Proceedings of the Design Society, Volume 6: DESIGN 2026
https://doi.org/10.1017/pds.2026.10381

Identifying the right BOM setup in engineer-to-order companies: a focus identification model

Georgios Konstantinos Kourtis✉, Jonas Drewsen Andersen, Jacob Hedegaard Mortensen, Lars Hvam and Niels Henrik Mortensen

Technical University of Denmark, Denmark

✉ gkoko@dtu.dk

ABSTRACT: Engineer-to-Order (ETO) companies often grow around ad-hoc know-how, and when they scale, usually they must standardize and choose a BOM setup, yet literature offers options but little guidance on how to decide. We propose a Focus Identification Model, a lightweight, tool-agnostic method that profiles context drivers, asks weighted decision questions, and links answers to a go-to setup with explicit governance. Calibrated on two industry cases, it yields a driver heatmap, decision matrix, and governance card to establish a common language and identify fit-for-purpose BOMs with less friction.

KEYWORDS: design management, bill of materials (BOM), product lifecycle management (PLM), engineer-to-order, context-driven selection

1. Introduction

Engineer-To-Order (ETO) companies often evolve around accumulated know-how and local practices. As they scale, the need to standardise product definition intensifies; engineering, manufacturing, procurement, and service all depend on an accurate Bill Of Materials (BOM) to say what the product is (Wang et al., 2023). The literature mentions many BOM setups, like multiple BOMs across the lifecycle [e.g. Engineering BOM (EBOM), Manufacturing BOM (MBOM), Service BOM, Assembly BOM], single integrated BOMs exposed via role-based views, dynamic order-specific BOMs, and hybrids (He et al., 2014; Jung et al., 2014; Lee et al., 2012; Stolt, 2023), these can be organized into two practical classes for selection: (i) a single-source/enterprise BOM with enforceable views, and (ii) a traditional separated EBOM–MBOM setup with explicit transformation and synchronization.

ETO characteristics make the BOM setup choice highly consequential: high interface variety, late design freeze, frequent engineering changes, stringent compliance and traceability requirements (Stekolschik, 2017; Zhao et al., 2024). Poor fit of BOM setup manifests; as unclear items, wrong quantities/levels, shop-floor rework, traceability gaps, and heavy Product Lifecycle Management (PLM) - Enterprise Resource Planning (ERP) reconciliation effort (Hu et al., 2023). While the literature describes BOM types, their intended use, new innovative BOM structures and ways to visualize them (Zhu et al., 2007), it offers limited guidance on how to decide which setup fits a given ETO context. Companies often inherit historical patterns in the way of working and then compensate with manual coordination (Wang & Yuan, 2010). Decision frameworks exist for selecting the right product platforms/configurators setup (Zhao & Hvam, 2024), but they do not operationalize BOM setup selection across portfolio contexts and governance constraints (Chatras et al., 2016).

This paper addresses this gap by proposing a Focus Identification Model (FIM), a lightweight, tool-agnostic method that turns an open-ended debate into a structured selection process. The model consists of four steps (i) Clarify the relevant option set for the portfolio, (ii) Profile context drivers like variant breadth, non-standard share, multi-site, localization intensity, supplier multiplicity and alternates, traceability, compliance depth, BOM transition error surface, lifecycle volatility (rate of change), data

https://doi.org/10.1017/pds.2026.10381 Published online by Cambridge University Press

governance, and IT capability, (iii) Apply a weighted decision-question bank that makes trade-offs explicit and (iv) Converge on a go-to setup paired with operating rules.
The use of the FIM creates a set of artefacts, a driver heatmap, a decision matrix, and a governance card. This paper has three contributions. First, by providing a common language and a repeatable identification process for selecting a BOM setup in ETO context, explicitly linking context drivers to a recommendation and governance. Secondly, by calibrating the model with two contrasting industrial contexts (a capital goods manufacturer with site adaptations and a custom laser manufacturer with configurable modules), showing how different driver profiles lead to different go-to setups without changing enterprise systems priorities. Thirdly, by treating the BOM setup as a governance choice, helping mixed portfolios adopt the right setup with less friction.
The paper is structured as follows. Section 2 presents the literature study and identifies the gap. Section 3 outlines the method and the two industrial contexts used to calibrate the model. Section 4 details the FIM and its artefacts. Section 5 applies the model to the business cases. Section 6 discusses and concludes the paper.

2. Literature review

2.1. BOM fundamentals and ETO context

The BOM is the central product definition artefact linking engineering, manufacturing, procurement, and service domains (Wang et al., 2023). ETO environments are characterized by late design freeze, high product variety, and project-centric delivery, BOMs evolve dynamically over the lifecycle (Lee et al., 2012; Zhao et al., 2024). Unlike in Configure-To-Order (CTO) industries, where BOMs are often stable and modular, BOMs in ETO environments must accommodate frequent engineering changes, compliance-driven requirements, and site-specific adaptations (McKendry et al., 2022).
ETO's late customer order decoupling point (Hvam et al., 2008; Rudberg & Wikner, 2004) means that engineering and manufacturing structures cannot be fully frozen before order intake. This creates governance challenges such as ownership, efficiency, and handover (Gann & Salter, 2000) that directly influence which BOM setup is most appropriate.

2.2. BOM variants and structural models

The literature describes a wide range of BOM structures addressing different lifecycle and integration needs. This papers is focusing on the following BOM types, including separated EBOM-MBOM approaches used in PLM-ERP integrations (He et al., 2014; Hu et al., 2023), integrated or enterprise BOMs that rely on role-based views (Lee et al., 2012; Stolt, 2023), configurable (Hegge & Wortmann, 1991; Jianxin et al., 2000) and composite BOMs (Zhou et al., 2018) for managing high product variety, lifecycle-wide master BOMs (Stolt, 2023), and more recent graph-based models proposed to improve flexibility and cross-domain integration (Hu et al., 2023). Innovations such as dynamic BOMs (Zhu et al., 2007) and attribute-driven BOM generation (Matías et al., 2008) further expand the design space. All these structures can be grouped into two practical classes for selection and governance:

- Class A - Single-source BOM with views. One enterprise BOM is the single source of product data; different stakeholders (engineering, manufacturing, service) access role-based views without physically splitting structures. The promise is "one truth with filtered perspectives."
- Class B - Multiple separated BOMs, such as EBOM-MBOM. Engineering maintains an EBOM expressing design intent, manufacturing maintains an MBOM expressing how the product is built (sequence, plant/local content, consumables, alternates), and synchronisation rules keep them aligned. Separation adds governance clarity where processes diverge.

However, most studies focus on defining and managing a single chosen structure rather than on how to select between these two classes.

2.3. Governance, synchronization, and change management

Across BOM setups, factors like governance, ownership, effectiveness policy, and synchronisation, are as critical as BOM structure. Poor alignment between EBOM and MBOM can lead to not clear items, rework, and heavy reconciliation effort (Hu et al., 2023; Huang et al., 2003).

https://doi.org/10.1017/pds.2026.10381 Published online by Cambridge University Press

Prior research addresses governance challenges through EBOM–MBOM transformation methods (Hanchuan et al., 2008; He et al., 2014; Wang et al., 2023), lifecycle-wide integration across multiple BOM types (Wang & Yuan, 2010), change propagation mechanisms (He et al., 2014; Wang & Yuan, 2010), and PLM–ERP synchronization approaches aimed at reducing BOM errors and reconciliation effort (Lee et al., 2011; Ming et al., 2008). ETO-specific governance issues are amplified by long lead times, compliance traceability, and frequent design changes (Koskinen et al., 2020; Srinivasan, 2011).

2.4. ETO-specific BOM challenges

ETO/CTO companies face some general pain points. Some of those are presented below:

- Evolutionary nature of BOMs: Structures and content change across design phases, requiring versioning and effectivity management (Lee et al., 2012).
- Multiple stakeholders: Engineering, manufacturing, supply chain, and service have differing needs and BOM views (Hicks & McGovern, 2009; Wang & Yuan, 2010).
- Data ownership and handover: Misaligned responsibilities cause delays and inconsistencies (Hu et al., 2023).
- Mixed Customization Setup: Companies might have a combined ETO, CTO product setup, which complicates the product standardisation (Zhao & Hvam, 2024).

Some decision-support frameworks exist for product platform/configurator scope (Zhao & Hvam, 2024), but they do not address the choice of product structure/BOM setup and its impact on governance and IT constraints.

2.5. Gaps in BOM setup selection guidance

The reviewed literature documents a wide range of BOM structural innovations, EBOM–MBOM transformation and integration mechanisms, and ETO-specific adaptations, but largely assumes that the BOM setup itself is given rather than a decision variable. However, what is missing is a context-driven selection process: a way to match organisational drivers, such as product complexity, compliance, customer order decoupling point, supplier integration, and IT capability, to a fit-for-purpose BOM setup and or optimised within a single paradigm, leaving ETO companies to rely on historical patterns and ad-hoc debate (Stark, 2020; Sudarsan et al., 2005).

3. Method

3.1. Research approach and industrial context

This study follows a constructive, design-oriented research approach. The goal is to build a practical decision-support tool, the FIM, that helps ETO companies choose between two BOM setup classes (single-source with views vs. separated EBOM-MBOM with explicit transformation and synchronisation).

Rather than testing a pre-defined hypothesis, (i) the decision problem and requirements were framed, (ii) the model was constructed (drivers, question bank, scoring logic and artefacts), and (iii) the evaluation happened from the material of two industrial contexts. The tool is a method, not a software tool, so the evaluation focuses on decision usefulness, transparency, and governance fit, rather than algorithmic performance. The FIM is applied to a defined decision scope, rather than as a universal corporate mandate. The scope may be defined at (i) enterprise or portfolio level, (ii) per plant or value stream, or (iii) per product family or module. The resulting recommendation should be interpreted as valid for the defined scope only. If manufacturing plants differ structurally (e.g., different kits, routings, or branch logic), the model must be applied at plant level, or the level of plant heterogeneity must be reflected explicitly in the driver assessment. To ensure relevance under differing conditions, by using two contrasting company contexts as calibration touchpoints and data sources but not test beds:

- A capital-goods manufacturer combining standardised platforms with site-dependent adaptations.
- A custom laser manufacturer, delivering configurable modules with compliance-critical items (e.g., labels/firmware).

These contexts were used to assess the importance of drivers, refine questions, and determine whether the resulting recommendations and governance rules are credible given the documented constraints.

https://doi.org/10.1017/pds.2026.10381 Published online by Cambridge University Press

3.2. Data collection and analysis procedure

The data were collected and synthesised from the three following sources:

1. Literature synthesis on BOM structures, governance/effectivity, and PLM-ERP synchronization to derive a candidate option set, driver list, and initial decision-question bank.
2. Document review from both companies (item/BOM policies, release workflows, PLM-ERP interface notes, compliance procedures, exemplar BOMs).
3. Targeted stakeholder conversations (clarifications with engineering, manufacturing, procurement, PLM) to validate terminology and pain points.

Using this data, the following steps were developed to produce the FIM and are outlined below:

1. **Driver extraction and consolidation.** Guided by the thirteen lifecycle-spanning BOM management requirements identified by Mortensen (2026), the initial list was reduced from thirteen factors to seven drivers explaining when each BOM setup class fits ETO/CTO contexts. The remaining six factors were deemed noncritical to BOM setup selection.
2. **Question bank construction.** For each driver, two closed diagnostic questions were formulated to surface the key trade-offs. Items were iteratively refined using literature anchors and company documents to ensure answers are observable and unambiguous.
3. **Mapping to BOM setup classes.** A two-tier mapping was derived from answers to the two BOM setup classes: (i) guardrails (hard rules) that can force or exclude a class (e.g., plant- or sequence-specific structural content, regulated late entries), and (ii) preference scoring (weighted per-class desirability) that ranks the two setup classes; ties are broken by the governance readiness (ownership clarity, PLM-ERP capability).
4. **Artefact packaging.** The model outputs have three artefacts: a driver heatmap, a decision matrix (questions, answers, weights, per-class desirability and two class totals) and a governance card summarising the selected setup and the associated "how it will work" rules.
5. **Evaluation (author-led).** An evaluation was conducted using real company materials to assess the clarity of terms and questions, convergence toward a concrete setup recommendation, basic sensitivity to driver weight changes, and perceived decision usefulness.

4. Focus identification model

4.1. Deriving the drivers

The driver set was grounded in two inputs:

1. The lifecycle-spanning BOM management requirements identified by Mortensen (2026) for complex CTO/ETO environments.
2. A synthesis of relevant BOM literature combined with company documents and example structures. Overlapping or closely related requirements were consolidated into seven drivers that can be assessed in a workshop and that directly support selection between the two BOM setup classes (single-source with views vs. Separated EBOM-MBOM).

Table 1 summarizes how each driver traces back to the underlying requirements.

Table 1. Drivers traces to the requirements

Driver	Coverage
Variant breadth	Product variants, non-standard content, ETO/CTO mixes
Multi-site/localization intensity	Multi-site production, regional regulations, local content
Supplier multiplicity & alternates	Multi-supplier handling and site-specific alternates
Traceability & compliance depth	As-built/serialized lineage, labels/firmware, documentation integrity
BoM transition error surface	EBOM-MBOM transitions, cross-system reconciliation burden
Lifecycle volatility (rate of change)	Engineering Change Order (ECO) frequency and BOM volatility
Data governance & IT capability	Mastership clarity, PLM-ERP integration, ability to enforce views.

https://doi.org/10.1017/pds.2026.10381 Published online by Cambridge University Press

4.2. Boundary conditions and extensions

The model is intentionally focused on selecting between the two BOM setup classes and does not attempt to model all lifecycle domains exhaustively. Software and firmware are treated as configuration domains; where releases require effectiveness or serialised traceability at delivery, they are captured under the Traceability & compliance depth driver. Component obsolescence is addressed indirectly via Supplier multiplicity & alternates and Data governance & IT capability drivers, particularly where supersession chains and effective governance are required. Service BOMs and "as-maintained" structures were not primary inputs to the industrial contexts used in this study and therefore represent a limitation. However, service requirements typically increase the importance of traceability and governance drivers and can be incorporated without changing the model's core logic.

4.3. Question set design

A two-layer question set was used per driver to keep the method auditable and fast to run: closed gate questions (hard constraints) and preference questions (weighted score). Here are the principles for drafting questions:

- **Questions must be specific and observable:** each question targets one fact that can be evidenced by policies, logs, or exemplars (e.g., ECO metrics, site kits).
- **Questions must be grounded in literature and applicable to the company:** questions are drafted using canonical terms from the literature (e.g., EBOM-MBOM, effectivity, alternates) and then lightly reworded to match the vocabulary and document labels of the company piloting the method.

Table 2. Question bank

Driver	Question	Type
Variant breadth	Do many orders contain non-standard content that still requires engineering work after order intake?	Gate (Y/N)
Variant breadth	What share of orders include such non-standard content in a typical year?	Preference
Multi-site/localization intensity	Do two or more plants/regions need structurally different kits, routings or BoM branches for the same design?	Gate (Y/N)
Multi-site/localization intensity	How many plants/regions impose localized content or regulatory variants that change the BoM structure?	Preference
Supplier multiplicity & alternates	Are there cases where alternates or supplier choices are site-specific or regulated so they cannot be handled as a simple design-level attribute?	Gate (Y/N)
Supplier multiplicity & alternates	How common are items with two or more qualified suppliers/alternates where the choice is made at manufacturing or sourcing stage?	Preference
Traceability & compliance depth	Do compliance-critical items (e.g., labels, firmware, calibration data) enter outside design and require traceable as-built/as-delivered evidence?	Gate (Y/N)
Traceability & compliance depth	What level of serial or batch traceability is required across the BoM?	Preference
BoM transition error surface	Do mismatches between engineering structures (EBOM or equivalent) and manufacturing structures (MBOM or equivalent) cause recurring rework or non-conformities across functions?	Gate (Y/N)
BoM transition error surface	What is the typical effort needed to reconcile an engineering change with the corresponding manufacturing structures and systems?	Preference
Lifecycle volatility (rate of change)	Do late changes after order intake regularly change how products are built (e.g., sequence, consumables, plant-specific operations)?	Gate (Y/N)
Lifecycle volatility (rate of change)	How would you rate the typical rate of engineering changes that affect manufacturing structure (not only documentation)?	Preference
Data governance & IT capability	Is the capability to generate and maintain role-based BoM views with effectivity and change propagation proven and monitored in your production IT landscape (PLM/ERP/MES)?	Gate (Y/N)
Data governance & IT capability	How often do defects or misalignments occur in BoM views or BoM-related integrations (e.g., PLM–ERP) over a typical period?	Preference

https://doi.org/10.1017/pds.2026.10381 Published online by Cambridge University Press

4.4. From questions to BOM setup recommendation

The question set is not intended as a survey but as a structured, reproducible decision aid. The connection between answers and the two BOM setup classes is defined as a priori through a fixed mapping from observed conditions to per-class desirability. This mapping is grounded in lifecycle BOM requirements reported by Mortensen (2026) and in documented ETO/CTO governance patterns and is not adjusted during application. For each driver, gate and preference questions are combined into per-class scores using a consistent scoring logic described below:

- **Gate questions as guardrails:** For each driver, the gate question captures conditions under which operating one BOM setup class would be structurally unsafe or infeasible (e.g., plant- specific structural content, regulated late entries, or missing view-generation capability). Gate answers act as hard constraints: if a gate excludes a setup class, that class is marked infeasible and removed from further consideration, regardless of its preference score.
- **Preference questions as per-class desirability:** Preference questions express the degree to which a driver is present (e.g., low to high change frequency, rare to common alternates).

Each preference answer is mapped to an ordinal level (e.g., 1–5). For each driver, a desirability vector

$$D_q = \left(d_A(q), d_B(q)\right) \tag{1}$$

is defined on a small integer scale (e.g., –2 to +2), where d_A and d_B represent how strongly the given answer level supports the single-source with views setup (Class A) and the separated EBOM-MBOM setup (Class B), respectively. The sign and magnitude follow the orientation in Table 3.
Weighted aggregation to class scores: Two driver-level scores are computed, one per BOM setup class, by aggregating the desirability contributions of its preference questions weighted within the driver:

$$S_d^A = \sum_{q \in d} w_{d,q}\, d_A(q), \quad S_d^B = \sum_{q \in d} w_{d,q}\, d_B(q) \tag{2}$$

where $w_{d,q}$is the within-driver weight of question q. Using the driver weights W_d, an aggregation happened across drivers to obtain one total score for each class:

$$\text{Score}^A = \sum_d W_d\, S_d^A, \quad \text{Score}^B = \sum_d W_d\, S_d^B \tag{3}$$

Decision logic. The decision process follows a fixed sequence:

1. For each driver, evaluate gate questions and mark infeasible BOM setup classes.
2. For all feasible classes, compute weighted preference scores using the predefined desirability vectors.
3. Aggregate scores across drivers to obtain one total score per class.
4. If both classes remain feasible and scores are equal or near-equal, ties should be broken using the Data governance & IT capability driver.

The recommended BOM setup is the feasible class with the higher total score. Figure 1 illustrates the logic of how to go from driver questions to a BOM setup recommendation The dominant drivers and applied guardrails are documented in the decision matrix and summarized in the governance card.

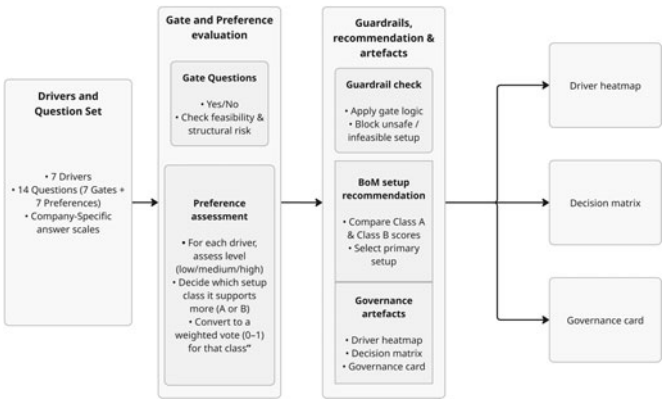


Figure 1. From driver questions to BoM setup recommendation

https://doi.org/10.1017/pds.2026.10381 Published online by Cambridge University Press

Table 3 summarises how low and high levels of each driver tend to support either setup.

Table 3. Driver orientation towards the two BOM setup classes

Driver	When the driver is low	When the driver is high	Which setup the driver tends to support
Variant breadth	Mostly standard/ configured orders; few need engineering after order intake.	Many orders include non-standard content requiring engineering after order intake.	High levels provide stronger arguments for a separated EBOM-MBOM setup that can absorb design changes without disturbing manufacturing.
Multi-site/ localization intensity	Few plants; structural differences handled by simple parameters/views.	Several plants/regions need structurally different kits, routings or BoM branches.	High multi-site variation tends to support a separated EBOM-MBOM setup with plant-specific MBOMs.
Supplier multiplicity & alternates	Alternates are rare or manageable as design-level attributes.	Many items have alternates and site-dependent supplier choices at manufacturing stage.	A high prevalence of site-specific alternates tends to support a separated EBOM-MBOM setup, where sourcing is captured explicitly in MBOM.
Traceability & compliance depth	Limited traceability; few regulated late entries.	Extensive serial/batch traceability and compliance-critical late entries.	Deep traceability with late entries tends to support a separated EBOM-MBOM setup that reflects manufacturing reality and as-built structures.
BoM transition error surface	Few issues translating between engineering and manufacturing structures.	Recurring EBOM-MBOM mismatches and PLM-ERP reconciliation problems.	A high error surface tends to support a single-source with views setup to reduce duplication and manual reconciliation.
Lifecycle volatility (rate of change)	Few ECOs change "how to build"; mainly documentation changes.	Frequent late changes altering build sequence, consumables or plant-specific operations.	High volatility in "how to build" tends to support a separated EBOM-MBOM setup, with MBOMs evolving per plant.
Data governance & IT capability	Weak view/integration capability; frequent defects in views.	Proven role-based views and integrations with low defect rates.	Weak capability tends to support a simpler separated EBOM-MBOM setup; strong capability makes a single-source with views setup viable and attractive.

4.5. Artefacts

The FIM is implemented through three artefacts created in a short cross-functional workshop: a driver heatmap, a decision matrix, and a governance card. Together, they make the reasoning behind the BOM setup recommendation transparent, document the link between the question set, weights and per-class scores, and translate the recommendation into governance rules. The artefacts are not tied to any specific software tool and can be implemented as simple spreadsheets or slide templates.

Figure 2 shows the driver heatmap. Rows correspond to the seven drivers and columns to qualitative levels (e.g., low, medium, high, very high). The heatmap is populated from the question set and basic indicators (ECO statistics, number of plants, traceability scope), providing a one-page overview of the strongest pressures on the BOM setup.

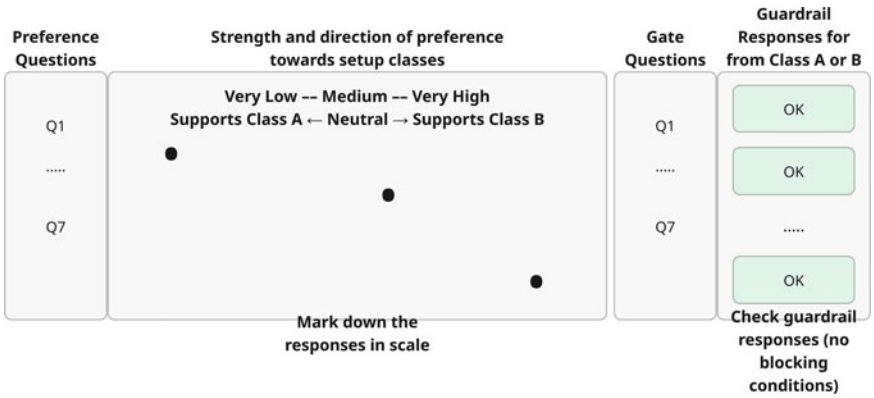


Figure 2. Driver heatmap for BoM setup selection

https://doi.org/10.1017/pds.2026.10381 Published online by Cambridge University Press

Figure 3 presents the decision matrix. For each driver, it lists the gate result, the driver weight, the assessed preference answer, and the per-class desirability scores obtained from the vector mapping described in Section 4.3. The bottom row shows the aggregated scores for the "single-source with views" (class A) and "separated EBOM-MBOM" (class B) setup classes. This artefact makes the link from workshop answers and weighing to the recommended setup transparent and auditable and exposes which drivers drove this.

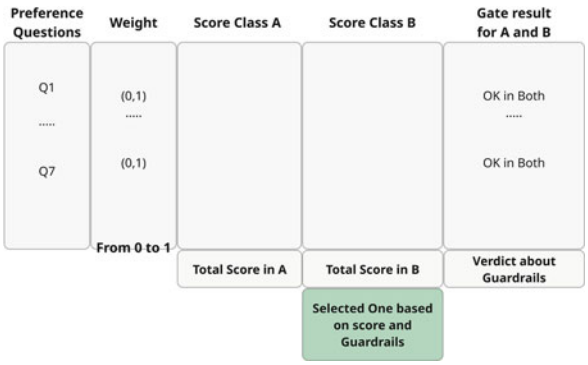


Figure 3. Decision matrix linking drivers, questions, weights and class votes

Figure 4 shows the governance card for a chosen BOM setup. It summarises the selected class and scope, ownership, key rules for effectiveness and engineering changes, main PLM–ERP integration decisions, and a small set of Key Performance Indicators (KPIs) and system requirements. The card translates the abstract recommendation into a concise, communicable operating mode.

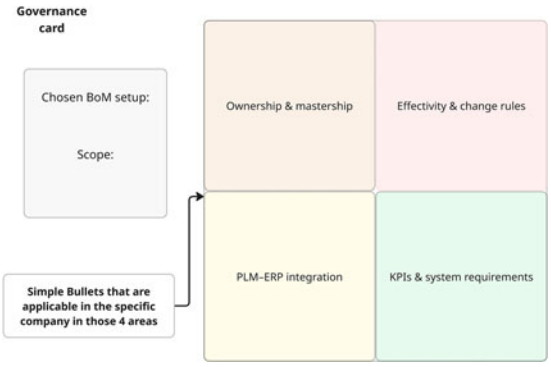


Figure 4. Governance card for the chosen BOM setup

5. Testing case

The The FIM was applied for validation in an industrial context. The validation happened in two completely different product lines in the custom laser manufacturing company. In this industrial context, the model was applied through an author-led desk analysis supported by short validation sessions with key stakeholders. The heatmap, decision matrix and governance card were populated using real data (ECO statistics traceability rules) and then reviewed with representatives from engineering, manufacturing, supply chain, quality/compliance PLM. While the detailed results cannot be shown for confidentiality reasons, Table 4 summarises how the artefacts were created (data sources, workshop format, and artefacts produced) and which roles were involved in each company.

Across both product lines, the resulting recommendations were judged as credible and aligned with ongoing internal discussions about BOM setup. In the first product line, the model pointed to a separate EBOM-MBOM setup with plant-specific MBOMs, consistent with the existing multi-site complexity and localisation needs. In the second product line, the model favored a more integrated single-source BOM setup with specific views, reflecting relatively fewer plants but an provided a structured way to challenge or confirm the current direction without forcing a binary "right/wrong" verdict. The scoring logic and desirability mappings were defined prior to application and were not adjusted to fit the observed outcomes.

https://doi.org/10.1017/pds.2026.10381 Published online by Cambridge University Press

Table 4. Testing procedure and stakeholder involvement in the two industrial contexts

Context	Main environment	How artefacts were populated	Stakeholders involved (validation)	Evaluation format
Product line A - Supercontinuum wavelength lasers	Multi-site CTO/ETO, several plants, regional localization	Author-led desk analysis of internal documents (BoM and routing examples, ECO statistics, plant/region setup, traceability rules), followed by short online review session	Engineering (product & platform), Manufacturing engineering, Supply chain	1 × 90 min joint review meeting; asynchronous comments on slides and spreadsheet templates
Product line B - Single-frequency lasers	Low number of plants, high traceability and compliance demands	Author-led desk analysis of BoM structures, ECO logs, PLM–ERP integration descriptions and traceability policies, followed by focused feedback rounds	R&D/Engineering, Manufacturing, Quality/Regulatory, Service, PLM	2 × 60 min review meetings with core team; targeted follow-up with quality and PLM on governance card content

6. Conclusion

This paper introduced a FIM to support ETO/CTO companies in selecting between two fundamentally different BOM setups: a single-source BOM with role-based views and a separated EBOM-MBOM structure with explicit transformation and synchronisation. Grounded in lifecycle-spanning BOM requirements and consolidated into seven practical drivers, the model operationalises the decision through a small question set and three artefacts: a driver heatmap, a decision matrix and a governance card. Application in an industrial context comparing two completely different product lines shows that the approach can be implemented with modest effort, yields recommendations practitioners perceive as credible, and helps make assumptions about BOM use, governance and IT capability explicit. Rather than prescribing a universal "best" BOM structure, the model offers a transparent way to explain why a given setup is appropriate for a particular context and what governance implications follow. The work is limited by the small number and the qualitative evaluation; future studies should apply the model to additional companies, refine the scoring scheme, and investigate how setup choices affect BOM quality, change handling, and downstream engineering and manufacturing performance over time.

References

Chatras, C., Giard, V., & Sali, M. (2016). Mass customisation impact on bill of materials structure and master production schedule development. *International Journal of Production Research*, 54(18), 5634–5650. https://doi.org/10.1080/00207543.2016.1194539

Gann, D. M., & Salter, A. J. (2000). Innovation in project-based, service-enhanced firms: the construction of complex products and systems. *Research Policy*, 29(7–8), 955–972. https://doi.org/10.1016/S0048-7333(00)00114-1

Hanchuan, X., Xiaofei, X., & Dechen, Z. (2008). A novel BOM model based on product identifier for mass customization. *2008 International Symposium on Information Science and Engineering, ISISE 2008*, 1, 244–248. https://doi.org/10.1109/ISISE.2008.219

He, L., Ni, Y., Ming, X., Li, M., & Li, X. (2014). Integration of bill of materials with unified bill of materials model for commercial aircraft design to manufacturing. *Concurrent Engineering Research and Applications*, 22(3), 206–217. https://doi.org/10.1177/1063293X14542443

Hegge, H. M. H., & Wortmann, J. C. (1991). Generic bill-of-material: a new product model. *International Journal of Production Economics*, 23(1–3), 117–128. https://doi.org/10.1016/0925-5273(91)90055-X

Hicks, C., & McGovern, T. (2009). Product life cycle management in engineer-to-order industries. *International Journal of Technology Management*, 48(2), 153. https://doi.org/10.1504/IJTM.2009.024913

Hu, X., Barwasser, A., Werner, A., Schuseil, F., Lentes, J., Hertwig, M., & Zimmermann, N. (2023). Graph Model Based Bill of Material Structure for Coupling Product Development and Production Planning. In *Lecture Notes*

https://doi.org/10.1017/pds.2026.10381 Published online by Cambridge University Press

in Production Engineering: Part F1164 (pp. 593–605). Springer Nature. https://doi.org/10.1007/978-3-031-18641-7_55
Huang, G. Q., Yee, W. Y., & Mak, K. L. (2003). Current practice of engineering change management in Hong Kong manufacturing industries. *Journal of Materials Processing Technology*, 139(1-3 SPEC), 481–487. https://doi.org/10.1016/S0924-0136(03)00524-7
Hvam, L., Mortensen, N. H., & Riis, J. (2008). *Product Customization*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-71449-1
Jianxin, J., Tseng, M. M., Qinhai Ma, & Yi Zou. (2000). Generic Bill-of-Materials-and-Operations for High-Variety Production Management. *Concurrent Engineering*, 8(4), 297–321. https://doi.org/10.1177/1063293X0000800404
Jung, S.-Y., KIm, B. H., Choi, Y. J., & Choi, H. Z. (2014). BOM-centric product data management for small and medium manufacturing enterprises. In D. Marjanovic, M. Storga, N. Pavkovic, & N. Bojcetic (Eds.), *Proceedings of International Design Conference, DESIGN* (pp. 1799–1810).
Koskinen, J., Mustonen, E., Harkonen, J., & Haapasalo, H. (2020). Product-level profitability analysis and decision-making: opportunities of IT application-based approach. *International Journal of Product Lifecycle Management*, 12(3), 210. https://doi.org/10.1504/IJPLM.2020.109793
Lee, C., Leem, C. S., & Hwang, I. (2011). PDM and ERP integration methodology using digital manufacturing to support global manufacturing. *International Journal of Advanced Manufacturing Technology*, 53(1–4), 399–409. https://doi.org/10.1007/s00170-010-2833-x
Lee, J. H., Kim, S. H., & Lee, K. (2012). Integration of evolutional BOMs for design of ship outfitting equipment. *CAD Computer Aided Design*, 44(3), 253–273. https://doi.org/10.1016/j.cad.2011.07.009
Matías, J. C. H., García, H. P., García, J. P., & Idoipe, A. V. (2008). Automatic generation of a bill of materials based on attribute patterns with variant specifications in a customer-oriented environment. *Journal of Materials Processing Technology*, 199(1), 431–436. https://doi.org/10.1016/j.jmatprotec.2007.08.038
McKendry, D. A., Whitfield, R. I., & Duffy, A. H. B. (2022). Product Lifecycle Management implementation for high value Engineering to Order programmes: An informational perspective. *Journal of Industrial Information Integration*, 26. https://doi.org/10.1016/j.jii.2021.100264
Ming, X. G., Yan, J. Q., Wang, X. H., Li, S. N., Lu, W. F., Peng, Q. J., & Ma, Y. S. (2008). Collaborative process planning and manufacturing in product lifecycle management. *Computers in Industry*, 59(2–3), 154–166. https://doi.org/10.1016/j.compind.2007.06.012
Mortensen, J. H., A. J. D., M. N. H., & B. M. (2026). Beyond the Traditional BoM: Challenges of Bill of Materials in Global Industrial Companies. *Procedia CIRP* (in Press).
Rudberg, M., & Wikner, J. (2004). Mass customization in terms of the customer order decoupling point. *Production Planning & Control*, 15(4), 445–458. https://doi.org/10.1080/0953728042000238764
Srinivasan, V. (2011). An integration framework for product lifecycle management. *CAD Computer Aided Design*, 43(5), 464–478. https://doi.org/10.1016/j.cad.2008.12.001
Stark, J. (2020). *Product Lifecycle Management (Volume 1)*. Springer International Publishing. https://doi.org/10.1007/978-3-030-28864-8
Stekolschik, A. (2017). Methods for automated semantic definition of manufacturing structures (mBOM) in mechanical engineering companies. *IOP Conference Series: Materials Science and Engineering*, 241(1). https://doi.org/10.1088/1757-899X/241/1/012032
Stolt, R. (2023). Integrating the Design of the Product Life Cycle by a Master Bill of Materials. *Advances in Transdisciplinary Engineering*, 41, 33–41. https://doi.org/10.3233/ATDE230595
Sudarsan, R., Fenves, S. J., Sriram, R. D., & Wang, F. (2005). A product information modeling framework for product lifecycle management. *CAD Computer Aided Design*, 37(13), 1399–1411. https://doi.org/10.1016/j.cad.2005.02.010
Wang, S., Liu, X., Bai, Z., & Xiao, J. (2023). A BOM model transformation method for hierarchical production planning management process of complex products. *Advanced Engineering Informatics*, 58. https://doi.org/10.1016/j.aei.2023.102138
Wang, W., & Yuan, C. (2010). A new approach to BOM management supporting enterprise information collaboration. *2010 International Conference on Intelligent Computation Technology and Automation, ICICTA 2010*, 1, 215–218. https://doi.org/10.1109/ICICTA.2010.698
Zhao, Q., & Hvam, L. (2024). Framework for Investigating Possible Areas to Apply Product Configuration Systems For Engineer-To-Order Products. *11th International Conference on Customization and Personalization (MCP 2024)*, 265–272.
Zhao, X., Wei, S., Ren, S., Cai, W., & Zhang, Y. (2024). Integrating MBD with BOM for consistent data transformation during lifecycle synergetic decision-making of complex products. *Advanced Engineering Informatics*, 61. https://doi.org/10.1016/j.aei.2024.102491

https://doi.org/10.1017/pds.2026.10381 Published online by Cambridge University Press

Zhou, C., Liu, X., Xue, F., Bo, H., & Li, K. (2018). Research on static service BOM transformation for complex products. *Advanced Engineering Informatics*, 36, 146–162. https://doi.org/10.1016/j.aei.2018.02.008

Zhu, S., Cheng, D., Xue, K., & Zhang, X. (2007). A Unified Bill of Material Based on STEP/XML. In *Computer Supported Cooperative Work in Design III* (Vol. 4402, pp. 267–276). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-72863-4_28

https://doi.org/10.1017/pds.2026.10381 Published online by Cambridge University Press