Latent Dimensions of Strategic Flexibility

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Abstract: Despite numerous scientific articles concerning strategic flexibility in various academic journals, the majority of those articles discuss the construct of strategic flexibility from theoretical perspective. Papers dealing with scale development of the construct are surprisingly rare. By applying part-machine grouping algorithm and multivariate analysis (principal component analysis, cluster analysis) on previous scientific publications that have developed measurement scales of strategic flexibility and validated the construct using confirmatory factor analysis (CFA), the following hidden dimensions of strategic flexibility can be revealed: continuous innovation, responsive value chain, supply chain relationship, and ambidexterity. A theoretical crosscheck indicates a distinct separation of these four latent dimensions into just two groups: strategic renewal and responsive supply chain, which then represent the higher-order dimensions, the building blocks of strategic flexibility. Based on the reviewed sample articles, the construct of strategic flexibility has been applicable in these four scientific disciplines (contexts of use): small-medium enterprises (SME) & human resources management (HRM), technology/engineering management, organisation & strategy, and business & marketing.

Keywords: Strategic flexibility, part–machine grouping algorithm, multivariate analysis

I. Introduction

There is still much unclearness surrounding the strategic flexibility construct, not only regarding its definition and measures [1] but also its link to operational (manufacturing) flexibility [2]. Hence, the richness (complexity) of strategic flexibility as a construct may be the reason behind the limited number of scientific publications that have developed and validated the measurement scales of strategic flexibility.

It appears that the developed measurement scales of strategic flexibility construct in many published articles mix together various approaches of defining flexibility. This causes difficulties in getting a comprehensive view on the "operating" scope and "fibres" of strategic flexibility, in the sense that it has not yet been carefully examined whether or not those measurement scales possibly construct latent, higher-order variables. Therefore, it is the purpose of this article to identify those "hidden" dimensions.

The remainders of this paper are organised in the following way. The next section describes a theoretical perspective on strategic flexibility and part-machine grouping algorithm. The methodological section is presented afterwards, where the samples, variables, and coding will be explained. The "result and analysis" section contains the output of principal component analysis, cluster analysis, and the interpretation of these results. After discussion on the findings, the conclusion finalises this paper.

II. Theoretical Background

Strategic Flexibility

According to [3], the concept of strategic flexibility is *polymorphous* (i.e. having or occurring in several distinct forms) in its nature. Therefore, depending on the contexts of explanation (ex-ante/ex-post and/or offensive/defensive), the terms: *agility*, *versatility*, *liquidity*, *elasticity*, *robustness*, *hedging*, *corrigibility*, and *resilience* may represent strategic flexibility. Strategic flexibility implies not only the *scope*, but also the *speed* and the *object* of the variation [2]. This means strategic flexibility refers to the scope and speed of variation or strategic options within a business (i.e. competitive priorities) and among businesses. The latter justifies the comparability between strategic flexibility and *agile business*, i.e. rapidity to move to different businesses [2].

Strategic flexibility may be defined as the ability to adapt to changes in the environment, to reform the productive process continually, to change the rules of the game, or to disengage from highly unpredictable environments [4]. Strategic flexibility is composed of *resource-* and *coordination flexibility*, where resource flexibility is inherent properties of resources that determine their potential uses [5]−[7], while coordination flexibility is "*a firm's capacity to effectively and efficiently deploy internal and external resources by exploring ways to create greater value and rapidly obtain extraordinary benefit and competitive advantage in an uncertain environment*" ([8], p: 3). The previous description is consistent with the fact that research on strategic flexibility clusters around three interrelated issues: resources, processes, and strategic options [9].

Strategic flexibility is a concept that consists of multiple dimensions (very likely due to its polymorphous nature). Table 1 displays the dimensions of strategic flexibility that can be found in article written by [10]. Comparing these dimensions with those that have been proposed by various researchers (e.g. [11]–[19]), it may be apparent that the

dimensions in table 1 are the combination of the dimensions of flexibility in the areas of, e.g. manufacturing, organisation, flexibility in a general sense, etc. Due to its broad coverage, the dimensions as listed in table 1 are, therefore, preferable to be used.

Table 1. The dimensions of strategic flexibility ([10])

Externally observable	**Internally observable**
Manufacturing process flexibility	Ability to implement strategy
Operational scope flexibility	Value chain flexibility
Market flexibility	Control flexibility
Product flexibility	Learning flexibility
Procurement flexibility	Functional flexibility
Financial flexibility	Human resource flexibility
	Information system flexibility

Based on the reviewed literature, it is arguable that strategic flexibility and ambidexterity (defined as reconciling or balancing exploration and exploitation) seem to overlap. This claim has been motivated by several reasons. Firstly, the *pre-emptive* and *exploitive* manoeuvres in achieving strategic flexibility [3] can be regarded as equivalent to exploration and exploitation respectively. Secondly, the formulation of ambidexterity as an acceptable solution to the battle between efficiency and flexibility [20] seems to indicate that being ambidextrous requires a certain extent of flexibility. Thirdly, some of the strategic flexibility dimensions as described by [10], i.e. *human resource (labour) flexibility* and *learning flexibility*, seem to be related to the organisational definitions of flexibility in [2], which thus implicitly indicates the similarity between flexibility and ambidexterity (in the organisational context). Furthermore, a conceptualisation of [strategic] flexibility as a high degree of proactiveness and reactiveness [21] makes it even more difficult to deny that strategic flexibility and ambidexterity are not mutually exclusive.

Part-Machine Grouping Algorithm

Cellular manufacturing is one of the applications of Group Technology principles to manufacturing, where similar parts are grouped into families and associated machines into groups [22]. The process of determining part families and machine groups is referred to as Cell Formation (ibid), which is the fundamental problem in Cellular Manufacturing [23].

The formation of manufacturing cells conceptually views a manufacturing system as a $n \times m$ part-machine incidence matrix, where the elements of the matrix could be *binary* (nominal) or containing other measurement scales (e.g. ratio). If the i-th part visits the j-th machine, the respective element of the incidence matrix is given a value of one (1). Otherwise, the value of this element is zero (0). The use of binary data in cell formation (part-machine grouping algorithm) can be found in e.g. [24]. Later in the development of this algorithm, more manufacturing aspects have been taken into consideration, for example the sequence of operations, volume to be produced, etc. An extensive review of part-machine grouping has been provided by, for example [22]. There are many algorithms developed to facilitate the grouping, from the simplest (heuristic) to the advanced one (e.g. using simulation or mathematical programming). One of the techniques being used is cluster analysis (multivariate technique), for example by [25]. An illustration of how manufacturing cells can be grouped from an initial incident matrix is available in e.g. [26]. The later part of this paper will also describe the execution of this method/algorithm

III. Method

Samples

The selected samples are published articles which have developed scales to measure and empirically tested the construct of strategic flexibility. The authors of these articles have previously validated the strategic flexibility construct using confirmatory factor analysis (CFA) and then use the construct as either an independent or a dependent variable in the developed structural equation models. Nine (9) publications (as listed in table 2) are being used as the observed samples.

Table 2. The samples and the original variables

[Author(s)], Original measurement scales (variables)
[27] Manufacturing flexibility; Marketing flexibility; Knowledge flexibility; Financial flexibility.
[28] Resource allocation needs; Need to modify business partnership; Emerging market opportunities; Changing environmental conditions; Changing technology needs
[29] Speed of strategic change; Variety of strategic change alternatives; Control over competitors; Control over trade regulations.
[5] Shared investments across business activities; Emphasis on deriving benefits from diversity in the environment; Importance put on benefit from opportunities arise from variability in the environment; Strategic emphasis on managing macro-environmental risk.
[30] Variety in resource deployment; Shifts in resource deployment; Shifts in competitive action; Competitive simplicity.
[31] **Competitive variety** (Wide range of products/services; Emphasis on development of innovative products/services; Emphasis on development of new markets); **Competitive speed** (Rapid changes in design; Speed of product/service design; Capable of getting ahead of competition in new product development).
[4] Reformulating or dismantling current strategies quickly when market conditions or competition requires it; Variety of alternative strategies and change strategy easily when environmental conditions vary; Production machineries or service technologies that enable a large of operations to change quickly and without large costs; Introduce a large number of products or services modifications every year; Able to offer new products or services (enlarge variety) easily and quickly (with low costs) with consequent changes in production tasks.
[32] **Alliance modification** (Modification of agreement; Flexibility in response to request for changes; Adjustment in the on-going relationship to cope with changing environment);

Alliance exit (Likelihood of ending the alliance; Perception on performance –*outcomes, fulfilled expectations, and overall effectiveness*).
[33] Ability to handle opportunistic shifts in economic conditions; Ability to handle emergence of an unexpected market opportunity; Ability to handle emergence of a new technology that adversely affect existing business; Ability to handle opportunistic shifts in customer needs and preferences; Ability to handle market entry of new competition; Ability to handle adverse change in government regulations.

Variables and Measurement Scales

In order to improve the degree of fit (or applicability) in accommodating various conceptualisation of strategic flexibility by different researchers, the dimensions of strategic flexibility as described by [10] are modified and extended (shown by table 3), into sixteen (16) manifest variables. These modified (and extended) dimensions are then being applied as the new manifest variables representing the recoded original measurement scales found in the selected sample articles. Here, binary coding is being used, meaning that if a researcher uses a variable, the value input of this variable is one (1). Otherwise, the value given to this variable is zero (0).

Table 3. Manifest variables (modified from [10])

1	Production process	9	Control
2	Operations	10	Learning
3	Market	11	Marketing
4	Product & design	12	Resource
5	Supply chain	13	Information & knowledge
6	Financial	14	Technology
7	Strategic action	15	Change (organisational)
8	Value chain	16	Relationship (partnership)

Coding Procedure

The coding is conducted in such a way that the original variables will, to the greatest extent, be preserved. Ideally, in an observed sample, the number of manifest variables (as the result of coding) is equal to the number of original variables which have been previously used. However, there might be cases where two or more original variables are being "compressed" into a single manifest variable because the original variables: i) essentially measure the same things although they are formulated slightly different, or ii) measure different things but still within the same scope.

As an example, [28] measure strategic flexibility with respect to five strategic imperatives: resource allocation needs, the need to modify business partnerships, emerging market opportunities, changing environmental conditions, and changing organisational technology needs. Based on table 3, the above scales are transformed into the following manifest variables: market (variable 3), resource (variable 12), technology (variable 14), change (variable 15), and relationship (variable 16).

When the (re)coding has been completed, it is noticeable that operations (variable 2) and learning (variable 10) do not appear to be as useful as the other variables, which is why each of these variables contains zero vector. In case of variable 2 (operations), a possible explanation is that manufacturing flexibility cannot be easily distinguished from operational flexibility, in the sense that " ... *manufacturing flexibility is often used to refer to all the operations that concur to manufacture a product*" ([2], p. 525). Meanwhile, variable 10 (learning) could have been excluded during the validation of the construct using confirmatory factor analysis (CFA).

Incidence Matrix

The "new" set of variables, which contains a binary scale, becomes an incidence matrix. In this matrix (table 4), the authors of the selected articles are identified as the "machines", while the coded variables are analogue to the "parts". This logic enables us to group researchers with similar or related conceptualisation on strategic flexibility and then reveals the variables that have (or might have been) used by this group of authors. Hence, the intention is to avoid re-identifying manifest variables that had already been used by a researcher. Contrarily, it attempts to identify which manifest variables may fit into a particular group of researchers. As indicated in the previous subsection, the second and tenth variables were deleted because these variables only contain zeros.

Table 4. Initial incidence matrix

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**
V1	1						1		
V3		1				1			1
V4						1	1		
V5								1	
V6	1			1					
V7				1	1		1		
V8				1					
V9			1						
V11	1								
V12		1			1				
V13	1								
V14		1							1
V15		1	1				1		
V16		1						1	

IV. Result and Analysis

Principal Component Analysis

The principal components are extracted using Minitab® software, where only Eigen values larger than one (1) are being considered when determining the number of factors. There are four (4) principal components explaining more than 70% of the total variation (table 5). The members of each principal component are shown by table 6.

Table 5. Extracted principal components

	Eigen values	Variance Extracted (cumulative)
PC1	2.2697	0.252
PC2	1.5502	0.424
PC3	1.4100	0.581
PC4	1.3515	0.731

Table 6. Principal component loading

	PC1	PC2	PC3	PC4
A2	**0.535**	-0.101	0.200	-0.135
A6	**0.329**	-0.210	-0.496	0.103
A9	**0.502**	0.006	-0.375	-0.158
A1	-0.394	**0.339**	-0.373	0.169
A4	-0.383	-0.209	-0.092	-0.412
A5	-0.110	-0.489	**0.217**	-0.507
A8	0.122	0.437	**0.463**	-0.172
A3	0.063	-0.219	0.405	**0.601**
A7	-0.145	-0.556	-0.031	**0.316**

It is apparent that sample A4 seems to be a special case, which could be the member of a distinct (separate) principal component. However, adding another principal component (where A4 may fit into) is not desirable because this solution will produce two principal components containing a single variable each. Therefore, variable A4 will be "inserted" to the "nearest" principal component. The most suitable principal component to accommodate A4 can be identified when re-arranging the initial incidence matrix.

Cluster Analysis

K-means clustering method applies when clustering the variables (i.e. the "parts"), where the number of clusters is deliberately being set at the same number of extracted principal components. Table 7 shows which variables belong to which cluster.

Table 7. Cluster membership

Cluster	Members (variables)	Cluster	Members
A	3, 14	C	4, 9, 15
B	1, 6, 7, 8, 11, 13	D	5, 12, 16

Re-arranged Incidence Matrix

The next step is to re-arrange the initial incident matrix according to the result of PCA and cluster analysis. The incidence matrix after rearrangement is shown by table 8. Since the method is being applied in social science, we may be able to "relax" the requirement on certain criteria (for example *grouping efficiency*), therefore less "strict" than the applications of the same method in the manufacturing context. Moreover, the meaning behind the principal components is more of interest rather than "perfect" cell formation.

Table 8. Incident matrix after re-arrangement

	A2	A9	A6	A1	A4	A5	A8	A7	A3
V3	1	1	1						
V14	1	1							
V1				1				1	
V6				1	1				
V7					1	1		1	
V8					1				
V11				1					
V13				1					
V5							1		
V12	1					1			
V16	1						1		
V4			1					1	
V15	1							1	1
V9									1

Identifying the Latent Dimensions

In order to identify the dimensions that are "hidden" in the construct of strategic flexibility, a preliminary interpretation is first conducted in order to get an insight of what the manifest variables in a particular principal component might represent. Next, the preliminarily identified latent variables are being compared with the similar or related concepts in the existing literature in order to crosscheck and verify the initially defined ones.

The results (table 9) reveal that the following four dimensions are "hidden" in the strategic flexibility construct: continuous innovation, responsive value chain, supply chain relationship, and ambidexterity.

Table 9. The latent dimensions of strategic flexibility

Manifest Variables	**Latent Variables**
Market (3); Technology (14)	Continuous Innovation
Production process (1); Financial (6); Strategic action (7); Value chain (8); Marketing (11); Information & knowledge (13)	Responsive value chain
Supply chain (5); Resource (12); Relationship/partnership (16)	Supply Chain Relationship
Product & design (4); Control (9); Change (15)	Ambidexterity (ambidextrous organisation)

Continuous Innovation

Based on [34] and [35], the manifest variables "technology" and "market" seem to have contributions in defining the *strategic renewability* construct, i.e. a firm's ability to refresh or replace the attributes of its organisation. *Strategic renewal* is a firm's attempts to adapt on the dramatic shifts of the external environment. It may take continuous or disruptive form of renewal, where innovation is obviously an important matter and significantly related to strategic renewability. Based on [36], the "technology" and "market" variables refer to the conception of *continuous innovation*, the continuous form of strategic renewal. In a general sense, continuous innovation indicates the state of *innovation speed* (e.g. [37]).

Responsive value chain

This latent dimension seems to be closely related to (or has its orientation on) the concept of *Responsive Supply Chain* (RSC) by [38], where: i) value chain or a collaborative network of partners, ii) information technology and systems, and iii) knowledge management are the identified three enablers. In this case, the term "value chain" may refer to the collaboration of a firm's functions. The variable "strategic action" may thus correspond to the strategic planning in RSC. The relevance of responsive value chain as a dimension of strategic flexibility seems to be confirmed by [38] conceptualisation that RSC is leading to speed and flexibility.

Supply chain relationship

"*Firms are building collaborative relationships with their supply chain partners in order to achieve ... flexibility ...*"

([39], p: 101). The relevance of the manifest variables in building this latent dimension seems to be self-justified. Good (successful) supply chain relationships require resources, such as excellent individuals [40] and transaction-specific investments [39].

Ambidexterity

This latent dimension may be best conceptualised as "[strategic] ambidexterity", defined (in the simplest way) as an act of balancing exploration and exploitation (e.g. [41]), which in this case being exercised through changes and control respectively. Ambidexterity also refers to dynamic organisation configurations that allow short term efficiency and long-term innovation (see e.g. [42]). Ambidexterity (ambidextrous form) is a way of transforming a business [43], the key to achieve strategic renewal [44]. A comparison with [36] indicates that the member variables of this principal component tend to explain *discontinuous transformation*, the other pathway towards strategic renewal.

V. Discussion

Strategic flexibility is the capability to relatively quickly and efficiently switch from one competitive priority to another (e.g. from rapid product development to low cost) [45], which is very similar to the concept of ambidexterity, i.e. a firm's ability to operate complex organisation designs that provide for short-term efficiency and long-term innovation [42]. Hence, it doesn't seem to be a big surprise if the results indicate that strategic flexibility and ambidexterity are not mutually exclusive.

Reflecting back to the theory, we may be able to draw a clear (distinct) line that separates those four latent dimensions into two main groups. This is because putting together continuous innovation and ambidexterity completes the "puzzle" of *Strategic Renewal* (*-ability*). It seems that "summing up" supply chain relationship and responsive value chain will "produce" *Responsive Supply Chain*. Therefore, the above described latent variables can further be "compressed" into just two (higher-order) latent variables: i) responsive supply chain and ii) strategic renewability, which thus represent the inseparable building blocks of strategic flexibility. This representation has been consistent with the fact that strategic flexibility can be expressed in terms of *speed* and *variety* [2]. The necessity of infusing innovation in the supply chain [46], and the criticality of a responsive supply chain in e.g. fashion industry (where most of the products are innovative product) seem to provide further evidence for the aforementioned claim.

By identifying the title of the paper and the title of the journal, we can attempt to identify the context where strategic flexibility had been conceptualised. The Principal Component Analysis (PCA) indicates that those dimensions are "tied" to these respective academic/scientific fields: Small-Medium Enterprises (SME) & Human Resources Management (HRM), Technology/Engineering Management, Strategy & Organisation, and Business & Marketing.

VI. Conclusions

The richness and complexity of strategic flexibility as a construct make it uneasy to get a coherent view regarding the concept. Consequently, published scientific articles containing the developed and validated measurement scales of the construct are very rare, in spite of many available scientific publications offering the theoretical perspective.

The study in this paper starts with an exclusive search of published scientific papers that have developed and validated the construct of strategic flexibility, and then utilise them as the samples for multivariate statistical analysis. The original manifest variables are first recoded into new manifest variables, modified and extended from the dimensions of strategic flexibility as suggested by [10]. The new set of data is then equivalent to the initial incidence matrix in the Cellular Manufacturing literature, where the authors of those publications are analogue to the "machines", while the new manifest variables are the "parts".

Conducting principal component analysis (PCA) and cluster analysis on this data set enable the rearrangement of the initial incidence matrix, which thus leading to the formation of four (4) "cells" containing the closely related authors/researchers and new manifest variables that they [might] have used. Analysis on the "part families" reveals that *continuous innovation*, *responsive value chain*, *supply chain relationship*, and *ambidexterity* are "hidden" in the strategic flexibility concept. These latent dimensions tend to form two larger groups: *strategic renewal* and *responsive supply chain*. Meanwhile, the "machine groups" analysis implies that strategic flexibility has been applicable in the following contexts (academic/scientific fields): small-medium enterprises (SME) & human resources management (HRM), technology/engineering management, strategy & organisation, and business & marketing.

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