Journal of Manufacturing Systems 48 (2018) 9–20

Contents lists available at ScienceDirect

Journal of Manufacturing Systems

journal homepage: www.elsevier.com/locate/jmansys

Research opportunities on manufacturing flexibility domain: A review and theory-based research agenda

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ARTICLE INFO

Keywords:
Flexibility
Review
Manufacturing
Bibliometrics
Theory-based agenda

ABSTRACT

This work proposes a systematic literature review on manufacturing flexibility that provides a broad map of the main investigated research issues in manufacturing flexibility and future research opportunities on the topic. A sample of 284 academic articles published in peer-reviewed international journals up to 2017 constitutes the knowledge base of the study. This sample is analysed through the combination of two complementary methods: 1) a co-words bibliometric technique to identify the thematic sub-fields as well as their relative standing and 2) a critical reflection based upon an in-depth reading of each of the articles that compose the subfields previously identified with the purpose of interpreting the intellectual structure of the research. This information makes it possible to identify trends and deficiencies in this context, providing well-structured information helping to centralise the efforts required for future work. Based on information from the literature, this paper proposes a theory-based research agenda that summarises different axes of development for future investigations within the field.

1. Introduction

Despite the general agreement about the relevance and benefits of manufacturing flexibility as a key competitive strategy [1,2] and one of the most important success factors for coping with uncertainties and sustaining companies' operations [3–7], research in manufacturing flexibility can, to some extent, be considered fragmented and unstructured [1,8–10]. This may be an effect that the discipline has developed over an explosion of empirical research on a wide variety of topics [11], with a limited presence of theoretical frameworks [1,10,12–14] and a high ambiguity in the terminology used to refer to the multidimensional nature of flexibility itself [8,15]. This situation means manufacturing flexibility has not been properly understood [9], while the relationships explored to date are considered insufficient rationale [10,16,17]. Consequently, further analysis is needed taking the time to consider the discipline's broader knowledge output to make future research investments more productive.

To achieve this goal, a systematic analysis of past work emerges as the most relevant approach for both evaluating a field's accrued knowledge and informing new inquiries [18,19]. In other words, "literature reviews are essential for making sense of existing scholarship and to identify new research directions" [20], especially when an accumulated body of research exists to warrant a literature review for synthesis and analysis [21]. Along with several papers reviewing specific aspects of manufacturing flexibility, such as its operationalisation [22–24], its conceptualisation [8,25,26] or its intersection with the adjoining field of supply chains [1,10,27,28], only a few papers focus on providing further discussion and a more holistic view of the manufacturing flexibility field [9,29–33]. In fact, these previous literature review studies either suffer from lack of a systematic review (the only exception is [29] or in-depth content discussion in agreement with a theoretical framework that lets us understand how trends in manufacturing flexibility need to be developed (the only exception is [31]. In summary, previous literature reviews seem to fail to present a comprehensive picture of the structure and the development of this academic field, even though a number of years have passed since interest in this topic began.

Given this scenario, in order to sum up the status of ongoing research and stimulate future investigations, this study aims to address an updated state-of-the-art study of this field, following the suggestions of [34–36] for the systematic literature review. Specifically, the systematic literature review is developed through the combination of two complementary methods: 1) identification of internal subfields of the manufacturing flexibility field by using a co-words technique (a

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https://doi.org/10.1016/j.jmsy.2018.05.009
Received 2 February 2018; Received in revised form 20 April 2018; Accepted 16 May 2018

systematic and objective technique that allows for the identification of mature vs. emerging research clusters (for a review, see [37,38]) and 2) a critical reflection based upon an in-depth reading of each of the articles that compose the research subfields previously identified for interpreting the intellectual structure of research, current trends and gaps to be addressed in future research. Specifically, this critical analysis is made in accordance with a recent conceptual systematisation of the manufacturing flexibility construct [8] for two reasons: a) it provides standardised terms and definitions for the different flexibility types of manufacturing flexibility constructs contributing to overcome the traditional terminological ambiguity surrounding its conceptualisation, i.e., at least 50 overlapping flexibility types have risen from manufacturing research literature [1,9], and b) it opens the possibility to rethink how the discipline could be developed on the basis of a conceptual and terminological consensus. Based on the results of these two complementary methods, a limited set of key messages, highlighting underdeveloped topics are synthesised in a theory-based research agenda.

These features allow this work to offer several contributions to the manufacturing flexibility field by examining previous evidence in search of promising avenues of research. First, this work contributes to the literature by developing an all-encompassing view of manufacturing flexibility domain still absent in previous studies. Second, this systematic literature search is, to the best of our knowledge, the first review within the field developed through the combination of two complementary methods—co-words technique and critical reflection—that, applied together, help to reveal the underlying patterns of intellectual activity that give shape, structure and direction to the manufacturing flexibility domain as it evolves while also making sure conclusions are meaningful, coherent and robust. Third, to the best of our knowledge, this is the first review that proposes an integrative theory-based research agenda for bringing order and clarity to the academic field from the point of view of the recent conceptualisation of [8].

The remainder of the paper is as follows: Section 2 explains the structured methodology used to identify the literature reviewed and evaluated in this study. Section 3 presents a critical analysis and evaluation of the results according to an integrative framework that enables a better understanding of the present and future development of the field. Section 4 discusses opportunities for future research suggesting a theory-based future research agenda.

2. Material and methods

According to [39] or [40], literature reviews aim to evaluate past bodies of literature, through a structured, explicit, and reproducible design that helps to identify potential research gaps and highlight the boundaries of knowledge [41]. Structured literature reviews are typically completed through an iterative cycle that focuses on question formulation and locating studies, study selection and evaluation, analysis and synthesis, reporting and using results for reflection on future opportunities [34,36]. In a similar approach, we use a four-step methodology [42]: a) systematic search of past literature, b) evaluation of the sample of collected literature for refinement, c) application of the co-words technique to identify the major research sub-fields or subdomains within the field, and d) critical discussion based upon an in-depth reading of each of the articles that compose the research subfields for a comprehensive evaluation and integration of the manufacturing flexibility research lines. The specific approach for each of these steps is explained below:

2.1. Step 1: collection of past literature

We applied two phases to ensure our review results took into account all available studies [43,44]. First, a search on the Social Sciences Citation Index electronic database (SSCI), reviewing bibliographies published in the “Operations Research Management Science” and “Business Economics” subject areas, enabled us to cover not only influential articles in the production and operations management field but also articles in adjacent fields [45,46]. This search is suitable because SSCI is both frequently used in conducting systematic literature reviews [47,48,43] and the most comprehensive database of peer reviewed journals in the social sciences [49,38].

Second, to ensure the search was exhaustive [50,51], we conducted a manual search of peer-reviewed journals listed in the academic journal quality of Association of Business Schools 2015 (ABS), which is the most recent and extensive international ranking of English-speaking journals [52,53,18]. More specifically, the ABS search was limited to the Grade 4, Grade 3 and Grade 2 journals in the two operations categories of ‘Operations and Technology Management’ and ‘Operations Research and Management Science’ [54,55].

Both searches were performed in July 2017. The keywords for data collection used a number of carefully selected key Boolean search terms [56,51] following the general trend used in field-specific systematic reviews [8,29]. Specifically, three main terms were used to identify a list of papers fitting into our research objective. First, “flexibilit*” is the primary keyword related to the object to be classified. Second, "manufact*" and “operat*” are the two secondary keywords that are used interchangeably for referring to the nature of manufacturing flexibility [29,15]. The use of the truncation symbol “*” in the keywords considers all the grammatical variations, as well as other suffixes, of the selected terms [44,51,57]. These search terms are sufficiently inclusive to capture most relevant articles within the conceptual boundaries and exclusive enough to eliminate less relevant articles. The search procedure was repeated a few times during the research to confirm that some articles had not been missed [57] and the topic was completely covered by the keywords used [41]. These search criteria allowed us to retrieve an initial sample of 311 documents.

2.2. Step 2: evaluation of collected literature for appropriateness

From the initial sample and to ensure inter-rater reliability, two researchers screened the sample for retaining works that contained one of the search keyword combinations in sections that provide a reasonably detailed picture of an article's theme that is within the title, abstract or author keywords [43,41,38]. In contrast, when keyword combinations appeared only in the references list, these articles were removed from the sample [58]. Furthermore, works identified as misclassifications were deleted. Finally, to gain sample robustness, researchers discussed those articles in which the research domain was uncertain until agreement was reached [51,59]. After excluding articles following these inclusion/exclusion criteria, 284 articles remained in the sample.

2.3. Step 3: co-words analysis to establish research sub-fields

To establish the research sub-fields in an objective manner [60], the co-words technique was used through the program REDES2005. The co-words technique is a method for analysing the content of a variety of data that enables the reduction of phenomena or events into main research clusters to better analyse and interpret them [61,62]. To this end, this technique entails reducing the number of article keywords to a set of research clusters that build on the strongest associations between keywords [63]. Specifically, the co-words technique is applied to the keyword information that defines each article of the sample. With this essential information, the software computes the frequency of two keywords appearing together in the same paper, getting a symmetrical co-occurrence matrix based on the word co-occurrence. This co-occurrence is measured by a normalised index whose value depends on both the individual and joint appearance of the keywords. The results of this index make it possible to graphically represent the research clusters present in the field within the four quadrants of a strategic matrix according to their different levels of development [1], that is, according to