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The impact of flexible warehouse lease contracts on the configuration of a two-echelon distribution network

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Verantwortlich für den Inhalt der Beiträge sind die jeweils genannten Autoren.

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SUPPLEMENTARY MATERIAL

This document contains the supplementary material to the following book chapter:

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The summary and keywords of the chapter are included next.

Abstract

Facility location decisions play a critical role in the design of supply chain networks. This chapter outlines key features of facility location problems and their integration with various logistic operations in the context of network (re)design. Modeling approaches and solution methods are also discussed for these challenging combinatorial optimization problems. In addition, we examine five emerging trends that will continue to drive research in this area, namely, sustainable development, the transition to a circular economy, data source-related issues, disruptive events and resilience, and omnichannel distribution in the retail sector. We review and classify recent contributions, identify research gaps, and provide directions for future research.

Keywords

Facility location, Sustainable network design, Circular economy, Data scarcity, Resilience, Omnichannel.

□ **Tables with all numbered references**

Table 1 Comprehensive classification of FLPs

| Key feature | Aspect | Recent study |
|----------------------------------|---|--------------|
| Number of objectives | ☒ single objective (total cost/profit) | [49] |
| | ☒ multi-objective (e.g., total cost + responsiveness) | [65] |
| Type of objective function | ☒ covering (set covering) | [37] |
| | ☒ median (p-median) | |
| | ☒ center (p-center) | |
| | ☒ hierarchical (successively inclusive) | |
| | ☒ flow capturing | |
| | ☒ hub location | |
| | ☒ dispersion (p-dispersion) | |
| | ☒ anti-median & anti-center | |
| Number of facilities | ☒ single facility (no demand allocation) | [159] |
| | ☒ multiple facilities | [136] |
| Decision space | ☒ continuous (points of a continuous space) | [99] |
| | ☒ discrete (finite list of potential sites) | [184] |
| | ☒ graph (located on vertices/arcs) | [45] |
| Number of commodities | ☒ single commodity | [178] |
| | ☒ multi-commodity | [38] |
| Planning horizon | ☒ single period | [44] |
| | ☒ multi-period | [48] |
| Input parameters | ☒ deterministic | [78] |
| | ☒ probabilistic | [208] |
| | ☒ possibilistic | [76] |
| Capacity configuration | ☒ static (unlimited and limited capacity) | [127] |
| | ☒ dynamic setting (expansion and contraction) | [47] |
| Supply chain structure | ☒ single echelon | [46] |
| | ☒ multi-echelon | [52] |
| Facility typology | ☒ single type (e.g., warehouses) | [159] |
| | ☒ multi-type (e.g., warehouses, stores) | [16] |
| Competition & cooperation | ☒ with interaction (multiple players) | [54] |
| | ☒ without interaction (single player) | [127] |
| Integration with other decisions | ☒ location-routing models | [204] |
| | ☒ location-inventory models | [155] |
| | ☒ location-inventory-routing models | [189] |

Table 2 Performance indicators of SCND models addressing all dimensions of sustainability

| Performance indicator | Studied aspect | Reviewed article |
|-----------------------|--------------------|--|
| Economic | cost | [6], [10], [11], [26], [33], [59], [72], [76], [77], [81], [90], [94], [95], [115], [136], [137], [164], [165], [166], [176], [181], [201], [210], [227], [229], [230], [232] |
| | profit | [73], [79], [145], [147], [148], [169], [183], [191], [192], [234] |
| Environmental | facility location | [6], [10], [11], [59], [76], [77], [81], [90], [94], [95], [147], [148], [165], [169], [181] |
| | procurement | [6], [11], [79], [94], [95], [183], [227], [229] |
| | production | [6], [11], [26], [59], [72] ⁺ , [76], [77], [79], [81], [90], [94], [95], [137], [145], [147], [148], [165], [166], [169], [176], [181], [183], [191] ⁺ , [201], [227], [229] |
| | material handling | [11], [59] [73] ⁺ , [81], [90], [94], [95], [145], [165], [166], [169], [181], [183], [201], [227], [229] |
| | transportation | [6], [10], [11], [26], [33], [59], [72] ⁺ , [76], [77], [79], [81], [90] ⁺ , [94], [95], [136], [137], [145], [147], [148], [165], [166], [169], [176], [181], [183], [191] ⁺ , [192] ⁺ , [201], [210], [227], [229], [230], [232] |
| | recycling/disposal | [11], [59], [79], [227], [229] |
| | energy consumption | [76], [77], [137] |
| | waste generation | [11], [76], [77], [95], [136], [164], [234] |
| | water consumption | [6], [76], [77], [137], [176], [191] ⁺ , [201] |
| | other indicators | [115], [164], [176] |
| | Social | job creation |
| accidents/damages | | [59], [90], [95], [145], [164], [169], [181], [192] |
| regional development | | [10], [11], [33], [81], [165], [230] |
| equity | | [10], [90], [136] |
| other indicators | | [10], [11], [72], [73] ⁺ , [76], [77], [94], [95], [115], [176], [191], [201], [210], [234] |

⁺indicator embedded in one or several constraints; ⁺⁺consideration of fixed and variable number of job opportunities

Table 3 Classification of articles that use optimization methods to deal with supply chain disruptions

| Article | Source of risk | Disruption | Application context |
|---------|----------------|---------------|-----------------------------------|
| [74] | DD, SD, ED | DD1, SD1, ED1 | glass sector |
| [174] | DD | DD4 | automotive industry |
| [21] | SD | SD1, SD3 | agri-business |
| [135] | DD, SD | DD2, SD1 | |
| [60] | ED | ED1 | humanitarian logistics |
| [122] | SD | SD1 | HP case study |
| [86] | SD | SD1 | filter manufacturer |
| [223] | ED | ED1 | dairy industry |
| [83] | DD, SD | DD4, SD1 | automotive industry |
| [186] | ED | ED3 | COVID-19 vaccine supply |
| [161] | PD | PD1 | pharmaceutical sector |
| [100] | ED | ED1 | medical device manufacturer |
| [137] | DD | DD2, DD3 | tire industry |
| [113] | ED | ED1 | glass sector |
| [224] | ED | ED1 | dairy industry |
| [195] | SD | SD1 | printers-cartridge manufacturing |
| [97] | PD, ED | PD2, ED1 | humanitarian logistics |
| [120] | ED | ED1 | humanitarian logistics |
| [123] | ED | ED3 | |
| [171] | SD | SD1 | electronic manufacturing industry |
| [98] | ED | ED1 | humanitarian logistics |
| [111] | SD | SD1 | plastic sector |
| [179] | DR, SD, ED | DD2, SD1, ED1 | pharmaceutical sector |
| [5] | ED | ED3 | |
| [182] | DD, SD, ED | DD2, SD1, ED1 | humanitarian logistics |
| [75] | ED | ED1 | |
| [185] | ED | ED3 | COVID-19 vaccine supply |
| [153] | SD | SD1 | |
| [84] | ED | ED3 | food sector |
| [207] | SD | SD1 | pharmaceutical sector |

PROCESS (PD): product quality problems (PD1), equipment failure (PD2), IT-driven problems (PD3), labor strike (PD4). **CONTROL** (CD): safety stock policy (CD1), ordering quantity policy (CD2), asset management policy (CD3), transportation management problems (CD4). **DEMAND** (DD): volatile demand (DD1), unanticipated demand (DD2), market changes (DD3), competition changes (DD4), forecasting errors (DD5), unusual customer payment delays (DD6). **SUPPLY** (SD): shortage in supply market (SD1), sudden supplier demise (SD2), variability of lead time (SD3), supplier quality problems (SD4). **ENVIRONMENTAL** (ED): natural disaster (ED1), terrorism and war (ED2), diseases and epidemics (ED3), political instability (ED4), technology changes (ED5)

Table 4 Selected features of articles addressing omnichannel network design

| Studied component | Specific aspect | [14] | [39] | [92] | [104] | [126] | [130] | [132] | [142] | [143] | [219] | [220] | [221] |
|--------------------|---------------------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Main decision | Warehouse location | | ✓ | ✓ | | | ✓ | | ✓ | ✓ | | | ✓ |
| | Inventory in store | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | |
| | Demand allocation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Customer behavior | | ✓ | ✓ | | ✓ | | | | | ✓ | | |
| Objective function | Economic | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Environmental | | | | | | | | | | | | ✓ |
| | Social | | | | | | | | | | | | |
| Modeling approach | MILP | | | | | | | | ✓ | ✓ | | | ✓ |
| | TS-MILP | ✓ | ✓ | | | | | | | | | | |
| | LP | | | ✓ | | | | | | | | ✓ | |
| | NLP | | | | ✓ | ✓ | ✓ | ✓ | | | ✓ | | |
| Solution approach | Commercial software | | | ✓ | | | | ✓ | ✓ | ✓ | | | ✓ |
| | Exact method | ✓ | ✓ | | ✓ | | ✓ | | | | ✓ | ✓ | |
| | Heuristic | | | ✓ | | ✓ | | | | | | | |
| Flow type | Single product | | ✓ | | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Multi-product | ✓ | | ✓ | ✓ | ✓ | | | | | | | |

□ **Figures with all numbered references**

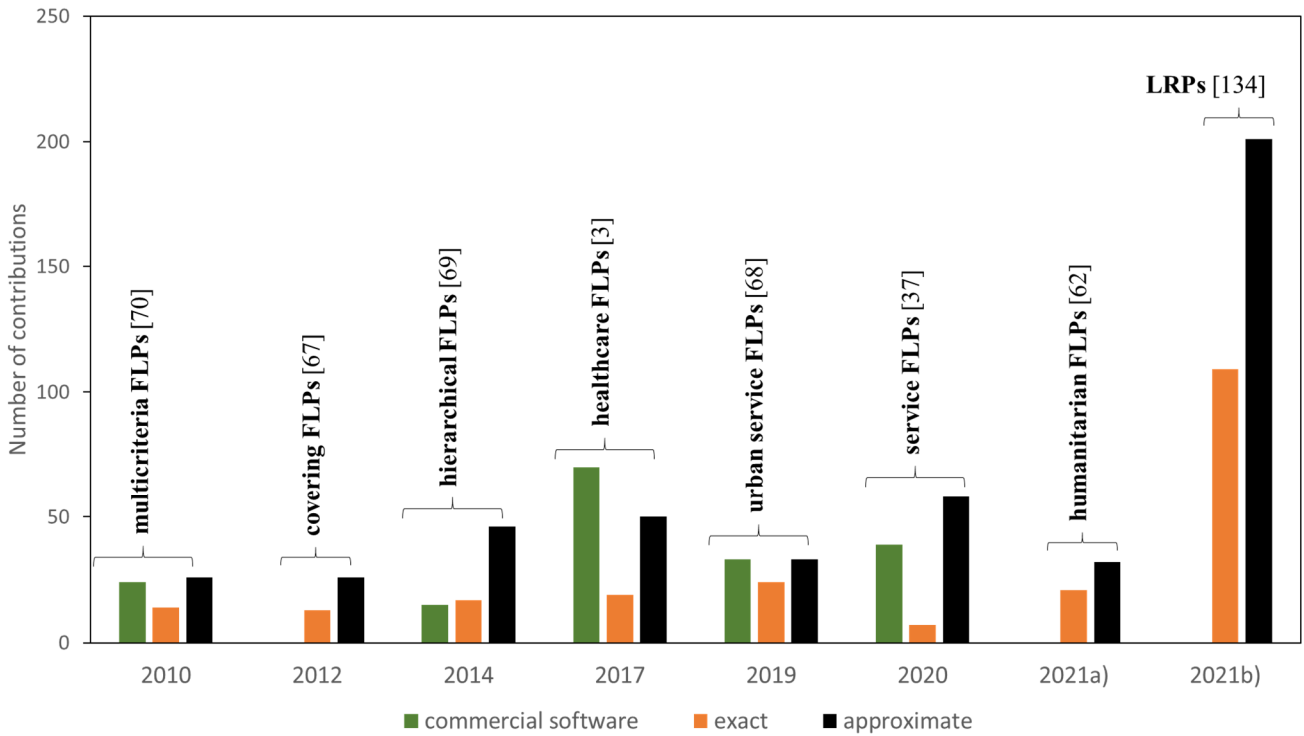


Fig. 2 Key review articles that provide comprehensive analyses of solution methods for FLPs

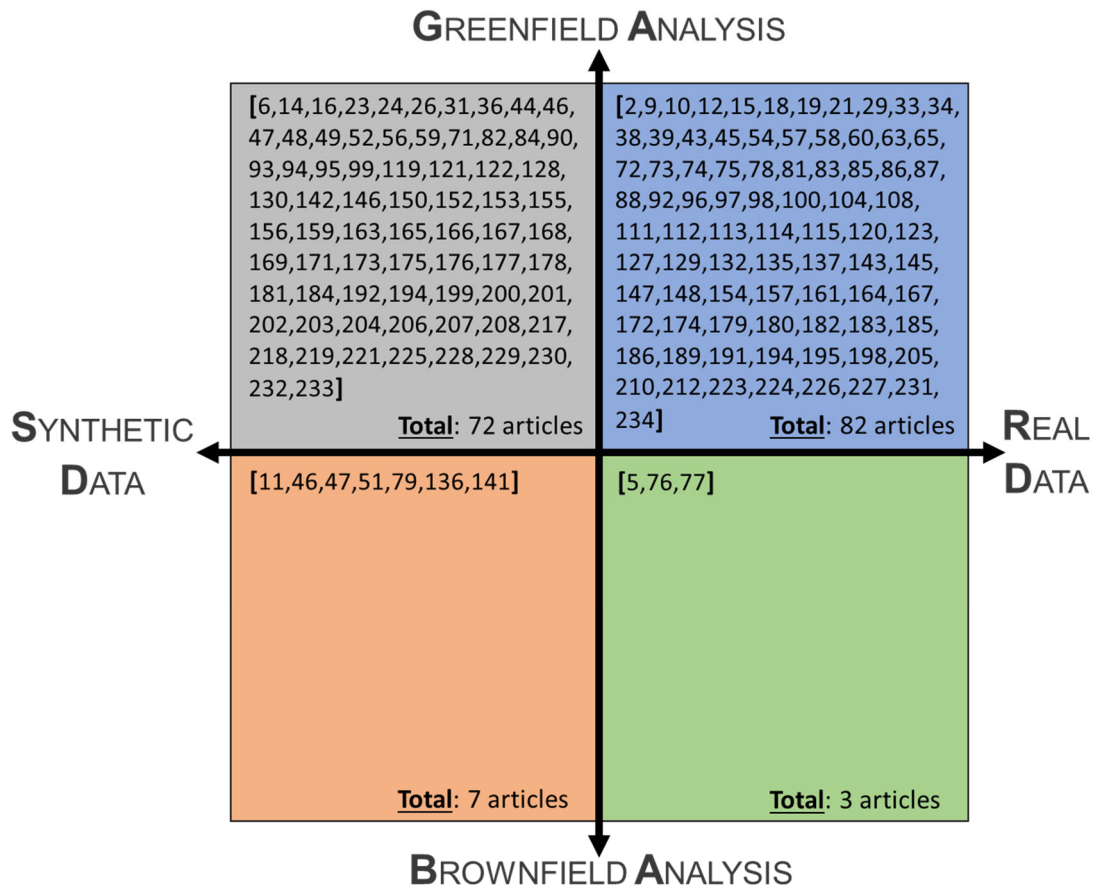


Fig. 3 General approaches and data sources used in the reviewed articles

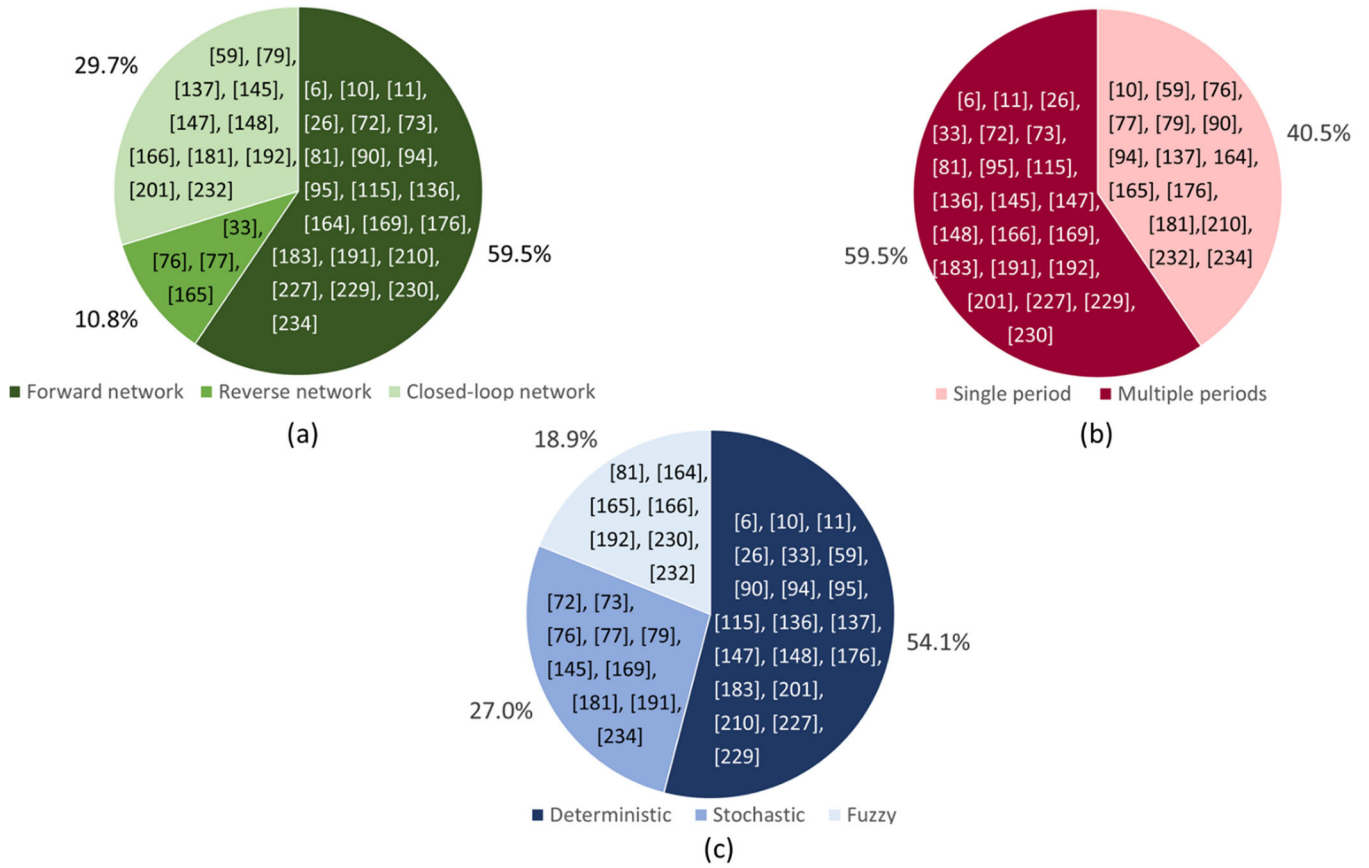


Fig. 4 Selected features of sustainable SCND models. (a) Type of supply chain network. (b) Planning horizon. (c) Type of modeling approach

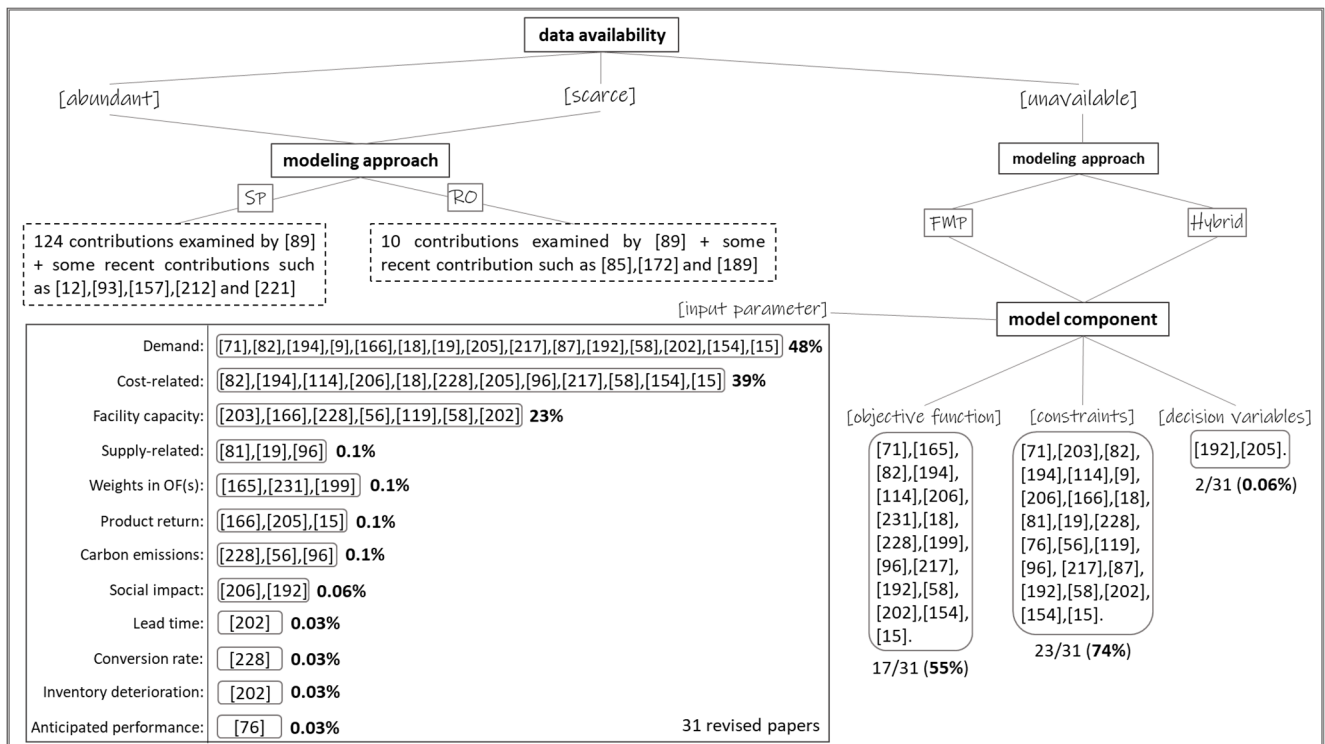
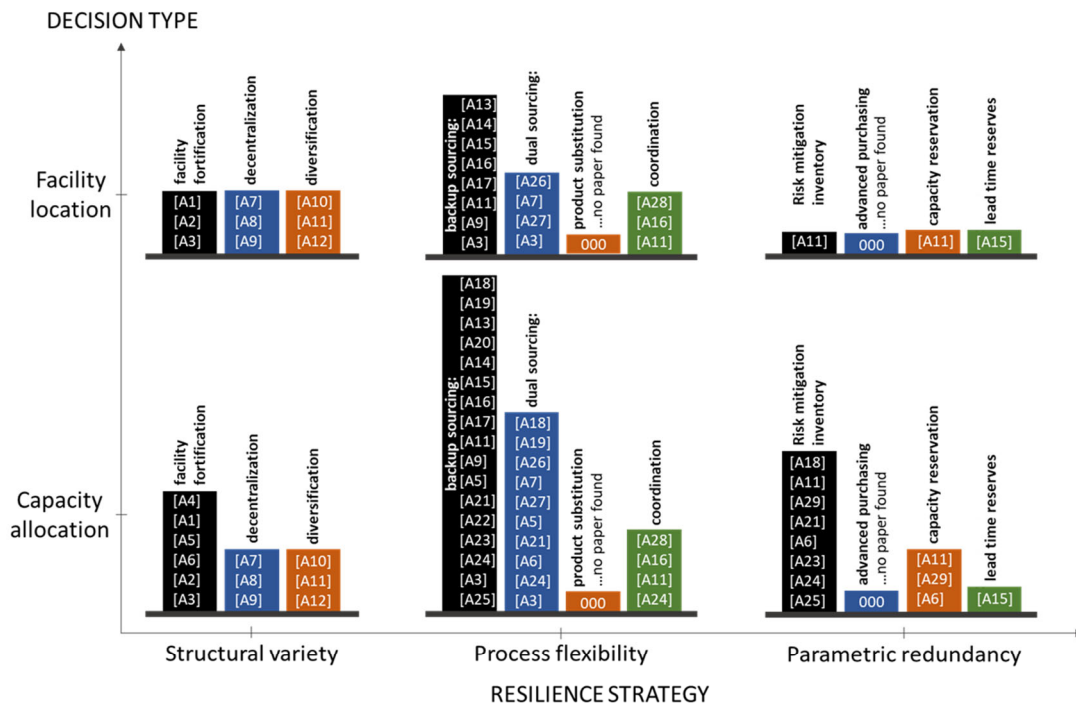


Fig. 5 Decision tree summarizing the DM environments and their respective modeling approaches



Revised articles:

Diabat et al. (2019) [A1]; Samani & Hosseini-Motlagh [A2]; Gholami-Zanjani et al. (2021) [A3]; Fattahi et al. (2017) [A4]; Jabbarzadeh et al. (2018a) [A5]; Alikhani et al. (2021) [A6]; Hasani et al. (2021) [A7]; Haeri et al. (2020) [A8]; Rajesh (2020) [A9]; Ghavamifar et al. (2018) [A10]; Yavari & Zaker (2020) [A11]; Kungwalsong et al. (2022) [A12]; Margolis et al. (2018) [A13]; Ghomi-Avili et al. (2018) [A14]; Sazvar et al. (2021) [A15]; Mehrjerdi & Shafiee (2021) [A16]; Jabbarzadeh et al. (2018b) [A17]; Rezapour et al. (2017) [A18]; Behzadi et al. (2017) [A19]; Kristianto et al. (2014) [A20]; Sabouhi et al. (2018) [A21]; Fattahi et al. (2020) [A22]; Sawik (2022) [A23]; Namdar et al. (2018) [A24]; Tucker et al. (2020) [A25]; Yavari & Zaker (2019) [A26]; Haghjoo et al. (2020) [A27]; Pariazar & Sir (2018) [A28]; Taleizadeh et al. (2022) [A29]

Fig. 6 Review of resilience strategies applied in disruptive supply chains

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