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Sustainable and Agile Manufacturing Outsourcing Partner Selection: a literature review

Mohammad Akhtar

Galgotias University, Greater Noida, U.P., 203201, India.

*mk71b@yahoo.com, mohammad.akhtar@galgotiasuniversity.edu.in

Abstract:

Outsourcing to third party to manage non-core activities helps the firm to focus on core activities. Manufacturing firms are outsourcing product development, manufacturing, logistics, customer care etc. to enhance production capacity and flexibility, and to reduce operational costs, which in turn can improve profitability and competitive advantage of the enterprise. Sustainability in operations and supply chain is gaining momentum due to increased global environmental concern, pressures from consumers and communities, and enforced regulations. Volatile and uncertain business environment necessitates the adoption of agility and flexibility to effectively manage manufacturing and supply chain. Globalisation has made the market very competitive and hence manufacturing firms are adopting manufacturing outsourcing to third parties. Selecting a sustainable and agile manufacturing outsourcing partner (MPS) is crucial as it will improve sustainability, efficiency, and effectiveness of the supply chain and competitive advantage to the firm. Detailed literature review on sustainable and agile manufacturing outsourcing partner selection has been carried out from EBSCO data base and Goggle scholar. Selection criteria used are classified into agile, operational, economic, environmental and social. The techniques use are mostly multi criteria decision making methods (MCDM) while few have adopted programming techniques. Discussion, implication and the scope of future work is also provided.

Key words:

Manufacturing outsourcing partner selection, Contract manufacturer selection, Outsourcing partner selection, Manufacturing outsourcing criteria, Multi criteria decision making.

1. Introduction

Supply chain starts with procurement of raw materials, storage, inventory control, to transportation, and distribution of finished goods to customers to meet their demand. Outsourcing establishes a contract with an outside party to manage its non-core work in order to efficiency improvement, cost reduction, increase profits and to focus on core activities. Outsourcing has become an important business approach to manufacture products more efficiently by a contract manufacturer to gain competitive advantages. Logistics, finance, accounting, legal services, marketing and customer care are already outsourced to external service providers. New technologies, globalization and increasing demand from end-users provide extra scope for outsourcing activities (Yang et al., 2007). Ineffective outsourcing may lead to loss of core capabilities and competencies, and may cause to business failure (Wang and Yang, 2007). To attain effective manufacturing outsourcing, manufacturing outsourcing partner selection (MPS) or contract manufacturer selection (CMS) is essential. MPS affects upstream, downstream and reverse supply

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chain operations, hence both qualitative and quantitative factors need to be examined carefully.

With the increased global environmental awareness and pressure, firms' decision-makers should consider environmental perspective in all commercial activities (Afred and Adam, 2009). Sustainable supply chain will improve environmental efficiency and social responsibility, meet stakeholder requirements and enhance firm competitiveness and profit (Gualandris et al., 2014). Environmental factors in product design, material purchasing, and supply network design have become important (Hervani et al., 2005; Sarkis, 2005). Manufacturing outsourcing partner selection (MPS) directly affects the sustainable initiatives implementation. For successful sustainable business practices, companies need to consider economic, environmental, and social sustainable criteria for outsourcing partners performances evaluation (Govindan et al., 2013). Companies should share their capabilities and resources with outsourcing partners in areas of green and technological innovations, environmental management systems, social responsibilities and sustainable initiatives (Luthra et al., 2017). Agile supply chain is needed to efficiently and effectively respond to volatile business environment (Christopher, 2000). To achieve necessary levels of SC agility, it is essential to align supply partners with firm operations to improve efficiency (Wu and Barnes, 2011). Therefore, a sustainable and agile (susgile) supply chain is desired to meet the sustainability obligation and business volatility.

Manufacturing outsourcing partner selection process (MPS) involves several criteria, number of outsourcing partners and multiple decision makers (DM) and it is said to be a multi-criteria group decision making (MCDM) problem. A structured approach should be adopted to select the right criteria, and technique to assess and select the manufacturing outsourcing partner (MP) or contract manufacturer (CM). In the literature, many selection criteria and techniques including MCDM have been applied by various researchers for MPS. Research questions has been framed that should be addressed in the literature review.

RQ1. What are the operational criteria used for manufacturing outsourcing partner selection?

RQ2. What are the economic, environmental and social sustainable criteria used for manufacturing outsourcing partner selection?

RQ3. What are the agile criteria used for manufacturing outsourcing partner selection?

RQ4. What are the techniques used for the assessment and ranking of manufacturing outsourcing partners?

The paper is organised in following sections. Section two presents the detailed review of the literature; section three provides the findings and discussion, and section four offers the conclusion and scope for future work.

2. Review of Literature

To undertake literature review, guidelines provided by Denyer and Tranfield (2009) have been adopted, which help researchers to formulate a research question and define the boundaries of a literature review. The literature review is carried out by searching the word 'manufacturing outsourcing partner selection', 'manufacturing outsourcing provider selection', 'contract manufacturer selection', 'manufacturing outsourcing', 'contract manufacturing', 'strategic outsourcing partner', 'strategic outsourcing provider' 'vendor selection', 'triple bottom line sustainability', 'agile criteria', 'sustainable criteria', 'economic criteria', 'environmental criteria', and 'social criteria' in EBSCO database and Google scholar.

Outsourcing is the process where an external company takes the responsibility of certain activities and processes through a contract with the company (Yang et al. 2007). Outsourcing reduces operating costs and improve competitiveness of a firm. Outsourcing manufacturing activities to MP or CM decreases operational cost, increases the flexibility of production capability and improves the profit. It is therefore, crucial for a company to select appropriate MP. Supply chain managers have incorporated sustainability in manufacturing outsourcing partnership which improved firm's competitiveness (Govindan et al. 2013; Luthra et al. 2017).

Suppliers and vendors selection affects supply chain operations and performances which is evident from the significant number of studies found in the literature (Malviya et al., 2018). Right supplier selection reduces purchasing costs, improves end-user's satisfaction, and competitiveness in the market (Onut et al., 2009), while wrong supplier selection can negatively impact the operational and

financial performance of the firm (Bhattacharya and Singh, 2019). Selection right supplier is an important part of sustainable supply chain (Sen et al., 2018) and key concern for business firms (Seuring, 2013; Grimm et al., 2014). It is challenging for many firms to adopt a dependable approach for supplier selection (Ortiz-Barrios et al., 2017; Sen et al., 2018) that can enhance cost savings, delivery, quality, flexibility, service level (Govindan et al., 2013), and innovation (Nair et al., 2015). Ebrahimipour et al. (2016) suggested product characteristics, finished products reliability and product life cycle to choose the right vendor and suppliers for manufacturing firms. Process of supplier selection is to select the right criteria and right technique (Büyüközkan and Göçer, 2019). Fan et al. (2020) studied battery outsourcing for electric vehicle manufacturers considering battery production cost, electric vehicle manufacturing and assembly cost, government subsidy. Helo et al. (2021) designed Cloud Ecosystem for cloud-based collaborative manufacturing portals for sheet metal manufacturing companies. Lahiri et al. (2022) carried out meta-analysis to examine the effect of industrial nature of activity (manufacturing *vs*. services), value chain activity (core *vs*. non-core), and provider's location (domestic *vs*. international) in sourcing on firm performance and found that effect is stronger for non-core and international outsourcing equally for manufacturing and service outsourcing.

2.1. Criteria for Manufacturing Outsourcing Partner Evaluation

It is crucial for decision-makers to identify effective evaluation criteria, as well as assess outsourcing partner's feasibility and compatibility prior to outsourcing. A number of evaluation criteria for MPS have been used in the literature. Mummalaneni et al. (1996) adopted price, quality, on-time delivery, responsiveness, expertise, and supplier relationship. Ho et al. (2010) suggested price, quality and delivery. Liou et al. (2012) considered cost (flexibility in billing, cost saving), quality (on-time rate, customers' satisfactions, knowledge skills), risk (management control loss, labor union, information security), and compatibility (information sharing, flexibility, relationship) criteria outsourcing provider selection in a Taiwanese airline. Garg and Sharma (2020) adopted economic factors (service delivery and access, firm performance and reputation, resources capacity, financial capacity, outsourcing benefits, technical ability, and communication), environmental factors (green certification and accreditation, emission and pollution minimization, green purchasing and designing, green manufacturing and marketing, waste minimization, green practices, green packaging, energy efficiency, cleaner technology, and reverse logistics), and social factors (working conditions, health and safety, employee rights and fair wages, women specific issues, employee and community equity, social welfare, community connection and support, ethical and transparent practices) for sustainable outsourcing partner selection in Indian electronics company. Chen and Hung (2010) used service criteria such as on-time delivery, process capacity, experience, response to changes, and reputation; financial criteria such as services cost, long-term viability, and finacial stability; quality criteria such as product quality, processes for quality control, and program for continuous improvement; compliance criteria such as goods manufacturing practices compliance, environmental health and safety, intellectual property infringement; and culture criteria such as lasting and mutually profitable relationships, interaction ability for MPS in pharmaceutical R&D.

For sustainable supplier and vendor selection, Ulutas et al. (2016) used cost, supplier production capacity, financial position, order requirement, sectoral price compliance, percentage defective, percentage late delivered, volume flexibility, technological capability reputation, and communication issues. Luthra et al. (2017) adopted product price, quality, delivery & service of product, transportation cost, product profit, lead time, production capacity, flexibility, green manufacturing, waste management, green product design, green purchasing, green packing and labeling, technological and financial capability, green management, green research and innovation, pollution prevention, environment management systems, environmental costs, environmental competencies, employees interests and rights, occupational health and safety, stakeholders rights, and information disclosure. Fallahpour et al. (2017) considered cost (material cost, after-sales service cost, freight cost), delivery & service (on-time delivery, lead time, after-sales service, flexibility, complaint resolution time), quality (internal quality audit process, abnormal quality handling capability, rejection rate), flexibility (delivery time flexibility, ordering flexibility, discount flexibility) criteria. Song et al. (2017) adopted ten criteria; cost, quality, delivery,

resource consumption, eco-design, recycling, environmental management system, occupational safety and health, rights and welfare of employees, and community training and development. Awasthi et al. (2018) adopted five sustainable criteria; economic, quality, environment, social, and global risk. Cheraghalipour and Farsad (2018) used three main criteria of economic (delivery, quality, loyalty, cost, service, financial situation, technology), environmental (product performance, environmental commitment, environmental pollution, greenhouse gas, environmental management), and social (working hours, worker safety and health, freedom of association and wages, social commitment, social management). Arabsheybani et al. (2018) used delivery, quality, green supply chain, suppliers of the supplier, environmental management system (EMS), worker safety and health, worker safety cost, worker dismissal, and employee interests & rights criteria. Sinha and Anand (2018) adopted criteria such as cost, delivery reliability, quality, technology capability, green product, financial situation, pollution control, environmental management system, green image, health & safety contractual, social responsibility management, local community and stakeholder influence. Vasiljević et al. (2018) considered price, delivery, quality, environmental and social criteria that help organizations in achieving long-term economic sustainability, ecological stability, and market position. Sen et al. (2018) proposed price, on-time delivery, quality, flexibility, service, production facility, financial capability, innovation, green design, green product, resource consumption, waste, recycling, EMS, work safety, stakeholders' rights, and information disclosure.

For agile contract manufacturer selection, Adali and Isik (2017) adopted product cost, on-time delivery, production capacity, equipment, material quality, geographic location and reliability criteria, Hu and Yu (2015) considered cost, delivery, quality, and flexibility. Supply chain agility studies have been conducted across industries; manufacturing (Blome et al., 2013; Um, 2017; Al-Shboul, 2017; Kim and Chai, 2017); auto components (Dubey et al., 2018); fashion and textiles (Ngai et al., 2011; Chan et al., 2017); electronics (Tse et al., 2016; Wu et al., 2017); telecommunications (Collin and Lorenzin, 2006), and oil and gas (Yusuf et al., 2014). In Moroccan manufacturing companies, Barhmi (2019) studied the supply chain agility and resilience effect on the supply chain performance.

2.2. Technique for Manufacturing Outsourcing Partner Selection

Manufacturing outsourcing partner selection involves multiple inter-related criteria, alternatives and decision makers and hence complex process. In the literature, various techniques including MCDM have been applied for MPS by various scholars. Vendor selection for outsourcing in Taiwanese semiconductor company, Lin et al. (2010) applied Analytic network process (ANP) method. Parthiban et al. (2012) adopted fuzzy SWOT and DEA for vendor selection. Liou et al. (2012) adopted integrated DEMATEL, fuzzy preference programming and ANP method to select outsourcing provider in a Taiwanese airline. For outsourcing provider selection, Hsu et al. (2013) applied DANP and GRA method. Festel et al. (2014) proposed an action research-based selection of strategic outsourcing partner in a global pharmaceutical manufacturing company. Hu and Yu (2015) proposed an integrated voting method and the goal programming (GP) model for electronic contract manufacturer selection. For vendor selection in the steel industry, Kar (2015) adopted Delphi and fuzzy AHP method. Rezaeisaray et al. (2016) utilized DEMATEL-fuzzy ANP-DEA to select outsourcing supplier in pipe manufacturing company. Adali and Isik (2017) applied CRITIC and Multi-attribute utility theory (MAUT) methods for CMS. Momeni and Vandchali (2017) proposed a Data envelopment analysis (DEA) model using evidential reasoning (ER) algorithm for strategic outsourcing in an Iranian software company. Ji et al. (2018) proposed neutrosophic linguistic sets based MABAC–ELECTRE method for outsourcing provider selection. Büyüközkan and Göçer (2019) proposed pythagorean fuzzy AHP and COPRAS for digital supply chain partner selection. Song (2019) adopted AHP for selection of outsourcing partner in Korean pharmaceutical R&D. Fei et al. (2019) presented Dempster–Shafer evidence theory (DS theory) and VIKOR for supplier selection. Ghorabaee et al. (2017) applied interval type-2 fuzzy CRITIC–WASPAS for selection of third party logistics provider. Rostamzadeh et al. (2018) proposed FCRITIC and FTOPSIS method, while Abdel-Basset and Mohamed (2020) applied a plithogenic CRITIC and TOPSIS model for managing sustainable supply chain risk. Awasthi and Kannan (2016) proposed nominal group technique and fuzzy VIKOR for green supplier development program. Chen et al. (2019) designed a model based on capability index and manufacturing time performance index for outsourcing partner selection. Percin (2019) adopted

FSWARA and fuzzy axiomatic design method for selecting outsourcing provider in Turkish chemical manufacturing company. Liaw et al. (2020) proposed DEMATEL-CRITIC method for criteria weight and classifiable TOPSIS to classify green manufacturing outsourcing providers in Taiwanese multinational machine tool manufacturing firm. For Malaysian manufacturing SMEs, Zulkiffli and Padlee (2021) used confirmatory factor analysis to study sustainable outsourcing impact on the competitive capabilities and business performance. Yazdani et al. (2021) assessed outsourcing risk using triangular fuzzy hesitant sets, Failure mode and effect analysis (FMEA) and Combined compromise solution (CoCoSo) in Iranian chemical company. Singh and Sarkar (2021) applied integrated AHP and VIKOR method for sustainable contract manufacturer selection in automotive industry. Akhtar et al. (2021) applied stochastic fuzzy TOPSIS to select sustainable vendor in the Indian petroleum refining sector. Haoues et al. (2021) presented genetic algorithm techniques under reliability maintenance constraint to minimize total cost for inhouse and outsourced manufacturing maintenance. Teerasoponpong and Sopadang (2022) applied genetic algorithm and artificial neural network (ANN) for sourcing and inventory management, which reduced raw materials purchasing cost, order interval and on-hand inventory cost in medium-sized food company.

For sustainable supplier and vendor evaluation, Dobos and Vörösmarty (2014) utilized DEA with the common weights analysis (CWA) method; Bai and Sarkis (2014) adopted rough set theory based DEA; Zarbakhshnia and Jaghdani (2018) adopted two-stage DEA; Mohammed et al. (2018) proposed hybrid AHP and TOPSIS; Sivakumar et al. (2015) used AHP and Taguchi loss functions; Trapp and Sarkis (2016) applied Integer programming technique; Luthra et al. (2017) applied integrated AHP and VIKOR; and Cheraghalipour and Farsad (2018) used BWM, MILP, and Revised multi-choice goal programming. Garg and Sharma (2020) adopted integrated BWM-VIKOR method for selection of sustainable outsourcing partner in an Indian electronics company.

For agile supplier and vendor selection, Hasan et al. (2008) adopted DEA and ANP methods; Luo et al. (2009) proposed a radial basis function based ANN; Alimardani et al. (2014) demonstrated hybrid DEMATEL, ANP and TOPSIS application; and Beikkhakhian et al. (2015) applied ISM for agile selection criteria and integrated TOPSIS-AHP method for vendor ranking. Lee et al. (2015) used FAHP and FTOPSIS for agile supplier selection and studied the impact of agility criterion and order allocation strategy on business performance. Matawale et al. (2016) presented fuzzy multi-level (FML) approach for selecting agile supplier and compared the result with FTOPSIS and FMOORA. Goker (2021) applied intuitionistic fuzzy cognitive map and COPRAS method for agile outsourcing provider selection in Turkish white goods industry.

Fuzzy variant of MCDM methods have also been reported by many researchers in the literature. Chen and Hung (2010) adopted FAHP and FTOPSIS method for selecting outsourcing manufacturing partner for pharmaceutical R&D. Akhavan et al. (2015) applied fuzzy quantitative strategic planning matrix-based SWOT for strategic alliance planning; F-ARAS, F-COPRAS, F-TOPSIS, and F-MOORA for strategic outsourcing partner evaluation in an Iranian car manufacturer company. For supplier selection with triple bottom line sustainability, Wang et al. (2019) proposed fuzzy AHP and TOPSIS in Vietnamese garment industry. Dos Santos et al. (2019) adopted Shanon Entropy and FTOPSIS in the furniture industry. For sustainable supplier selection, Zhou et al. (2016) utilized Type-2 multi-objective DEA; Fallahpour et al. (2017) proposed FAHP and FTOPSIS; Paydar et al. (2017) and Arabsheybani et al. (2018) utilized integrated F-MOORA and failure mode and effects analysis (FMEA); Awasthi et al. (2018) proposed FAHP and FVIKOR; and Mohammed et al. (2018) adopted FAHP, FTOPSIS and multi-objective programming model. Rabbani et al. (2019) presented interval-valued fuzzy group decision model-based reference point systems with fuzzy possibilistic statistical concepts.

3. Findings and Discussion

Based on the literature review, discussions on the findings are summarized under following headings.

3.1. Distribution of Articles Journal Wise

Though large number of articles are published on supplier selection but few articles related to manufacturing outsourcing partner selection are available in the literature. The manufacturing outsourcing partner selection with sustainability consideration are rarest. The manufacturing outsourcing partner selection articles published in

Table 1. Manufacturing Outsourcing Partner Selection Articles publication in Journals.

S. No.	Journal Name	Year	No. of Publication
1	International Journal of Production Research	2010	1
2	Expert System with Applications	2010	1
3	Expert System with Applications	2013	1
4	Journal of Business Chemistry	2014	1
5	Technological and Economic Development of Economy	2015	1
6	Resources Policy	2015	1
7	Omega	2016	1
8	Journal of Modelling in Management,	2016	1
9	European Journal of Multidisciplinary Studies	2017	1
10	Computers & Industrial Engineering	2018	1
11	Journal of Manufacturing Technology Management	2019	1
12	International Journal of Reliability, Quality and Safety Engineering	2019	1
13	Journal of Pharmaceutical Innovation	2019	1
14	International Transactions in Operational Research	2020	1
15	Symmetry	2020	1
16	Environment, Development and Sustainability	2020	1
17	International Journal of Industrial and System Engineering	2021	1
18	Soft Computing	2021	1

journals are listed Table 1. Most of the articles are published once in any journal.

3.2. Distribution of Articles Year wise

The number of articles published year wise from 2010 to 2021 are 18 as shown in Figure 1. The highest number of articles published are 3 in years 2019 and 2020.

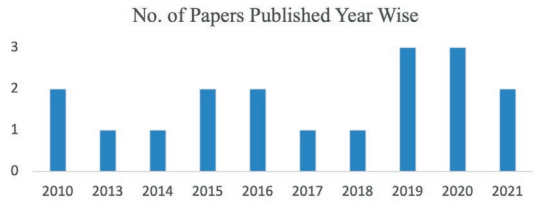

Figure 1. Manufacturing Outsourcing Partner Selection Articles Publication Year Wise

3.3. Selection Criteria

From the literature review, important criteria for manufacturing outsourcing partner selection are operational, agile, and economic, environmental and social sustainable criteria as displayed in Table 2. The operational criteria are process and production capacity, product quality, on-time delivery, response to customer needs, and Technological ability. The agile criteria are production capability & flexibility, service level, lead time minimisation, delivery flexibility, sourcing flexibility, multi-skilled & flexible workforce, collaboration with partners for innovation & capacity enhancement, and customer driven innovation. The economic criteria are product price, resource consumption, and financial stability. The environmental sustainability criteria are green product, green manufacturing process, green R&D, and environmental management system. The social sustainability criteria are worker's wages and welfare, worker's occupational health & safety, and social welfare & community development. Most of the papers cover operational, economic and agile criteria. Latest trend is to include environmental and social sustainability criteria in selection process.

3.4. Evaluation Methods

Techniques used for outsourcing partner selection in the literature are shown in Table 3 and 4. For criteria weight determination AHP, ANP, CRITIC, SWARA, BWM, MABAC, Cognitive map and fuzzy variant, and voting method have been used. For outsourcing partner evaluation and selection, MCDM methods such as AHP, TOPSIS, ANP, MAUT, ELECTRE, VIKOR, COPRAS, GRA, and fuzzy variant have been adopted. Other methods such as goal programming (Hu and

Table 2. Important Criteria for Sustainable and Agile Manufacturing Outsourcing Partner Evaluation from the literature.

Criteria type	Criteria	Benefit/ Non-Benefit	Description	References
Operational performance criteria	Process and production capacity	Benefit	Production and process capacity	Chen and Hung (2010), Ulutas et al. (2016), Luthra et al. (2017), Adali and Isik (2017)
	Product Quality	Benefit	Product quality and reliability	Liou et al. (2012), Chen and Hung (2010), Mummalaneni et al. (1996), Ho et al. (2010), Ulutas et al. (2016), Awasthi et al. (2018), Cheraghalipour and Farsad (2018), Gören (2018), Sinha and Anand (2018), Arabsheybani et al. (2018), Song et al. (2017), Luthra et al. (2017), Fallahpour et al. (2017), Hu and Yu (2015), Adali and Isik (2017).
	On-time delivery	Benefit	On time delivery to customers	Garg and Sharma (2020), Chen and Hung (2010), Mummalaneni et al. (1996), Ulutas et al. (2016), Luthra et al. (2017), Fallahpour et al. (2017 Fallahpour et al. (2017), Song et al. (2017), Cheraghalipour and Farsad (2018), Arabsheybani et al. (2018), Sinha and Anand (2018), Vasiljević et al. (2018), Adali and Isik (2017), Hu and Yu (2015)
	Response to customer needs	Benefit	Responsiveness and order fulfilment	Mummalaneni et al. (1996), Chen and Hung (2010).
	Technological ability	Benefit	Technology and technical ability	Garg and Sharma (2020), Ulutas et al. (2016), Luthra et al. (2017), Cheraghalipour and Farsad (2018), Sinha and Anand (2018)
Agile Performance criteria	Production flexibility and capability	Benefit	Production ability for variety of products to meet customer's demand.	Chen and Hung (2010), Ulutas et al. (2016), Awasthi et al. (2018), Gören (2018), Luthra et al. (2017), Fallahpour et al. (2017), Hu and Yu (2015), Adali and Isik (2017).
	Service level	Benefit	Providing service without stockout situation	Garg and Sharma (2018), Chen and Hung (2010), Bhutta and Huq (2002), Ulutas et al. (2016), Awasthi et al. (2018), Cheraghalipour and Farsad (2018), Fallahpour et al. (2017).
	Lead time	Benefit	Lead time and variability minimisation	Liou et al. (2012), Gören (2018), Luthra et al. (2017), Fallahpour et al. (2017).
	Delivery flexibility	Benefit	The ability to exploit various dimensions of delivery	Garg and Sharma (2018), Chen and Hung (2010), Mummalaneni et al. (1996), Ho et al. (2010), Ulutas et al. (2016), Awasthi et al. (2018), Cheraghalipour and Farsad (2018), Sinha and Anand (2018), Arabsheybani et al. (2018), Song et al. (2017), Luthra et al. (2017), Fallahpour et al. (2017), Hu and Yu (2015), Adali and Isik (2017).
	Sourcing flexibility	Benefit	The availability of range of sourcing options	Garg and Sharma (2018), Chen and Hung (2010), Luthra et al. (2017), Hu and Yu (2015).
	Multi-skilled and flexible workforce	Benefit	Multi-skilled workforce will provide flexibility in scheduling workers	Liou et al. (2012), Chen and Hung (2010), Mummalaneni et al. (1996), Ulutas et al. (2016).
	Collaboration with partners	Benefit	Collaboration with suppliers will enhance innovation and capability	Garg and Sharma (2018), Liou et al. (2012), Chen and Hung (2010), Mummalaneni et al. (1996), Ulutas et al. (2016), Gören (2018), Sinha and Anand (2018), Cheraghalipour and Farsad (2018), Arabsheybani et al. (2018), Luthra et al. (2017), Awasthi et al. (2018).
	Customer driven innovation	Benefit	Customer need based innovation	Liou et al. (2012), Mummalaneni et al. (1996), Sinha and Anand (2018).

(Table 2 continues in the next page)

(Table 2 continues from the previous page)

Criteria type	Criteria	Benefit/ Non-Benefit	Description	References
Economic performance criteria	Product Price	Non-benefit	Product price	Garg and Sharma (2018), Liou et al. (2012), Mummalaneni et al. (1996), Chen and Hung (2010), Ho et al. (2010), Ulutas et al. (2016), Gören (2018), Luthra et al. (2017), Fallahpour et al. (2017), Song et al. (2017), Arabsheybani et al. (2018), Hu and Yu (2015), Cheraghalipour and Farsad (2018), Adali and Isik (2017), Awasthi et al. (2018), Sinha and Anand (2018).
	Resource consumption	Non-benefit	Resource consumption in production process	Luthra et al. (2017), Song et al. (2017).
	Financial stability	Benefit	Financial position and stability	Garg and Sharma (2020), Chen and Hung (2010), Ulutas et al. (2016), Sinha and Anand (2018), Cheraghalipour and Farsad (2018).
Environmental Performance criteria	Green Product	Benefit	Product requiring less physical resources and low environmental impacts	Garg and Sharma (2018), Awasthi et al. (2018), Gören (2018), Sinha and Anand (2018), Song et al. (2017), Arabsheybani et al. (2018), Luthra et al. (2017), Cheraghalipour and Farsad (2018).
	Green Manufacturing Process	Benefit	Manufacturing process that minimise waste, pollution, and energy use.	Garg and Sharma (2018), Awasthi et al. (2018), Sinha and Anand (2018), Gören (2018), Luthra et al. (2017), Arabsheybani et al. (2018), Song et al. (2017), Cheraghalipour and Farsad (2018).
	Green R & D	Benefit	Environmental sustainability in research and development	Garg and Sharma (2018), Awasthi et al. (2018), Luthra et al. (2017). Sinha and Anand (2018), Cheraghalipour and Farsad (2018), Arabsheybani et al. (2018).
	Environmental Management System (EMS)	Benefit	Environmental planning, implementation, monitoring and controlling	Garg and Sharma (2018), Chen and Hung (2010), Gören (2018), Sinha and Anand (2018), Arabsheybani et al. (2018), Song et al. (2017), Luthra et al. (2017), Awasthi et al. (2018), Cheraghalipour and Farsad (2018).
Social Performance criteria	Worker's Wages and Welfare	Benefit	Workers' wages and welfare at supplier's firm	Garg and Sharma (2018), Liou et al. (2012), Arabsheybani et al. (2018), Luthra et al. (2017), Song et al. (2017), Cheraghalipour and Farsad (2018).
	Worker's Occupational health and safety	Benefit	Workers' occupational health and safety at suppliers' firm	Garg and Sharma (2018), Luthra et al. (2017). Cheraghalipour and Farsad (2018), Gören (2018), Sinha and Anand (2018), Arabsheybani et al. (2018), Song et al. (2017).
	Social welfare and community development	Benefit	Social welfare and community development	Garg and Sharma (2020), Luthra et al. (2017), Song et al. (2017), Cheraghalipour and Farsad (2018), Sinha and Anand (2018), Vasiljević et al. (2018)

Yu, 2016) and genetic algorithm (Haoues et al., 2021) have also been used in few cases. DEMATEL (Hsu et al., 2013; Rezaeisaray et al., 2016; Wu et al., 2017; Liaw et al., 2020) and ISM (Beikkhakhian et al., 2015) are used to show interrelationship among criteria. There is no clear trend on usage of any particular method. However, integrated fuzzy models have been used by majority researchers and among them fuzzy AHP and fuzzy TOPSIS are two most frequently used methods: Chen and Hund (2010), Liaw et al. (2020), Beikkhakhian et al. (2015), Lee et al. (2015), Singh and Sarkar (2021). There is no justification given for using a particular MCDM method in any of the papers.

Fuzzy theory and its variant (Intuitionistic fuzzy sets, Neutrosophic linguistic sets), and Grey theory have been applied to deal with imprecision and ambiguity in decision makers' judgments. Most of the papers have used integrated models. It has been observed that AHP or fuzzy AHP is highly used for evaluation while DEMATEL is used to find the inter-relationship among the criteria.

Table 3. Techniques for Sustainable and Agile Outsourcing Partner Selection in the literature.

Author (s)	Methodology and Techniques Adopted	Issues Addressed
Chen and Hung (2010)	Fuzzy AHP + fuzzy TOPSIS	Selection of outsourcing manufacturing partners
Lin et al. (2010)	ANP	Outsourcing Vendor selection in Taiwanese semiconductor company.
Hsu et al. (2013)	DEMATEL + ANP + GRA	Outsourcing provider selection
Festel et al. (2014)	Action research	Selection of strategic outsourcing partner in a global pharmaceutical manufacturing company
Akhavan et al. (2015)	Fuzzy quantitative strategic planning matrix (FQSPM) SWOT and F-ARAS, F-COPRAS, F-TOPSIS, F-MOORA.	Strategic outsourcing partners evaluation in car manufacturer company in Iran
Beikkhakhian et al. (2015)	ISM + fuzzy AHP + Fuzzy TOPSIS	ISM technique for agile supplier selection criteria evaluation and Fuzzy AHP and TOPSIS for suppliers ranking.
Lee et al. (2015)	Fuzzy AHP + fuzzy TOPSIS	Selection of agile supplier, assessing business impacts and comparison of business cost under skewed order and even order strategy.
Hu and Yu (2016)	Voting method +Goal programming (GP)	Electronic contract manufacturer selection
Matawale et al. (2016)	Fuzzy multi-level (FML) MCDM approach.	Supplier selection in agile supply chain
Rezaeisaray et al. (2016)	DEMATEL + DEA + fuzzy ANP	Outsourcing supplier selection in pipe and fittings manufacturing company
Adali and Isik (2017)	CRITIC + MAUT	Selection of Agile contract manufacturer
Wu et al. (2017)	Delphi method + ANP + DEMATEL	Supply chain agility under uncertainty to achieve competitive advantage
Ji et al. (2018)	Neutrosophic linguistic sets based MABAC + ELECTRE method	Outsourcing provider selection
Dubey et al. (2018)	Research based view (RBA)	Agility, adaptability, and alignment in supply chain create sustainable competitive advantage
Percin (2019)	Fuzzy SWARA + fuzzy axiomatic design method	Selection of Outsourcing provider in Turkish chemical manufacturing company
Chen et al. (2019)	Capability index and manufacturing time performance index-based model	Outsourcing partner selection
Liaw et al. (2020)	DEMATEL + CRITIC + classifiable TOPSIS	Evaluate and classify green manufacturing outsourcing providers in Taiwanese multinational machine tool manufacturing company
Garg and Sharma (2020)	BWM +VIKOR	Sustainable outsourcing partner selection in electronic firm
Haoues et al. (2021)	Genetic algorithm (GA) techniques	To minimize total cost for inhouse and outsourced manufacturing maintenance.
Goker (2021)	Intuitionistic fuzzy Cognitive Map + COPRAS method	Selection of agile outsourcing provider selection in Turkish white goods industry.
Singh and Sarkar (2021)	Integrated AHP + VIKOR	Sustainable Contract manufacturer selection in Automotive industry.

Based on literature review study, a proposed framework of manufacturing outsourcing partner selection based on five dimensions such as Operational, agile, economic, environmental and social sustainability is shown in Figure 2. The proposed model takes into consideration operational/ technical, agile as well as triple bottom line sustainability aspects.

Table 4. Techniques Used for Outsourcing Partners Selection in the Literature.

Methods/Techniques	Goker (2021)	Akhtar et al. (2021)	Yazdani et al. (2021)	Garg and Sharma (2020)	Liaw et al. (2020)	Percin (2019)	Chen et al. (2019)	Büyüközkan and Göçer (2019)	Song (2019)	Ji et al. (2018)	Adali and Isik (2017)	Momeni and Vandchali (2017)	Rezaeisaray et al. (2016)	Akhavan et al. (2015)	Hu and Yu (2015)	Sivakumar et al. (2015)	Festel et al. (2014)	Hsu et al. (2013)	Liou et al. (2012)	Chen and Hung (2010)	Lin et al. (2010)
AHP								x	x							x				x	
TOPSIS		x			x									x						x	x
ANP													x					x	x		
COPRAS	x							x						x							
VIKOR				x																	
GRA																		x			
ARAS														x							
MOORA														x							
DEA												x	x								
ELECTRE										x											
CoCoSo			x																		
BWM				x																	
CRITIC					x																
SWARA						x															
MABAC										x											
Cognitive map	x																				
DEMATEL					x								x					x	x		
FMEA			x																		
Taguchi Loss function																x					
Goal Programming						x									x						
Fuzzy													x	x					x	x	x
Neutrosophic linguistic sets										x											
Pythagorean fuzzy sets								x													
Fuzzy preference programming																			x		
Fuzzy axiomatic design						x															
Triangular fuzzy hesitant sets			x																		
Stochastic Fuzzy		x																			
Intuitionistic fuzzy	x																				
Action Research																	x				
Voting method															x						
Evidential reasoning												x									
Capability index and manufacturing time performance index							x														
CFA																					
ANN & GA																					

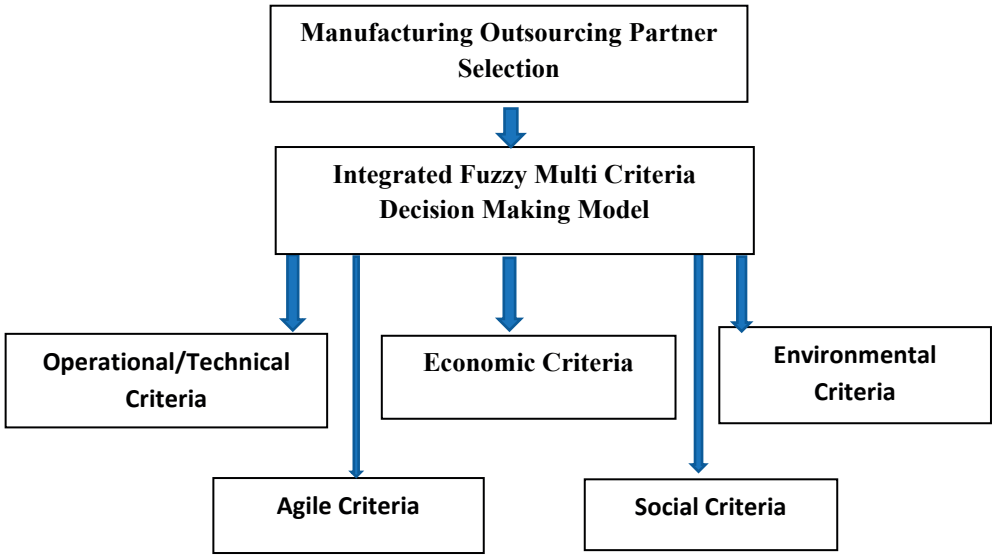

Figure 2. Proposed Framework of Manufacturing Outsourcing Partner Selection.

4. Conclusion and Scope for Future Work

The selection of a suitable manufacturing outsourcing partner is strategic decision that is complex and uncertain due to involvement of multiple qualitative and quantitative criteria, alternatives and decision makers. It also involves imprecision and ambiguity in ratings by a group of decision makers. In this paper, an attempt has been made to review the literature on manufacturing outsourcing decisions from 2010-2021. Various criteria have been used but there is increasing trend to use agile as well as environmental sustainability criteria. Majority have used integrated fuzzy MCDM method, which shows that importance of integrated model with fuzzy logic. However, there is no trend on usage of any particular MCDM method.

The proposed framework integrates the crucial dimensions of agility and triple bottom line sustainability in manufacturing outsourcing partner evaluation that would contribute to firm's agility, economics, sustainability and competitiveness. The model also covers the impreciseness in decision makers rating by using fuzzy logic. The criteria listed in Table 2 may be used in the proposed framework for future studies for MPS. Few criteria may be added or substituted depending upon industry and firms requirements. Future research may use fuzzy CRITIC or fuzzy SWARA for criteria weight and fuzzy TOPSIS or fuzzy VIKOR method for alternative selection. To understand the causal relationship among criteria, fuzzy DEMATEL or fuzzy DANP method are good suggestion. Future study should apply a suitable technique, compare the result with other techniques and also carry out sensitivity analysis to improve the accuracy and robustness of the framework. This study will contribute to better understanding of manufacturing outsourcing problem and scope for future studies. The study is also helpful to managers to understand different dimensions of assessment that will improve firm's agility, sustainability and competitiveness. This study may not be exhaustive. The future studies may cover more databases and latest papers to get a broader picture of manufacturing outsourcing provider evaluation and selection.

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