	1,94%	2,19%	1,84%	
S_4	27,40%	2,71%	2,12%	2,49%	1,95%	
C_1		**9,61%**	**7,95%**	**8,90%**	**7,36%**	**33,84%**
S_5	17,24%	1,83%	1,43%	1,77%	1,38%	
S_6	16,85%	2,20%	1,71%	1,32%	1,03%	
S_7	19,17%	2,35%	1,83%	1,65%	1,29%	

S_8	25,48%	3,72%	1,32%	3,26%	1,16%	
S_9	21,26%	2,41%	2,11%	1,80%	1,58%	
C_2		**12,50%**	**8,41%**	**9,81%**	**6,44%**	**37,16%**
S_{10}	30,75%	2,84%	2,48%	1,92%	1,68%	
S_{11}	35,84%	3,35%	2,29%	2,82%	1,93%	
S_{12}	33,41%	3,87%	1,46%	3,17%	1,19%	
C_3		**10,06%**	**6,23%**	**7,91%**	**4,80%**	**29,00%**
		32,18%	**22,59%**	**26,62%**	**18,61%**	**100%**

Analytical discussion

The FAHP analysis prioritizes the four reshoring decision alternatives in the following order of preference: make-onshore (A_1), make-nearshore (A_3), buy-onshore (A_2), and buy-nearshore (A_4).

With respect to the preferences, the group discussion elaborated on the current state of competitiveness of reshoring apparel supply chains to high-cost locations in EU. There was agreement that fabric and apparel manufacturing in EU is currently competitive and requires higher investments in innovative production processes, and supporting tools for automation and digitalization, with a focus on forward integration. Specifically, activities including printing, dyeing, and sewing were considered to need the most support in order to become competitive. Overall, the goal was suggested to have the whole supply chain (from fabric stage) available within the country (A_1), and to potentially develop regional *testbeds* for innovation. While there was benefit from co-locating design and production, and that producing in countries like Sweden was value-adding, owning production was deemed to have bad reputation due to the high costs as outsourcing is considered much cheaper. In line with this some of the decision makers also favored controlled production in countries near-by preferably cheaper in locations where skills and production know-how are considerably higher (A_3). However, sourcing in smaller batches was described as financially beneficial and increasing overall sustainability as well (A_2 or A_4).

Of the three criteria, *sourcing/production capabilities* (C_2) was adjudged to be most important w.r.t. the goal, and closely followed by *value-added products/services* (C_1). The most important aspect (sub-criteria) within C_2 as highlighted by the decision-makers was flexibility to respond to demand changes (S_8). Most often the demand variation in the fashion apparel sector is highly unpredictable hence the possibility to have volume and mix flexibility is crucial (Martínez-Mora and Merino, 2014). To support this even though shorter production or sourcing lead times were considered important, challenges were faced to meet the demand for producing high-quality materials (S_1), e.g. functional yarns that could require up to several months. This made S_7 not so highly weighted in the decision model.

Yet another trade-off for shorter lead time was the demand for high degrees of customization (S_4). Customer-specific approach for producing a wide range of niche products was considered as the most important aspect within the *value-added product/service* (C_1) category, however in some cases this meant increasing the lead time. Even though to lower the lead time and cost, process specialization (S_9) is often vital, in our model the participants did not weight it high. This shows that reducing cost in high-value added manufacturing was not very crucial, often as it would mean compromising with product customization.

Despite these arising trade-offs in the decision model, the importance of operational flexibility, and product customization and quality are in line with previous studies, e.g.

Fratocchi et al. (2016). In addition, the ability to produce or source sustainable (eco-friendly) products was also a crucial aspect. Within the group discussion, it was described that to some extent being environmentally friendly or more sustainable (S_3) should be assumed "given" with reshored high-cost production. This was explained to be related to the high level of social sustainability and environmental regulations within the country, but it was also stated that this aspect is potentially taken for granted and may require more emphasis.

Even though relationship category (C_3) was least important in the hierarchical decision-model, the importance of its underlining aspects, i.e. availability of skilled labor/know-how (S_{11}) and flexible supplier relationship (S_{12}) were top ranked in the overall weight to influence the reshoring decisions. Knowledge and skill availability was a critical precondition to determine location and ownership decisions, lack of which could pose a major challenge to reinforce reshoring. During the group discussion, specific suggestions to address this issue included regional support for internal training programs, to better meet the needs of the small diverse industry operating locally, and the possibility of hiring skilled refugees as a potential solution. Yet another requirement was to establish flexible relationship with component or raw material suppliers (S_{12}), in order to support the flexible manufacturing process. To add visibility to the real differences offered by each decision alternative, the decision makers further highlighted the need to develop a tool for calculating real production and sourcing costs and evaluate the benefits, much similar to that prescribed in Gray et al. (2017).

Relevance/contribution

The paper presents a FAHP-based model for right reshoring decision-making for apparel supply chains in EU's high-cost locations. The hierarchy for right reshoring decision-making based on operational capabilities contributes to reshoring research in terms of proposing a unified decision model using multi-criterion decision analysis. The empirical results of the study, i.e. the comparison and the priority weights of each category and alternative are valuable for supply chain managers to decide on what operational capabilities they should build their proximity make-buy decision. Future research can incorporate externalities, such can risk and uncertainty, and trade-offs between manufacturing challenges and transaction costs into the model to explore the how they influence the reshoring decision-making.

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