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International manufacturing networks: a literature review

De Toni A. F. (University of Udine)

Parussini M. (University of Udine)

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International Manufacturing Networks: a literature review

Alberto Felice De Toni

Department of Electric, Management and Mechanical Engineering, University of Udine
Via delle Scienze 208, Udine, Italy

Michela Parussini (michela.parussini@uniud.it)

Department of Electric, Management and Mechanical Engineering, University of Udine
Via delle Scienze 208, Udine, Italy

Abstract

Manufacturing internationalization has risen the lively interest of scholars in the last years, while a growing number of firms seek to restructure their manufacturing networks in order to better exploit the advantages of global production, taking configuration and coordination strategic decisions on a worldwide basis. This paper presents a review of relevant literature about International Manufacturing Networks and suggests some under-investigated areas that could be interesting for further research.

Keywords: international manufacturing, plant networks, literature review

Introduction

Internationalization of manufacturing activities has become a popular research issue during the last two decades, and topics like “globalization” and “global production” are raising growing attention in academic, industrial and political contests. To face the challenges of today’s global competition, firms need to restructure their manufacturing footprint, seeking the best opportunities worldwide.

Many scholars (e.g. Shi and Gregory, 1998; Ernst and Kim, 2002) highlight that one of the main consequences of globalization consists in the spread of international manufacturing networks. Ferdows (1997a) points out that building and managing such integrated global factory networks is the next challenge in manufacturing and this remark is still true today.

Research about international manufacturing networks (IMNs) appears as a many-sided and interdisciplinary subject, whose boundaries are not well-defined. The purpose of this paper is to present the state of the art of the literature, analyzing the main contributions and taxonomies and pointing out some research gaps for future studies. This work can be useful both for academics and practitioners, as it aims to put order in the wide and heterogeneous literature on this topic and to highlight the most interesting aspects that in our opinion need further attention.

The paper is structured as follows. The next section describes the methodology used; then we describe the origins and evolution of IMN research literature and we classify the main contributions in different research fields. Finally, we classify the main frameworks and discuss some directions for further research.

Methodology

The research of the articles was conducted in 5 most known databases using several keywords and without any time restriction, as shown in table 1.

Table 1 – Database research procedure

<i>Databases</i>	<ul style="list-style-type: none"> ▪ ISI Web of science ▪ Ebsco ▪ Emerald ▪ JSTOR ▪ Cilea
<i>Main Keywords</i>	International/global operations/production/manufacturing; International/global production/manufacturing/operations network; Dispersed manufacturing; Virtual production network; International plant network; Offshoring; Outsourcing.
<i>Time restriction</i>	None
<i>Filter Criteria</i>	<ul style="list-style-type: none"> ▪ Reading of the abstracts ▪ Removal of papers that do not regard international manufacturing and/or do not have a management perspective

The results achieved from the first database research highlighted some difficulties, because for some specific keywords (e.g. “international manufacturing network”) there are very few results, while for more general keywords (e.g. “international operations”) there are hundreds of outputs, most of them not pertaining to the subject. Therefore, it was necessary to make a screening of the results. After reading the abstracts, we removed the articles whose focus is not on manufacturing (for example we removed many papers about international sourcing, marketing or international R&D) or that do not have a managerial perspective, discarding articles about political economics or industrial policy. Afterwards, we analyzed the references lists contained in the most interesting papers, to find out further interesting works, some of them not strictly referable to the subject of international manufacturing but also concerning international supply chain management or international strategy.

At the end of this research and selection process, we critically reviewed 65 articles from 38 journals as shown in table 2. Figure 1 illustrates the frequency of publications over years.

Table 2 – Classification of journals by number of contributions

	<i>JOURNAL</i>	<i>Impact factor</i>	<i>No. of articles</i>
1	International Journal of Operations & Production Management	1,725	11
2	Journal of Operations Management	2,420	5
3	Harvard Business Review	1,793	4
4	Journal of Manufacturing Technology Management	-	4
5	Management Science	2,354	3
6	Integrated Manufacturing Systems	-	2
7	Journal of International Business Studies	2,992	2
8	Journal of Purchasing & Supply Management	-	2
9	Omega	2,175	2
10	Production and Operations Management	1,933	2
11	Production Planning & Control	-	2
12 - 38	Other reviews	-	1
	Total		65

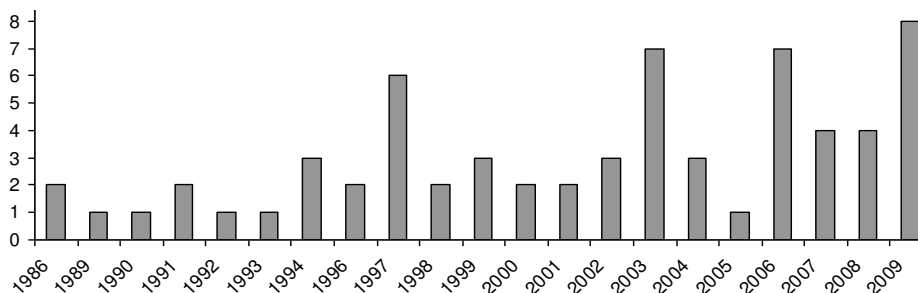


Figure 1 – Temporal distribution of the papers about IMNs

Origins and evolution of literature about International Manufacturing Network

Literature about international manufacturing networks has evolved rapidly in the last years and has some roots and connections with other research fields. In this section we offer a short view of the evolution of the literature about this topic, that can be useful for better understanding the heterogeneity of contributions.

From international business to international manufacturing

The theme of business internationalization aroused the lively interest of academics since the late 60s, when the first internationalization theories were developed. Among these, one of the most interesting theories is the Uppsala model developed by Johanson and Vahlne (1977), that sees internationalization as a stage process, where the international involvement of a firm grows as a result of the increasing knowledge about foreign markets and business characteristics.

In today's global economy, the fact that almost all businesses are international and many markets are becoming truly global is unquestionable (Rudberg and Olhager, 2003). Because of the quick widespread of global production activities and the complex interdependencies between companies and facilities in global supply chains, classical stage theories are becoming unsuited to explain today's international manufacturing strategies. Shi (2003) asserts that even if the Uppsala model makes an important contribution, it provides a very limited guidance for managers, especially when companies enter into the international manufacturing stage. During the last 20 years international business research has evolved from a focus on international marketing and financial issues towards a stronger focus on international manufacturing (Rudberg and West, 2008).

From international manufacturing to international manufacturing networks

From the '90s international manufacturing research showed a growing consensus around the idea that one of the most useful keys for understanding the complexity of the global economy is the concept of the "network" (Coe et al., 2008). Many authors underline the network characteristics of the new manufacturing system. Shi and Gregory (1998) define an international manufacturing system as a factory network with matrix connections, underlining the need of a wide perspective covering geographic dispersion and interdependent coordination rather than the traditional focus on separated manufacturing sites. In the network, plants affect each other, cannot be managed separately and are not necessary fully-owned by the company.

The conception of the IMN as a coordinated aggregation of plants located in different locations implies that there are two main levels of analysis, with a plant or a network perspective. These two perspectives are based upon different research fields.

From a plant perspective, IMN theory stems from the operations management field, that arose as a discipline with strategic implication in the '70s focusing on the management of a single factory (Rudberg and Olhager, 2003). With the increasing trend towards production internationalisation, operations management research extended its focus to multi-plant and network management.

Many scholars (e.g. Pontrandolfo and Okogbaa, 1999; Vereecke et al., 2006) assert that the network perspective of international manufacturing systems has some of its roots in multinational companies (MNCs) studies. Dunning's (1988) eclectic paradigm is useful to understand the economic rationale for international production. The rapid international growth of many MNCs during the '80s and the '90s stimulated an abundant literature about international multi-facility management.

From Intra-firm to Inter-firm International Manufacturing Networks

The deep restructuring in manufacturing activities that many companies implemented in the last two decades involves not only decisions about location, but also about the ownership of facilities. Many authors (e.g. Ferdows, 2009) have pointed out that the trend towards production outsourcing has escalated in the last years due to unprecedented competition and worldwide access to low-cost labour markets, and now it is a widespread practice in many industries. International manufacturing and international sourcing are increasingly interrelated. Therefore, IMN strategy needs to integrate a supply chain perspective (see figure 2).

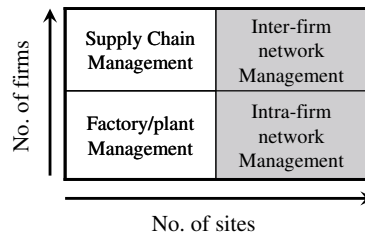


Figure 2 – Intra- and Inter-firm IMN perspectives (based on Rudberg and Olhager, 2003)

Classification and discussion of the main contributions in International Manufacturing Network literature

Analysing IMN literature, many taxonomies can be considered. Studies about IMNs can be classified between those that consider a plant perspective (e.g. Ferdows, 1997b) or a network perspective (e.g. Shi and Gregory, 2005), and between those that focus only on the intra-firm manufacturing network (e.g. Shi, 2003), while others enlarge the scope also to inter-firm network (e.g. Rudberg and Olhager, 2003). With a strategic perspective many authors (e.g. Porter, 1986) distinguish between decisions regarding configuration or coordination.

In this section we are going to describe the main contributions for international manufacturing strategy, IMN configuration and coordination research fields, while the review of the whole set of articles is reported in table 3.

Table 3 – IMN literature review (by author)

N.	Authors	Year	Journal	Int. Strat. Overview	Int. man. strategy	Int. SCM	IMN configuration					IMN coord.		
							Plant Roles	Typologies	Location	Allocation	Ownership	Capabilities	Coord. Mechanisms	Know-how transfer
1	Baden-Fuller and Stopford	1991	Strategic Management Journal	x	x									
2	Bartlett and Ghoshal	2000	Harvard Business Review	x	x									
3	Bolisani and Scarso	1996	International Journal of Operations & Production Management		x				x				x	
4	Bonaglia et al.	2007	Journal of World Business	x	x									
5	Camuffo et al.	2006	Journal of Purchasing & Supply Management		x	x								
6	Camuffo et al.	2007	Journal of Operations & Production Management		x	x								
7	Canel and Khumawala	1996	International Journal of Operations & Production Management						x					
8	Choy and Lee	2003	Supply Chain Management: An International Journal								x			
9	Coe et al.	2008	Journal of Economic Geography	x	x									
10	Colotla et al.	2003	International Journal of Operations & Production Management		x							x		
11	Dasu and de la Torre	1997	Management Science										x	
12	De Toni et al.	1992	International Journal of Operations & Production Management		x									
13	DuBois et al.	1993	Journal of International Business Studies		x				x					
14	Er and MacCarthy	2006	Journal of Manufacturing Technology Management			x								
15	Ernst and Kim	2002	Research policy		x							x		x
16	Feldmann et al.	2009	Production Planning & Control				x		x					

17	Ferdows	1997	Production and Operations Management		x														
18	Ferdows	1997	Harvard Business Review		x		x												
19	Ferdows	2003	Industrial Engineering		x								x		x				
20	Ferdows	2006	Production and Operations Management															x	
21	Ferdows	2009	Georgetown University Journal of Globaliz., Compet. & Govern.		x				x			x							
22	Ferdows et al.	2004	Harvard Business Review		x	x	x		x			x			x				
23	Fleischmann et al.	2006	Interfaces				x				x								
24	Gray et al.	2009	Decision Science		x							x							
25	Hendersons et al.	2002	Review of International Political Economy		x												x		
26	Karlsson and Skold	2007	Journal of Manufacturing Technology Management		x	x											x		
27	Ketokivi and Jokinen	2006	Journal of Operations Management		x		x												
28	Klassen and Whybark	1994	Journal of Operations Management		x														
29	Kogut and Kulatilaka	1994	Management Science														x		
30	Lee and Lau	1999	International Journal of Agile Management Systems		x					x									
31	MacCarthy and Athirawong	2003	International Journal of Operations & Production Management							x									
32	Magretta	1998	Harvard Business Review		x		x												
33	Maritan et al.	2004	Journal of Operations Management					x									x		
34	Mauri	2009	Management International Review							x							x		
35	Mauri and Sambharya	2001	International Business Review							x							x		
36	Mefford	1986	Journal of International Business Studies		x														
37	Meijboom	1999	International Journal of Operations & Production Management				x												
38	Meijboom and Vos	1997	International Journal of Operations & Production Management		x		x			x							x		
39	Meijboom and Voordijk	2003	Tijdschrift voor Economische en Sociale Geografie		x		x			x									
40	Meijboom and Vos	2004	Journal of Purchasing & Supply Management		x		x												
41	Miltenburg	2009	International Journal of Production Research		x		x	x	x						x				
42	Noori and Lee	2006	Journal of Manufacturing Technology Management		x					x									
43	Pontrandolfo and Okogbaa	1999	International Journal of Production Research			x											x		
44	Porter	1986	California Management Review		x	x													
45	Prasad and Babbar	2000	Journal of Operations Management		x	x													
46	Prasad et al.	2001	International Journal of Operations & Production Management		x	x													
47	Riis et al.	2007	Journal of Manufacturing Technology Management		x			x											
48	Rudberg and Olhager	2003	Omega		x	x													
49	Rudberg and West	2008	Omega		x		x										x	x	
50	Shi	2003	Integrated Manufacturing Systems		x				x						x				
51	Shi and Gregory	1998	Journal of Operations Management		x				x						x				
52	Shi and Gregory	2005	Production Planning & Control		x								x			x			
53	Shi et al.	1997	Integrated Manufacturing Systems		x				x						x				
54	Shin et al.	2009	Industry and Innovation		x														
55	Srai and Gregory	2008	International Journal of Operations & Production Management				x												
56	Sugitara	1990	Sloan Management Review							x									
57	Sweeney	1994	The International Journal of Logistics Management		x					x			x						
58	van de Ven	1989	Engineering Costs and Production Economics		x					x									
59	Vecchi and Brennan	2009	Research in International Business and Finance		x														
60	Vereecke and Van Dierdonck	2002	International Journal of Operations & Production Management									x							
61	Vereecke et al.	2006	Management Science		x		x											x	
62	Vos	1991	International Journal of Operations & Production Management		x					x	x								
63	Vos	1997	International Journal of Physical Distribution & Logistics		x	x				x									
64	Weller	2008	Growth and Change		x														
65	Wright et al.	2009	Asia Pacific Business Review		x	x													
TOTAL					7	47	9	14	4	19	2	6	7	14	4				

International manufacturing strategy

In IMN literature we found many contributions that deal with strategic issues, mainly about manufacturing strategy in an international context (e.g. Vos, 1991) and international operations strategy (e.g. Prasad et al., 2001; Rudberg and West, 2008).

International manufacturing strategy originates from high level corporate strategy, and have to consider the external opportunities and threats (including the characteristics of industry and market or the economic and political environment) and resources and capabilities available in the network (intra-firm and inter-firm).

The importance of a strong and thoughtful link between international manufacturing strategy and high level strategy is stressed by Ferdows (2009), as seemingly similar production networks work well in one company but not in another. Ferdows believes that the reason lies in the differences in higher-level strategies and identifies two antithetic strategic models for developing IMNs. The first model is called “footloose” and is characterized by continuous searching for the better location for production around the world, inside or outside the company. The second model is called “deep roots” and requires long-term commitment to each production site, giving to it the best resources to reach its full potential. Firms that choose a footloose strategy think that manufacturing is not a key element for their competitive advantage and prefer to focus

on other activities like R&D and marketing, while firms that choose a rooted strategy want to use own production capabilities as a competitive weapon. Ferdows also suggests a framework based on two variables: the uniqueness of product design and the exclusivity of production process. A footloose network is suitable for commodity products with standard production processes, while a rooted network is suitable for unique products with proprietary production processes. Companies with a differentiated range of products can also create an hybrid model: footloose network for simpler products and rooted network for more complex or time-sensitive ones.

International Manufacturing Network configuration

IMN configuration refers to the strategic decisions regarding the design of the multi-plant structure of the network in terms of location, composition (number, typologies, characteristics) and ownership of plants, resource allocation between facilities, plant roles and relationships. Since network configuration concerns many typologies of decisions, literature in this field is rich and diversifies.

As the basic unit of analysis of a manufacturing network is the single plant, the first topic we consider is the literature about plant roles and competences. The main contribution in this field is Ferdows (1997b), who introduced the concept of plant roles in a network and proposed a framework for classifying them. Vereecke and Van Dierdonck (2002) quote also other taxonomies present in literature (e.g. Bartlett and Ghoshal, 1989), but these are more generally referred to subsidiaries of MNCs, while Ferdows's model can be regarded as a translation of the strategic roles of subsidiaries into a classification of manufacturing plants.

Ferdows's model (1997b) is based on two variables: (1) the primary strategic reason for establishing a foreign factory; (2) the level of site competence. Ferdows distinguishes among three primary location drivers: access to low cost input factors, access to local skills and technological resources, and proximity to market. The level of site competence refers to the extent to which a selected set of technical activities that go beyond simply producing the goods are present at the site: for example process engineering and improvement, product customisation, after-sales service, decision-making on procurement and distribution, and product development (Meijboom and Voordijk, 2003). The combination of the two variables leads to the identification of six generic roles (i.e. Offshore, Outpost, Server, Source, Contributor and Lead) for international factories, that may also combine more than one role. Ferdows (1997b) asserts that the strategic role of a plant is dynamic and describes also the natural evolution of plants towards an increasing site competence. This upgrading process often takes years and requires great investment of resources, while less successful plants may be closed or sold.

Many other research works about strategic roles of plants are based on Ferdows's model and test it empirically (e.g. Vereecke and Van Dierdonck, 2002; Feldman et al., 2009). These studies are particularly helpful because they suggest some tools for operationalizing the model and point out some limitations of Ferdows's model.

These different typologies of geographically dispersed plants are the basic units for IMN configuration. Taking a network perspective, researchers investigate many topics, mainly concerning facility location and the inter-facility allocation of resources along the value chain. Vos (1991) for example identifies three types of configuration decisions: (1) the choice of a new production location; (2) the relocation of production; (3) the reallocation of production. Meijboom and Vos (1997) point out that the configuration issue is frequently addressed, but it is usually approached as an

international investment decision, therefore many of these studies have mainly an economic and finance perspective.

Many research works suggest a classification of manufacturing networks. Miltenburg (2009) for example identifies 9 typologies of network, while other scholars (i.e. Shi et. al, 1997; Shi and Gregory, 1998; Shi, 2003) propose an international configuration map, that is a framework which groups seven manufacturing configurations into four blocks along two dimensions: degree of geographical dispersion and level of co-ordination dimensions.

Another important element of IMN configuration is the ownership of plants, as part or even the whole of production is often outsourced to external suppliers. Strategic decisions regarding outsourced production require a wide perspective beyond firm's boundaries. Sweeney (1994) describes three strategic frameworks to help managers determine how the manufacturing and sourcing resources of a business should be configured to create and sustain competitive advantage, according to product and technology characteristics. Shi and Gregory (2005) underline that, as outsourcing manufacturing is an emergent trend, the concept of global manufacturing network (GMN) should be extended into global manufacturing virtual network (GMVN), that may be regarded in a dynamic perspective as a pendulum moving between virtual organizations and international strategic alliances.

Since different network configurations can generate or reserve different capabilities (Shi, 2003), many papers that deal with IMN configuration decisions also analyze the topic of IMN capabilities. Shi and Gregory (1998) for example categorize IMN strategic capabilities into resource accessibility, thriftiness ability, manufacturing mobility, and learning ability. Colotla et al. (2003) seek to explore the interplay and interdependencies of factory and network capabilities with manufacturing performance.

International Manufacturing Network coordination

IMN coordination decisions concern the management of the network, in particular the management of physical and information flow integration between facilities, control practices, competence groups for integration and control, management of facilities' roles and know-how exchange, diffusion of best practices, standard processes and methodologies.

Contributions about IMN coordination are fewer than those about IMN configuration. Pontrandolfo and Okogbaa (1999) assert that less attention has been devoted to the coordination issues and underline that a good planning of manufacturing activities is essential to facilitate coordination and to exploit the network advantages. Ferdows (2003) points out that companies with superior performances like Zara (Inditex) and Li&Fung are those who better coordinate and control production and logistics in the supply chain.

Studies about IMN coordination mainly draw on literature about coordination of facilities in MNCs, in particular referring to the "transnational solution", proposed by Bartlett e Ghoshal (1989), that aims at joining flexibly the advantages of the global scale economies with the best local adaptation.

Rudberg and West (2008) present an interesting model for manufacturing network coordination that is inspired by Bartlett e Ghoshal (1989): the Model Factory Concept (MFC), originally developed at the Ericsson Radio Systems AB. This model is built around three main components: the Model Factory (a virtual factory framework that facilitates coordination, a flexible use of network capacity, economies of scale and global efficiency), the Network Organization (an organization based on the concept of master and clone function responsibilities of factories) and the Competence Groups

(virtual organizations composed by expert members from different plants in the network that meet on a regular basis). In particular, Competence Groups help management to coordinate the manufacturing network, because they create a platform for communication and coordination and ensure the diffusion of knowledge and standard practices among factories.

Another important topic in IMN coordination is the management of production know-how transfer between plants, essential to increase capabilities in the network. Ferdows (2006) proposes a framework for classifying the different typologies of production know-how and suggests different primary transfer mechanisms, from the use of manuals and standard practices to the involvement of many experts in project working, making them move frequently between plants. Ernst and Kim (2002) consider the knowledge transfer mechanisms also across the borders of the focal firm (referred as “flagship”), involving local suppliers that have to constantly upgrade their learning capacity.

Even if IMN configuration and coordination decisions are usually presented separately, many scholars (e.g. Pontrandolfo and Okogbaa, 1999) highlight that these two topics are strategically tied. Meijboom and Vos (1997) underline that configuration and coordination aspects are often addressed in different branches of literature and are therefore seldom integrated, but it is recommended that coordination issues are explicitly considered in configuration decisions. Furthermore, many topics connect network configuration and coordination: for example the strategic role and the competencies of plants and the knowledge transfer among them and the level of central control.

Classification and discussion of frameworks about International Manufacturing Networks

After the review of the article set, we focussed our attention on several frameworks, that aim at helping managers in configuration and coordination decisions. We have analyzed 14 most interesting frameworks and we suggest a classification (shown in table 4), depending on the focus of analysis (plant or network), on the interest in intra-firm or inter-firm network, in configuration, coordination and capabilities aspects and on the presence of an explicit relationship with product characteristics and strategy.

Table 4 – Classification of frameworks about IMN

Framework	Focus		Strategy	Config.	Coord.	Capab.	Link with product
	Inter/intra firm	Plant /network					
DuBois et al. (1993)	Intra	Network		x			
Sweeney (1994)	Inter	Network	x	x			x
Ferdows (1997)	Intra	Plant		x			
Shi, et al. (1997)	Intra	Network	x	x		x	
Shi e Gregory (1998)	Intra	Network	x	x		x	
Ernst and Kim (2002)	Inter	Network			x	x	
Colotla et al.(2003)	Intra	Both		x	x	x	
Shi (2003)	Intra	Network	x	x		x	
Shi e Gregory (2005)	Inter	Network		x	x		
Vereecke et al. (2006)	Intra	Plant		x	x	x	
Karlsson e Skold (2007)	Inter	Network		x	x	x	
Rudberg e West (2008)	Intra	Network	x	x	x		x
Ferdows (2009)	Inter	Network	x	x			x
Miltenburg (2009)	Inter	Both	x	x	x	x	

Analyzing this framework classification, we identified many under-investigated areas that could be interesting both for academics and for managers, and that are the starting point for a research project that the authors are carrying out in major appliances industry.

First of all we notice that poor attention is generally paid to the relationship between IMN strategy and product characteristics and strategy, and most of the frameworks are focussed just on intra-firm network. Only Sweeney (1994) and Ferdows (2009) consider both an inter-firm perspective and product as a leading variable for network configuration. In our opinion these two research works could be revised and combined, as Sweeney's model needs to be updated while Ferdows's model considers just uniqueness of product and process as variables, and therefore could be enriched.

Furthermore, the differences and peculiarities in coordination and management skills between fully-owned and hybrid IMN strategies (according to the terminology used by Ferdows, 2009) are seldom addressed and need further research. As differentiated MNCs often manage separately more than one manufacturing network for different product typologies, it would be interesting to investigate the possible strategic interdependencies between different manufacturing networks referable to the same diversified company.

Another open question regards the performance assessment of the different IMN strategies. In literature there are only a few works (Colotla et al., 2003; Mauri, 2009) that deal with performance issues, and there is a lack of empirical knowledge about the differences in performance between different configuration and coordination choices.

Conclusions

In this paper we presented a review of relevant literature about International Manufacturing Networks and suggested some under-investigated areas that could be interesting both for academics and practitioners. Our aim was to put order in the wide and heterogeneous literature about this topic and to highlight some aspects that in our opinion need further attention.

There is still work that should be done for a wide comprehension of this many-sided research field. In our opinion it is essential to consider also scientific papers concerning topics close to IMN research, as manufacturing strategy, international operations strategy, international sourcing and international supply chain management research.

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