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Decentralised or centralised management of data and products: influence on revenue-generating processes

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Abstract: Products, services, product data, information systems, and business processes are very closely related issues. The products must be in control, and the product data and product portfolio suit the business to ensure process performance. Customers' demanding complex solutions necessitate considerations over decentralised or centralised management of data and products. Decisions on product and data management affect vital processes. Thematic analysis is applied to company product data management (PDM) and product portfolio management (PPM) practices to reflect the centralisation vs. decentralisation perspective and identify preconditions for centralisation. It appears that the volume of standard products, pressures to comply with regulations and standards, and product and process maturity influence whether a company benefits more from centralisation or decentralisation. Value is provided by revealing challenges of decentralised PDM and PPM, and by clarifying preconditions for centralisation. The findings indicate the order of priority for centralisation in terms of aligning processes and harmonising data.

Keywords: decentralised data management; centralised data management; decentralised product management; centralised product management; product data management; PDM; revenue-generating processes; product portfolio management; PPM; pre-conditions for centralisation; business process; decision-making.

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1 Introduction

The offering, whether products or services, related product data, information systems, and business processes are very closely related issues (Stark, 2020). All these are important for product data management (PDM) and product portfolio management (PPM). The offering is an important focal point in PDM and PPM and must be in control for processes to perform (Harkonen, 2021). This highlights the importance of considering the product portfolio and product data when making related decisions. The choice over centralised or decentralised PPM and PDM affect the company decision-making. Hence, managers can benefit from understanding over centralised or decentralised PDM and PPM. An example of the associated challenges relates to customers' demands for increasingly complex solutions that are tailored to their specific needs. The complex solutions drive towards using existing components to keep development and production costs low. The trend is towards the 'configured-to-order' approach (Fogliatto et al., 2012). To perform, companies need to consider their entire product portfolio. In larger companies, the product portfolio is often fragmented and managed in a decentralised manner in individual business units (BUs) (Tolonen et al., 2014a). The same applies to PDM and is found to cause challenges (Hannila et al., 2019). Decentralisation is seen as a source of flexibility and quick reactions to enable growth (Schwenker and Bötzel, 2007), but it fails to address the product portfolio perspective when the business environment change. The customer needs and demands for more complex solutions create the need for a centralised PPM.

Previous research seems to treat the centralisation vs. decentralisation considerations in isolation in terms of whether considering data, information systems, processes, products, or the product portfolio. It has been learned that decentralisation of data management allows for more variety in BUs, enables local tailoring and coping with higher uncertainty (Velu et al., 2013). Nevertheless, the decentralisation of information systems makes it challenging to match data among BUs (Neirotti and Paolucci, 2007). Further, decentralisation enables local control and ownership (Mikalef et al., 2021). On the other hand, the centralisation of data management increases the similarity of BUs and provides benefits in coordination and communication (Velu et al., 2013). The centralisation of information systems facilitates economies of scale (Mikalef et al., 2021). Regardless of the advantages, BUs not having ownership, the centralisation may result in perceptions of inflexibility and systems being sub-optimal (Sohal and Fitzpatrick, 2002). In terms of business processes, centralisation implies top management making important decisions while decentralisation allows for more autonomy (Modrak, 2013). Centralisation vs. decentralisation as regards considering product portfolios has been linked to portfolio decisions (Joseph et al., 2016). The decentralisation vs. centralisation of product management and data management should not be considered in isolation as products, business processes and data are interlinked.

The research has touched on the central role of product data in offering related processes (Christensen et al., 2006; Hannila et al., 2019, 2020; Stark, 2020), the role of PDM in the quote-to-cash (Q2C) process (Dumas et al., 2018) but the PPM process is yet to be studied thoroughly, especially if PPM is viewed broadly over the lifecycle. Some aspects are identified to weaken the PDM-PPM linkage, including the fragmented use of PDM, structure and validity of product data, and the process integration (Kropsu-Vehkapera et al., 2009). However, PPM and PDM have been identified both as

important areas that affect the accrual of revenue from products (Nepal et al., 2011). Particularly the transition from decentralised to centralised PDM and PPM has been addressed deficiently as specifically the PPM perspective has been limited. Considering the whole formed by, product data, business processes, data systems, products, and the portfolio is vital to avoid process discontinuities, potentially affecting the revenue-generating processes. Product portfolio analysis and decisions are based on product data. However, most companies do not make a conscious choice of having either a centralised or decentralised PDM and PPM.

This study investigates decentralised PDM and PPM and identifies related advantages and challenges by taking a holistic managerial perspective. The potential inhibitors for a centralised PDM and PPM are investigated to determine preconditions for centralisation. Specific attention is given to the revenue-generating Q2C process. The study is realised as an in-depth analysis of company practices, supported by relevant background knowledge, to identify some of the drivers that lead to decentralisation and the management rationale behind them. Preconditions for centralisation are identified. The following research questions guide the investigation:

RQ1 What are the advantages and challenges of decentralised PDM and PPM?

RQ2 What are the preconditions for centralised PDM and PPM?

2 Literature review

2.1 Product data management

PDM is the management of product data. Product data is defined as all the information broadly related to the offering (Saaksvuori and Immonen, 2008). To manage the offering and its lifecycle, the related data must be managed. PDM concerns all product data, including product master data and data from processes that enrich it (Hannila et al., 2019). Product master data is one category among multiple master data management (MDM) categories (Loshin, 2009), and is more complex than the other MDM domains (Silvola et al., 2011). MDM necessitates clear ownership, business justification, clear logic for master data storage and distribution, IT system considerations, quality monitoring, and support (Ofner et al., 2013). Nevertheless, understanding the MDM concept is difficult (Haug and Arlbjørn, 2011). Master data objects themselves are static and the data is enriched through transactions and business processes [Loshin, (2009), p.8]. In the case of product master data, the underlying static object is the product or service.

In companies, multiple business processes utilise product master data and enrich it with transactional data (Das and Mishra, 2011). Examples include the Q2C process and reporting. The Q2C process (Dumas et al., 2018), which can include sales, configuration, pricing, contracting, delivery, and billing, utilises the product master data and enrich it, creating multiple function-specific datasets. Q2C relates to participating in the marketplace, including the identification of customers with needs, applying the company products and services to address these needs, concluding with customer payment (Okrent and Vokurka, 2004). The existing literature has very little discussion on Q2C in conjunction with PDM and PPM. Certain success factors for PDM have been identified, including business process design, and ownership, i.e., the responsibility for product data

(Otto, 2012). The business processes, in general, have been discussed in this context (Echterfeld and Gausmeier, 2018; Hannila et al., 2019, 2020; Stark, 2020; Tolonen et al., 2015a, 2015b).

Centralisation of PDM ensures the connection of different organisational parts (Fisher, 2009), particularly from the data governance perspective to ensure quality, consistency, and relevance of data through standardisation and data ownership. Even though PDM systems are designed as central systems for product data, centralised PDM does not mean a central system only but also relates to centralised responsibility (Otto, 2012). PDM is too often considered an IT issue with a narrow view over product lifecycle (Neirotti et al., 2018). The centralisation of MDM has been argued to support product portfolio analytics (Hannila et al., 2020). On the other hand, decentralisation risks creating functional data silos (Silvola et al., 2011). Overall, the lack of centralised master data makes coherent data management challenging (Gregersen and Hansen, 2018). Decentralised master data may challenge the mastering of product data and the allocation of transaction data to master data. For example, allocating billing components to the related marketed product components. The existing literature is deficient in these considerations.

2.2 Product portfolio management

Product management is about managing products or services with a broad focus and understanding of technical and business aspects (Gorchels, 2003). PPM is concerned with the analysis and decisions about which products should be part of the company's portfolio and in which lifecycle stage they should be (Crowley, 2017; Lahtinen et al., 2021; Medini et al., 2020; Tolonen et al., 2014b). Focusing on product-level, instead of firm-level has value in understanding the performance (Barroso et al., 2016). Earlier PPM research has been mainly concerned with the management of the new product development (NPD) (Cooper, 2008; Szwejczewski et al., 2006), whereas only a few studies have taken the necessary wider approach (Andriani et al., 2016; Arromba et al., 2020; Crowley, 2017; Hannila et al., 2020; Lahtinen et al., 2021; Seifert et al., 2016; Tolonen et al., 2015a). PPM can be seen to cover product development, the lifecycle, master data, and assessing the product performance (Andriani et al., 2016). This study considers PPM through the product lifecycle.

PPM is an important method for implementing company strategy. While the strategy makes a statement about in which markets a company wants to compete, and which company-specific competitive advantages it chooses to apply, PPM implements the strategy by providing the range of products to achieve the strategic goal (Saeed et al., 2017; Tolonen et al., 2014b). Product portfolio is a result of strategy implementation measures, such as the development of new products or the update/upgrade of existing products (Cooper et al., 2001). Both, NPD and changes in commercial packaging affect the company's product portfolio. PPM should be considered more widely than product development to truly manage the products and the portfolio over the lifecycle (Arromba et al., 2020; Bey, 2018; Crowley, 2017; Hannila et al., 2020; Lahtinen et al., 2021; Tolonen et al., 2014a). For example, Bey (2018) views PPM to cover product development, activities after-launch, and the after-sales activities until the end-of-life of individual products, and all products in the market. The PPM lifecycle focus involves decisions, including discontinuities and renewal of products/services at the company

level (Crowley, 2017). Further, Arromba et al. (2020) link PPM to the product development process and industry 4.0 and understand how it is not about managing single products, but all the components in an integrated manner, covering all the products. This in turn allows better understanding and analysis of the product/service lifecycle. Nevertheless, the challenge can entail the lack of holistic knowledge, discussed for product lifecycle management (PLM) and linked to PPM (Conlon, 2020; Saaksvuori, 2011).

The purpose of PPM is threefold: strategic alignment, value maximisation, and portfolio balance (Cooper et al., 1997; Milani, 2019; Tolonen et al., 2014b). How well PPM practices work at a company, can thus be evaluated by assessing how well these three goals are met. It is from these three targets that the major drivers for the importance of PPM have emerged: Maximising the value of individual product lines is not enough to achieve profitability targets. Value maximisation, therefore, necessitates keeping the entire portfolio in view. With faster-changing technology cycles, it becomes increasingly important to maintain a balanced portfolio containing both established and emerging technologies. Portfolio balance is critical to keep the number of products at a manageable level to avoid 'portfolio explosion' (Abbasi et al., 2020; Tolonen et al., 2014b). The two aforementioned targets support the overarching goal of strategic alignment. Product portfolio analysis and the related decisions are based on data, making the data and PDM relevant dimensions (Hannila et al., 2020). Data and facts should be the basis for decision-making, not the gut feelings (Tort-Martorell et al., 2011). The product portfolio is often fragmented in companies and managed in a decentralised manner in individual BUs (Tolonen et al., 2014a). Centralisation of PPM is proposed to improve the company-wide PPM analysis and decisions (Tolonen et al., 2015b). In centralised organisations where resources are allocated at the level of individual products, resource allocation can base on the merits of each product, not on those of the individual BUs (Eklund, 2019). The decentralisation vs. centralisation perspective, however, necessitates further studies in the PPM and PDM contexts.

2.3 Decentralisation and centralisation in PDM and PPM

The decentralisation and centralisation considerations are important in conjunction with PDM and PPM as they link to many company challenges and influence revenue-creating processes.

2.3.1 The challenges of decentralised PDM and PPM

Some challenges of decentralised PDM and PPM are discussed in the literature. For example, as business processes are becoming more complex, they require that data is available in a centralised manner. Large corporations require a lot of extra effort to assemble fragmented data from multiple sources (Bernstein and Haas, 2008). The challenges resulting from decentralised PDM and PPM can be grouped into three categories: *organisational challenges*, *data structure related challenges*, and *process challenges*.

- *Organisational challenges:* The organisational challenges arise from functional siloes within the corporations (Hannila et al., 2022). As a result, there is a lack of a common PDM and PPM governance model. A thorough approach to governance is

seen to have the potential to maximise the value of technology, processes, people, and the data used for decisions (Larkin, 2008). However, the research is limited particularly from the PPM and the combined PDM and PPM perspectives. Previous research has merely indicated the benefits of a centralised governance model for maintaining a unified view across horizontal and vertical product portfolios (Tolonen et al., 2014b). However, empirical investigations are lacking.

- *Data structure challenges:* Having no common data management practices within an organisation is a challenge for managing centralised master data (Silvola et al., 2011). Because data is the prerequisite for processes, fragmented data leads inevitably to process discontinuities (Trąbka and Soja, 2013). A data model might be needed to capture the data necessary for processes, including business data, process status, and correlations (Su et al., 2017). It must be, however, understood that a company's data are unique to the company, sort of a strategic asset and the business requirements are directly linked to the data structure (Allen and Cervo, 2015). This further affects the creation of the data model.
- *Process challenges:* The fragmentation of processes across functional siloes lead to fragmented PPM and thus to decentralised decision-making (Das and Mishra, 2011; Jetson and Nelis, 2008; Hannila et al., 2020). Management decisions are taken within the individual siloes and the big picture is lost. This leads to partial optimisation and sub-optimal financial results.

Literature synthesis

The decentralisation vs. centralisation perspective is deficiently studied in the PPM and PDM contexts, both separately and in combination. The related considerations are, however, important as they link to many company challenges. The challenges includes; decentralisation risking creating functional data silos and making coherent data management and data governance difficult. Decentralisation may also influence the possibilities of allocating transaction data to the master data, causing challenges, for example in billing while all company transactions are done against master data. Decentralisation causes fragmentation of the company product portfolio and challenges the PPM analysis and decision-making. Decentralisation can, however, enable certain flexibility and quick reactions, but fail to reveal the merits of each product. The challenges resulting from decentralised PDM and PPM can be grouped into organisational challenges, data structure related challenges, and process challenges.

3 Research process

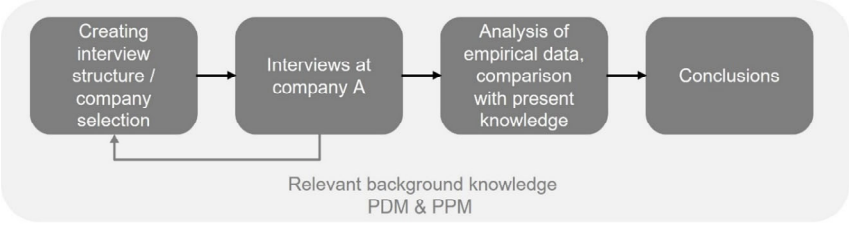
Figure 1 illustrates the followed research process. The study applies thematic, inductive analysis of qualitative data (Guest et al., 2014). A set of interview questions was created to support company interviews and enable identifying drivers that lead to decentralised PDM and PPM, and the management rationale behind them. The questionnaire (Appendix) consisted of items on process self-assessment form and focused on three areas: *organisational structure*, including governance, management, and operational structure; *product data structure*, including product structure in MDM systems (catalogues), and product data structure in systems utilising and enriching product master

data; *product process and related processes*, including PDM processes, PPM processes, and Q2C processes. Company selection was based on the suitability for the study and the possibility to have adequate access. Company interests in the topic favoured their selection. A list of key people was created to include interviewees with representation from all layers of governance, management, and operations. The interviewees represent the main processes of PDM, PPM and Q2C. Purposive sampling (Etikan et al., 2016) was used for interviewee selection to gain information-rich data and suitable well-informed participants. Relevant company practices were analysed through interviews and analysing internal materials. The interviews were realised in a semi-structured manner (Merton et al., 1990) to allow the interviewees to explain the topics as entities and were supported by process flow charts. The number of interviews was 12, including all the relevant key personnel concerned with PDM and PPM. The interviews were recorded and selectively transcribed by the researchers to allow detailed analysis. Detailed notes were taken during the interviews. The interviewee titles and responsibilities include Program Director, responsible for leading service offering development (SOD) program; business lead, responsible for portfolio management team (PMT); portfolio manager, PMT member, responsible for process design and implementation; enterprise architect, PMT member, responsible for architectural choices and alignment with the overall company architecture; development manager, PMT member, responsible for *Productmaster* catalogue; senior product design manager, PMT member, responsible for product structure design and implementation; development manager (production team), responsible for *Productmaster* catalogue; solution specialist (production team); development manager, core processes (SOD); development manager, responsible for billing and product management; senior project manager, billing and products; consultant, responsible for advising senior management on PDM and PLM decisions. Minor adjustments were made to the questionnaire after the first interviews. Also, a self-assessment (Appendix) was carried out for PPM processes over the lifecycle, and other available company materials were analysed. The multiple data sources enabled triangulation and reduced the possibility of recall bias. The self-assessment involved assessing process maturity through a company internal questionnaire. The questionnaire responses were analysed qualitatively through simple coding and grouping of responses. The company materials included process charts, mapping tables, and architecture charts. This study utilises samples that are enough for the type of analysis and intended interpretations. The collected primary data is adequate to understand the current situation and identify preconditions for centralised PDM and PPM. The supplementary data provided the necessary support for primary data and the data collection was seen saturated when additional evidence on the studied topics did not affect coherence or provide added clarity.

Data analyses were realised using MS Office and thematic coding. Themes and patterns were sought within the data. Each transcript was first read carefully, and initial codes were created. The codes were reduced to a manageable number of groups based on similarities and being in line with research objectives. Created categories were influenced by the purposive focus, resulting in division into systems, processes, and governance in terms of PDM, lifecycle and Q2C process stages in terms of PPM, and overall data flow and utilisation over the lifecycle. Active PPM over the lifecycle (Tolonen et al., 2014a, 2014b, 2015a, 2015b) was used as a framework for assessing the PPM practices, involving processes, tools, and governance. In terms of PPM, the specific focus was on the purpose of PPM at the analysed company. Multiple investigators debated the analysis

interpretations during data analysis, discussing different perspectives, also referred to as investigator triangulation (Denzin, 2017). The understanding of the current state of PDM and PPM and the related challenges are reflected against the centralisation vs. decentralisation perspective to identify preconditions for centralisation.

Figure 1 Outline of the research process



3.1 Analysed company

The analysed company A is the leading telecommunications company in Finland, listed on the Nasdaq Helsinki Stock Exchange. Most activities are in Finland and Estonia, with a large international footprint through sales, customer service and sourcing offices, including Madrid, St. Petersburg, and Hong Kong. The company has grown after the deregulation of the telecommunications market through mergers and acquisitions (M&A). The company delivers high volume products and services, of which about 30% are delivered to the heavily regulated public sector (including government and healthcare).

The company is divided into three BUs: consumer customer, corporate customer, and Production BUs. The production BU provides infrastructure and corporate IT services to internal customers, the other BUs. This paper will focus on the *corporate customer* BU, where the decentralisation of PDM and PPM is most evident due to the history of the BU.

Aside from local telecom operators, more companies were recently acquired to gain the capability to provide a wider scale of IT services and to build a long-term service strategy. These M&A have led to four rather independent BUs within the corporate customer BU. Each of these has its distinct service offering and delivery and billing processes. The delivery and billing processes are described below:

- *Connectivity:* The largest BU in terms of service offering and turnover. Connectivity provides fixed and mobile voice and broadband services and related services. As connectivity BU has grown due to M&A with local phone companies and service providers, the product structure within the same BU varies. The goal is to keep a unified service offering. Some fragmentation exists, and fixing efforts are ongoing.
- *Customer interaction services (CIS):* CIS offers call centre switching software and outsourced call centre services. Also, payment terminals and payment services complement the service offering. The offering is strongly service-based.
- *IT Business Unit (ITBU):* ITBU provides IT services, including outsourced workstation management, cloud storage, cloud services, unified communication and collaboration (UCC) solutions, and consulting. The service offering is a mix of standard products and highly tailored services. The broad range makes it difficult to

apply a single consistent product structure and adapt it to standard processes. Most of the larger deliveries require consulting and are delivered as projects.

- *Visual communication (VISCOM):* VISCOM offers visual communication hardware (HW) and software (SW) and related consulting services. This BU has the most international locations, as customer service is offered globally and in multiple languages. While the HW side and SW configuration are structured, the consulting projects and delivery are almost always tailored. All deliveries require a delivery project.

Due to the nature of the BUs, they have their own product structures, and no common company-wide product structure exists. In some cases, the differing product structures have led to distinctively different delivery and billing processes. This study investigates how these factors have influenced PDM and gives recommendations to develop PDM capabilities.

The analysed company mainly provides fixed-line and mobile telephone and broadband subscriptions under the main brand for their premium products and a secondary brand for more price-conscious consumers along with other services. They also have cable television subscriptions and services. For consumers, they have entertainment services for digital television and dedicated service for digital books.

4 Results

The current state is analysed from the viewpoint of PDM and PPM as PDM is a prerequisite for PPM. With regards to PDM, the systems and processes are investigated in detail. The focus on PPM is more on the purpose of PPM, and whether the company can achieve its stated purposes with the existing processes and governance model.

4.1 PDM systems

There are multiple PDM systems in use (six). Out of these, four have their own catalogues (product data structures). Figure 2 presents an overview of the PDM systems.

Comptel fulfilment (*CFF*) contains the technical products and capabilities necessary to create, activate, and deliver commercial products. CFF is used only as a delivery orchestrator, and to maintain resource facing services (RFS). CFF has the capability to maintain a centralised technical product catalogue or RFS catalogue. CFF process delivery requests but does not keep a record of completed deliveries. Installed base data could be stored but the capability is not utilised. Instead, installed base data is reconstructed later using billing information from Amdocs billing platform (ABP), and the delivery information.

MIPA contains an old product catalogue for fixed-line products and so-called end-to-end (E2E) products that include all other than subscription products. For example, devices or payment terminals. No new fixed-line products are created, and they are being phased out. MIPA has its own product catalogue and product structure.

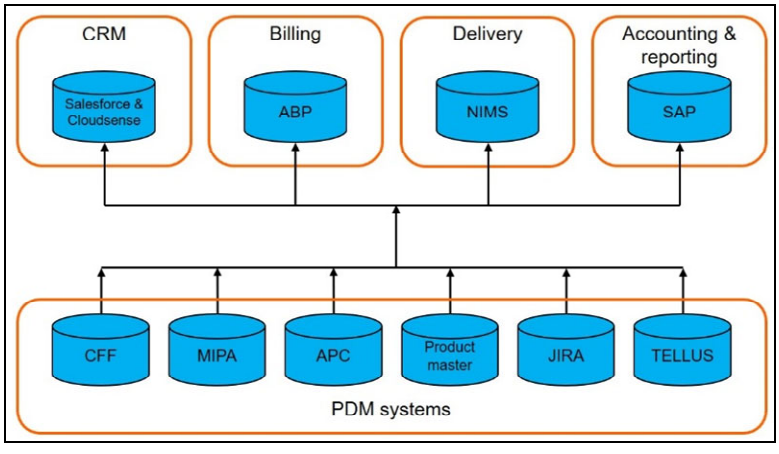
Amdocs product catalogue (APC) is a dedicated product catalogue that contains the product billing structure, which does not necessarily correspond to products' logical structures or the delivery components' structures. The billing structure is based on charge codes, based on commercial components that the company wants to invoice.

Productmaster is an Excel and ACCESS-based commercial product catalogue for the customer facing services (CFS). Productmaster was created as a temporary master for commercial products to consolidate the MIPA, TELLUS and APC catalogues. The scope has been however limited to CFS and the technical product catalogue is not mastered in Productmaster. There is no integration of Productmaster with other systems. All data migrations are done manually. To improve Productmaster functionality and provide the opportunity for integration, Productmaster 2.0 was introduced in March 2017. *Productmaster 2.0* is based on Microsoft master data services (MDS) and intended as a temporary system until implementing a PDM/PLM system. The scope of Productmaster 2.0 is to contain the commercial catalogue and function as the master for the commercial offering and related structure. Currently, both Productmaster and Productmaster 2.0 co-exist, due to user interface (UI) limitations. The old Productmaster will be phased out after resolving the UI issues.

JIRA is a ticketing system that contains product information when product changes are made. JIRA contains activities required to make product changes.

TELLUS contains all mobile subscription products such as mobile voice and mobile broadband. TELLUS product structure is optimised for the operator's mobile subscription products and thus differs from MIPA. Tellus has its own product catalogue, containing the CFS of the product structure.

Figure 2 Overview of PDM systems (see online version for colours)



4.2 Other systems processing product data

Salesforce is a new CRM system, containing a flat list of commercial products, without any structure. The product structure is provided by *CloudSense*, which is used as a sales configurator. Neither Salesforce nor CloudSense have product catalogues in the strict sense but a flat list of commercial products with the possibility to configure some items.

ABP contains product billing data. Billing information is associated with a product using the APC.

Network information management system (*NIMS*) contains product information required for network provisioning. NIMS are activated by commands from CFF and

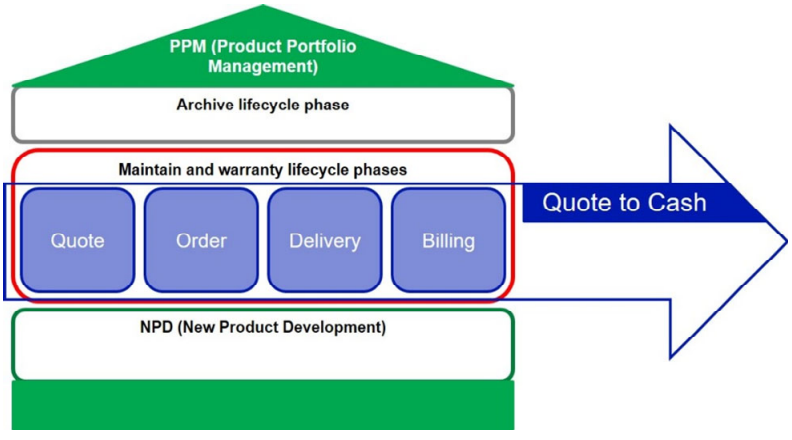
execute the actual delivery. NIMS accesses and configures the configuration items (CI) required for delivery fulfilment.

SAP is an enterprise resource planning system, used for financial reporting and accounting. The financial information is extracted from the ABP. Product billing information is collected through SAP4 codes, which are the equivalent of APC charge codes.

4.3 PDM processes along PPM lifecycle

PDM processes, various PPM lifecycle and Q2C process stages have been analysed in detail. Figure 3 supports understanding the relationships between the process stages.

Figure 3 Relationship between PPM lifecycle phases and the Q2C process (see online version for colours)



The Q2C process is the process by which company turnover is generated. The process starts with a quote (offering a service) and goes through the order and delivery process stages until reaching the cash (billing) stage. The last stage includes products' ongoing billing and maintenance.

The Q2C stage intersects with PPM lifecycle phases in which the product is available for sale, namely ramp-up, product use, maintain, and ramp-down, collectively known as the maintain catalogue. The last Q2C process stage also intersects with the product field maintenance lifecycle stage when the product is in the warranty catalogue. When analysing PDM processes, one must be acutely aware of the lifecycle phase and Q2C process stage to be able to assess whether the process fits the purpose.

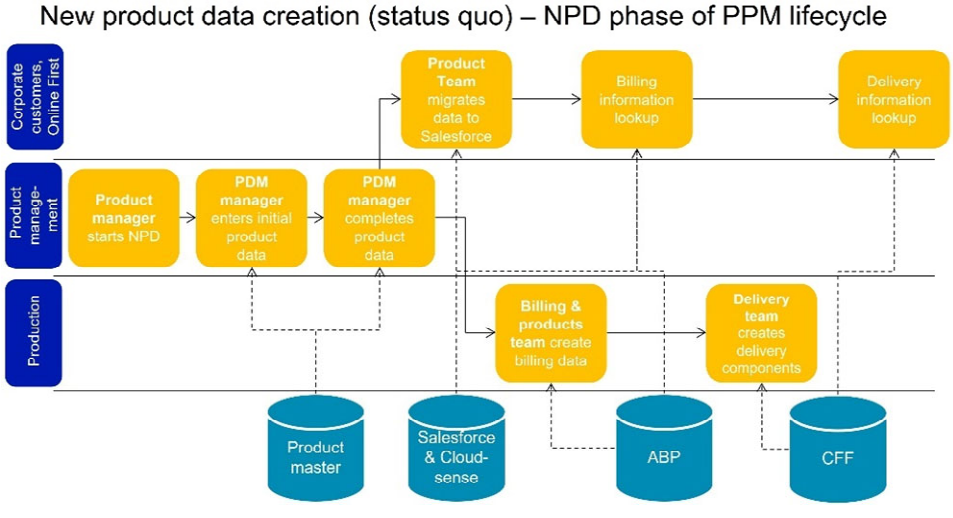
4.3.1 New product data creation in NPD phase

Figure 4 details the process for creating new product data in the NPD lifecycle phase. New product data is created and maintained in decentralised systems, depending on the user role and the function of the team or department.

The (logical) product structure is created in Productmaster by the managers, PDM and product. The product data is transferred manually to Salesforce and CloudSense to make it available for sales and configuration. To adapt to the systems' limitations, the

structure is changed from a multi-tiered hierarchical product structure to a two-tiered parent-child product structure. Also, product IDs is changed, requiring ID mapping to connect products in Productmaster with products in Salesforce and CloudSense.

Figure 4 New product data creation in the NPD phase (see online version for colours)



The billing product structure is created by the billing team (part of the production unit) in ABP, by attributing charge codes to the product ID. Charge codes' structure differs from the logical product structure.

The delivery product structure is created separately by the delivery team (part of the production unit) in CFF. The delivery structure differs from both the logical structure and the billing structure. CFF also uses its own IDs.

Due to the differing structures in used systems and product and component IDs, product managers must maintain a separate Excel table to map the various IDs to each other to be able to follow the product through the Q2C process.

4.3.2 Data utilisation for sales and product configuration

Figure 5 illustrates the data utilisation in the sales and product configuration process. One of PPM's operational goals is to enable the enterprise to deliver products as 'configured-to-order', as opposed to more costly 'built-to-order' or 'engineered-to-order'. The sales and configuration process is therefore a good indicator of the success of PPM implementation.

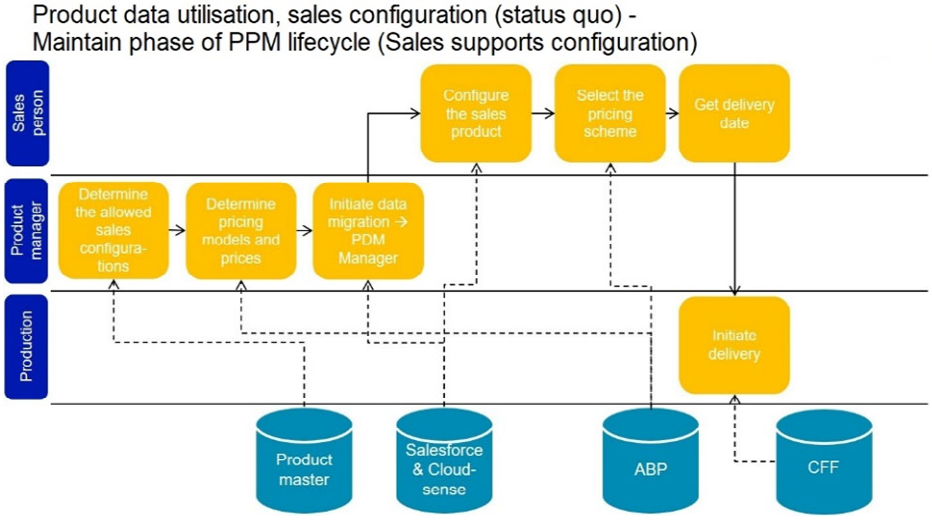
In the analysed company, the configuration takes place in two steps. There is a technical product configuration, followed by a commercial configuration by selecting the pricing scheme.

4.3.3 Data utilisation in self-service use cases

Figure 6 shows the product data utilisation in a self-service scenario. The customer configures the product and places the order without any help or input from sales or

customer service. One of the main cost advantages of 'configure-to-order' vs. 'engineered-to-order' is enabling self-service. Therefore, the maturity of the self-service process is a good indicator of the success of 'configure-to-order' implementation.

Figure 5 Product data utilisation in product launch and sales and configure process stage (see online version for colours)



The process begins by creating a pre-configuration of the product by limiting configuration choices in the self-service channel. The pre-configuration is based on the product's logical structure. The pre-configuration is published in the self-service channel ('as sold' product structure). The customer can configure the product, creating the 'as configured' product structure. In the second step, after configuration, the pricing structure is looked up and the price of the configuration is shown. After the order is placed, the fulfilment process is activated.

4.4 PPM practices

The company has a governance concept for PPM, referred to as SOD. The SOD process is classified as a 'core process'. A dedicated SOD core process development group has members from all BUs of the corporate customers unit. The core process development is led by a corporate customer management team member, who also owns the process. This ensures that SOD is represented at the highest management level. The company has divided the product lifecycle from idea until shutdown and archiving, six lifecycle phases (Figure 7).

In the *idea phase*, a new product is conceptualised, and the idea is recorded. This is done at each BU according to the BU's internal practices.

The actual development project is started in the *service development phase*, where all initial product development takes place. Corporate customer wide processes and accepted practices exist for service development. The process for this phase has the highest process maturity of all PPM processes.

During the *go to market* (GTM) phase, products are connected to delivery, billing, and maintenance processes. During this phase, customer service is trained and required sales and service documents are created. In some cases, the product can already be launched to specific limited customer groups. The GTM phase ends with the sales readiness audit, which ensures that the product can be launched for public sales.

Figure 6 Product data utilisation in the sales and configure process in the self-service case (see online version for colours)

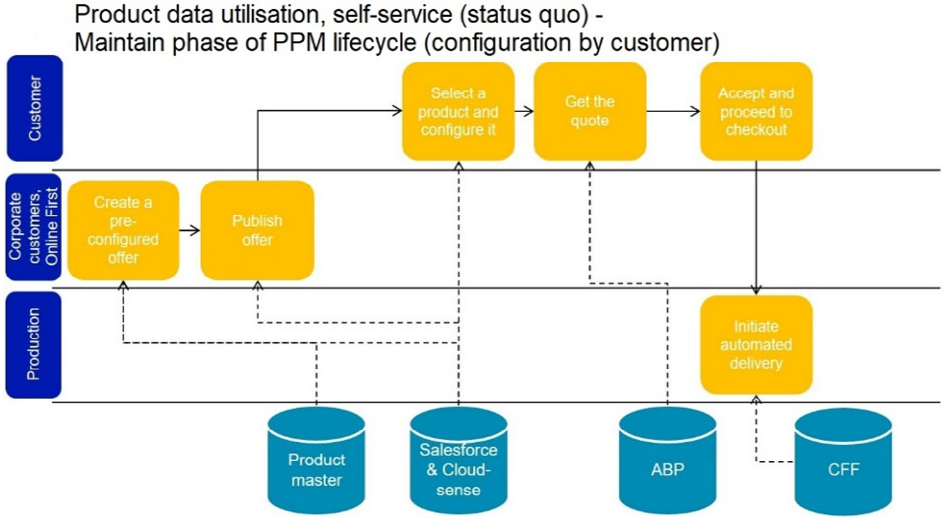
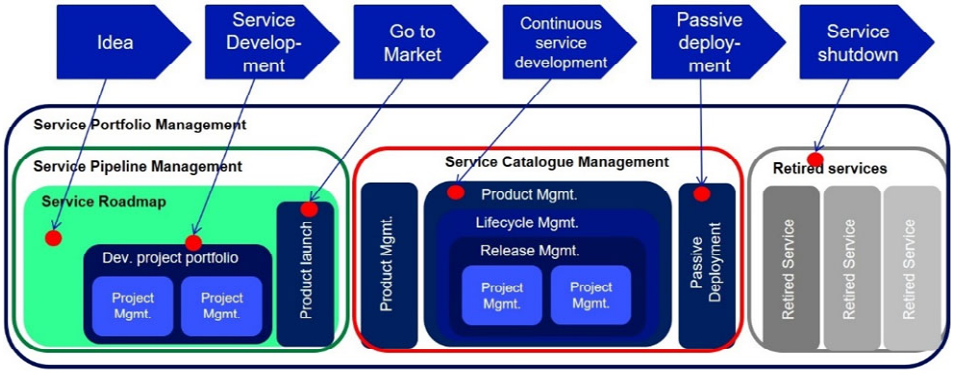


Figure 7 Current PPM concept (see online version for colours)



During *continuous service development*, the product undergoes multiple upgrades and updates, executed as small development projects. Only major version upgrades are cycled back to the service development phase. The continuous service development lifecycle ends with a decision to move the product to passive deployment.

During *passive deployment*, no new product updates or upgrades are made. Customers are informed about ending support and replacement products are promoted.

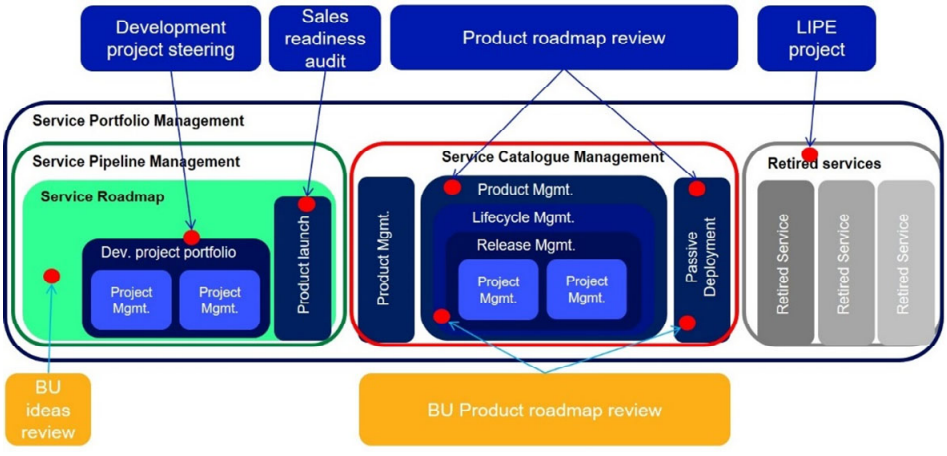
In the *service shutdown phase*, the product is ceased, and the related data are archived following legal requirements.

Because SOD is a governance process, a corresponding management level process is adopted to translate governance guidelines into daily operations. The SOD governance process is mapped to IT infrastructure library (ITIL), the commonly used best practice framework for IT service management. The ITIL lifecycles are based on the ITIL service offerings and agreements (SOA). ITIL SOA includes three main lifecycle phases: service pipeline management, service catalogue management, and retired services. All the above constitute 'service portfolio management', which is the ITIL equivalent to PPM.

4.4.1 PPM processes and tools

There is no centralised process for the entire PPM scope. However, there are dedicated processes for parts of PPM. Some of these processes are centralised, i.e., executed for the entire corporate customer unit, while some processes are executed within the individual BUs and are often BU specific. Figure 8 shows the centralised PPM partial process (on top) and the decentralised PPM partial process (bottom) and their relationship to the product lifecycle phases.

Figure 8 Management processes and management visibility to PPM (see online version for colours)



4.4.1.1 The centralised PPM partial processes: development project steering, sales readiness audit, product roadmap review, and LIPE project

Development project steering is the most mature of all partial PPM processes, with a purpose to check that development projects are ready to pass the four gates in the development process:

G1 planning permission

G2 funding decision and start of development project

G3 launch decision, closing product development, and passing sales-readiness audit

G4 formal project closing and development budget review vs. actual expenses.

The steering group makes the decisions about the gates.

Sales readiness audit consists of a sparring meeting to understand the criteria, and an audit meeting after 2–4 weeks. Sales readiness template is used and reviewed against documentation to ensure fulfilment of set criteria.

Product roadmap review is carried out quarterly by the corporate customer management team with the main purpose to allocate development resources and gain visibility over inter-product interdependencies.

LIPE project is dedicated to shutting down products and migrating customers to new products, initiated when the company noticed that there were too many products in active sales (over 2,000). A decision was made to ramp down to below 1,000 products. LIPE is a priority project, regularly followed by the corporate customer management team. The challenge involves middle management not having visibility to the product shutdowns in other BUs.

4.4.1.2 The decentralised PPM partial processes: BU ideas review, and BU product roadmap review

BU ideas reviews have their process and tools for collecting product ideas. Some use a dedicated SharePoint site for recording product ideas, others a shared Excel. The idea review practices differ between BUs. No commonly agreed criteria exist for evaluation and prioritisation.

BU product roadmap reviews have a monthly review meeting. There are no commonly agreed practices, nor are there any common prioritisation criteria. The format and the content of the roadmap items vary between BUs. The results from these meetings are reflected in the quarterly product roadmap review for the entire corporate customer unit.

4.4.2 PPM metrics and governance

PPM targets of strategic alignment, value maximisation and portfolio balance are reflected in the practices and metrics of company PPM practice:

- *Strategic alignment:* Criteria for strategic fit are defined in the SOD core process. Existing and new products are mapped to a strategic area, and their function (core product, enhancing product, additional product) are defined. In NPD, the strategic fit is reviewed at gates G1 (planning permission) and G2 (funding decision). For existing products, the strategic fit is evaluated at the quarterly product roadmap review.
- *Value maximisation:* Financial metrics are strictly followed and drive most decisions. New products in the NPD phase pass a business case review to pass gate G2 (funding decision). For existing products, the product profitability is reviewed monthly at the BU level.
- *Portfolio balance:* As the company is governed mainly by financial metrics, entirely new products (new technology for new customer segments) have difficulties in securing funding, and the balance aspect is deficiently addressed.

5 Findings

The findings involve multifaceted issues: company A has multiple domain-specific data models; multiple product catalogues serve as process-specific master data; there are requirements to map product data from various catalogues to maintain E2E visibility; there are challenges with the product data ambiguity; the findings lead to reporting problems; PPM processes are fragmented and of different process maturity; a unified approach to PPM is still in the planning and early implementation stage; and a comprehensive PPM governance process is in place, but its implementation in the management and operational layers is still ongoing.

5.1 PDM: systems related findings

Multiple products catalogue cause challenges, whereas the reasons for multiple catalogues are manifold: *structural*, *functional*, and *historical*.

- *Structural reasons for multiple catalogues:* Throughout the Q2C cycle the products exist in multiple stages that have their own structure: *as sold* represents the commercial product structure as offered to customers, usually the closest to the product's logical structure. *As configured*: contains the product structure as the salesperson or customer has configured. This usually is a subset of the product's commercial structure as specific options out of many have been selected or left out. The product structures 'as sold' and 'as configured' can be described in the same structure. *As contracted*: represents product's legal structure, which is out of the scope of this study. *As delivered*: contains the delivery structure of a product, which is made of delivery packages containing one or multiple RFS. The delivery structure usually differs from the commercial structure. *As invoiced*: represents the billing structure and differs from the 'as configured' and 'as delivered' structures. Billing components (expressed as charge codes) are based on the billing logic, which does not necessarily correspond to a logical structure in delivery packages. *As maintained*: represents the installed base of a product, containing the current actual product installation with the current component versions. It is a real-time version of the 'as delivered' structure. However, it may differ from the 'as delivered' structure as maintenance components do not necessarily correspond to delivery packages.

  The different product structures are divided among the various systems: as sold → Productmaster, MIPA, Tellus; as configured → CloudSense; as contracted → no central register exists; as delivered → retroactively assembled from billing and delivery data; as invoiced → ABP; as maintained → retroactively assembled from billing and delivery data.

- *Functional reasons for multiple product catalogues:* The company is structured along with functions, including product management, sales, delivery, billing, and maintenance. Each function is profit/loss responsible and aims at optimising its cost structure. This has led to the practice of each function selecting their systems to optimise their processes and reduce their costs. There is no view of costs across the various functions. The functions use the systems that best fulfil their process needs: product management: Productmaster, MIPA, Tellus; sales: salesforce, CloudSense; delivery: CFF, NIMS; billing: APC, ABP; maintenance: JIRA.

- *Historical reasons for multiple product catalogues:* Historical reasons for multiple product catalogues are mainly due to the evolution of products and the M&A history. For example, the existence of MIPA and Tellus product catalogues is due to fixed-line products and mobile products significantly differing in structure. Phasing out most fixed-line products, and keeping legally required ones, has resulted in the coexistence of the two systems for many years. Migrating the MIPA catalogue to another system is not seen as necessary.

5.2 PDM: processes related findings

Three main findings include PDM related processes being fragmented; product managers do not have a complete view of technical product structure due to the lack of technical product catalogue; and compatibility issues making product configuration challenging.

The PDM processes are fragmented across functions. There is no overall visibility of product data among functions as the product structure, and in many cases, even product IDs are changed across the functions. The only exception involves two roles, development manager for Productmaster and development manager for billing and product management, which can trace product data across all functions by using mapping tables. The mapping tables are Excel-based on development managers' laptops, making tracing product data extremely vulnerable.

Product managers only have a complete view of the commercial representation of their products across functions, but they lack the detailed technical view, as no technical catalogue is maintained.

Compatibility issues become challenging to clarify between products due to deficient technical product view. This hampers product configuration. While the Q2C process at the company has shown that they can offer products as 'configured-to-order', this requires additional efforts. Either the configuration is done with the help of sales and product management or the company offers pre-configured products with only limited configuration choices for the customer. The pre-configured products must be created by the responsible product manager and the development manager for Productmaster, who owns the product's logical structure.

5.3 PPM related findings

Based on analysing PPM processes, practices, and metrics, the process fragmentation is evident; senior management's view over the product portfolio is limited, and the middle management's view is also lacking. Only the NPD phase of the product lifecycle is given careful attention. The ramp-down phase is also given attention through the LIPE project as earlier the product portfolio had excessively many sales items in the catalogue. The customer requirement of delivering larger integrated solutions is a driver for centralised PPM processes. The company has started to address the challenges arising from decentralised PDM and PPM by creating a PMT and initiating a program for SOD implementation.

The PPM process fragmentation can be seen in Table 1. The PPM processes are mapped to the product lifecycles phases.

Table 1 shows the fragmentation of PPM processes on the management and operational levels. The reasons for fragmentation are manifold. One large contributor is

the fragmentation of PDM. Another root cause is the organisational structure. The different BUs is managed independently and enjoys great autonomy in their operations. This has led to organisational siloes. Only recently, the company has started to remedy the situation by making organisational changes. The creation of a PMT was among the biggest changes that started with process mapping and aligning processes by defining common decision points and criteria for passing them (stage gates).

Table 1 PPM processes for the product lifecycle phases

	NPD	*Ramp-up*	*Use and maintain*	*Ramp-down*	*Field maintenance*	*Archive*
Governance	SOD core process					
Management	Product development steering		Product roadmap review		LIPE project	
Operations	Product development process	Sales readiness audit	BU product roadmap review	BU specific product migration practices	BU specific practices	BU specific practices

5.4 Preconditions for centralised PDM and PPM

Three categories of pre-conditions for centralised PDM and PPM are identified: organisational; PDM; and product process. Depending on the type of organisation, their priority may vary.

1 *Organisational pre-conditions:* As long as there are organisational siloes, a common view of product data and organisation-wide PPM process are severely hampered. As organisational pre-conditions there needs to be:
   - commitment from top management to implement PPM across the organisation
   - creation of an organisational entity for the implementation of PPM across the organisation
   - giving the organisational entity authority to make product lifecycle decisions.

2 *PDM pre-conditions:* Product data has multiple instances that are often tied to functions, such as product development, sales, billing, and maintenance. In the analysed company, this has led to the creation of different product structures and product data is stored in multiple catalogues. To enable centralised PDM, the following pre-conditions must be met:
   - creation of a common product data model that will be complied with throughout the entire organisation
   - using only one centralised system for product master data
   - all other systems that support specific functions must utilise the centralised product master data and may only enrich it.

3 *Product process pre-conditions:* Most organisations organise around functions. Also, the analysed, which over the years has led to organisational siloes. These functional siloes have their separate processes, resulting in process fragmentation. To centralise PDM and PPM, the following pre-conditions need to be fulfilled:

- implementation of a central PPM process that cuts across all BUs and functions
- creating visibility of the entire portfolio throughout all lifecycle phases
- adopting metrics on the governance, management, and operational level for following the PPM goals (strategic alignment, value maximisation, and portfolio balance).

To move from a decentralised PDM and PPM to a centralised PDM and PPM, the aforementioned pre-conditions are vital. The practical implementation of the pre-conditions for centralised PDM and PPM are summarised in Table 2.

Table 2 Preconditions for centralised PDM and PPM

	Organisational	*Product data*	*Product process*
Governance	• Recognise PPM as a strategic process. • Top management buy-in for PPM implementation. • Creation of a PPM governance model.	• Decide on a company-wide product data model. • Decide on product-centric enterprise architecture. • Implement a centralised PDM system.	• Create a company-wide PPM governance process. • Decide on governance level criteria for stage gates. • Implement a company-wide PPM process.
Management	• Creation of a cross-organisational PPM team and assign decision-making power. • Creation of a PPM management model.	• Implement a common product structure. • Implement metrics for data quality.	• Align the stage-gate criteria with the governance level criteria. • Implement metrics for measuring process performance.
Operations	• For product lifecycle related work, organise the operational personnel into cross-functional teams.	• Implement a data standard that needs to be adhered to.	• Align operational work by aligning decision criteria with the stage gates.

Main finding

It seems that PDM and PPM centralisation should be started from processes and data should be considered in the second stage due to the harmonisation of data structures and systems for centralisation being much more challenging than the alignment of processes and decision-making. Both, the process alignment, and the harmonisation of product data models across the organisation are necessary to align the different BUs. Hence, the organisation, the processes and the data structures must be considered.

6 Discussion

This study takes a holistic managerial perspective over product lifecycle to investigate decentralised PDM and PPM, and to identify related advantages and challenges. Specific attention is given to revenue-generating processes. Pre-conditions for centralisation are considered. True company practices are analysed in telecom corporate business with evident decentralisation. The impacts of decentralisation on the revenue-generating Q2C process seem to culminate into the interplay of master data, processes, PDM systems, data, product structures, and decision-making. Three higher-level factors that appear to influence whether a company benefits more from centralisation or decentralisation of PDM and PPM, seem to include *the volume of standard products*, *pressures to comply with regulations and standards*, and *product and process maturity*.

PDM and related systems link to company processes. PDM concerns the management of all product data, including master data, and data from processes that enrich it. The Q2C process intersects with PPM and the related lifecycle phases, specifically linking to products that are available for sale, are delivered, and invoiced. Master data is vital for addressing the products, the layered product structure being focal for both PDM and PPM. Any discontinuities in master data influence marketplace participation as the Q2C process is affected.

Decentralised PDM makes coherent data management challenging as decentralisation can disturb the mastering of product data and the allocation of transaction data to master data. In practice this may for example disturb billing as linking necessary billing components to sold product components may involve unnecessary manual activities and additional challenges. Alternatively, creating a quotation, or order and delivery process stages can be challenged due to decentralisation. It is the data fragmentation that leads to process discontinuities. The scope of products must remain the same through the operations and lifecycle stages so that the product remains the same through quotation, ordering, delivery, and billing. Any deviations in scope will cause discontinuities in revenue-generating processes.

Decentralisation can also cause fragmentation in the data model, necessary to capture data for processes. Any process fragmentation further disturbs PPM by affecting decision-making and leading to loss of necessary big picture. After all, the role of PPM is to analyse and decide on the company's products over the lifecycle stages. The fragmentation of processes further links to organisational challenges. Fragmentation challenges the PDM and PPM governance necessary to maximise the value of technology, processes, people, and data, which are vital for decision-making.

In the analysed company, master data is process specific through the existence of multiple product catalogues. The decentralisation cause challenges in the visibility over products and product data. Unnecessary data-mapping activities are carried out to ensure visibility. Product data has become ambiguous and siloed, processes are fragmented, and reporting is affected. Partial optimisation is evident due to functional profit/loss responsibility and the selection of systems. Allocation of transaction data to master data is challenged. Specifically, the way product structures are addressed, both, the commercial and technical side. Certain compatibility issues that hinder configuration are due to decentralisation. The Q2C process is forced to make an extra effort while considering configurations, which leads to either unnecessary internal coordination or heavily limited possibilities. The concentration of critical capabilities on a few key people, the associated risks, and compatibility issues in case of updates and upgrades are

not desirable. The PDM and PPM governance are affected. Hence, the current decentralisation is not ideal neither from the perspective of the Q2C process nor the perspectives of PDM or PPM. The company PDM systems do not optimally support effective PPM.

PPM should implement company strategy by providing a range of products or services to achieve company goals and should enable addressing products over lifecycle stages. PPM focus enables maximising the value of the product portfolio and preparing for changes in the business environment. PPM analysis and decision-making are based on data, highlighting the role of PDM. Hence decentralised PDM is a large contributor to decentralised PPM. Also, the organisational structure has an influence. Specifically, the decentralisation of PPM to BUs cause challenges as the overall perspective over products and services is lost. Siloed organisations result in challenges in PPM responsibilities, but also PDM, and hinder possibilities for an effective Q2C process. In the analysed company the corporate customer BUs all use separate product structures, which challenges reaching consistency necessary for PPM. Many challenges follow throughout the Q2C process.

In this study, three categories of pre-conditions; organisational, PDM, and product process are identified for PDM and PPM centralisation. The practical implementation of the pre-conditions is considered at three levels of governance, management, and operations. The findings indicate that the priority in PDM and PPM centralisation should be in aligning processes and decision-making first, and the harmonisation of data should take place after. The motivation for the priority lies in the harmonisation of data structures and systems being much more challenging than process alignment. Also, process needs affect the system selection, making varying process needs unfavourable.

6.1 Decentralisation/centralisation advantages

The advantages of decentralisation involve certain flexibility and quick reactions. Faster decision-making is enabled by BUs acting independently. This enables a faster reaction to customer requests and more tailored solutions. Any decisions and customisation can benefit from specific domain knowledge by BUs that is not available in other parts of the company. Higher flexibility is also an advantage as, for example, processes can be executed, and products delivered with a lower process/product maturity. Even ad-hoc creation of processes/products is possible.

Companies may have a certain historical progression or structural or functional reasons that have led to decentralised management of data and products. The main advantages of decentralised PDM and PPM in the analysed company link to previous M&A. Quick integration of new BUs and avoiding lengthy migration projects was enabled as existing processes and systems were possible to be left largely untouched. The newly acquired companies had products that were largely different from the company's core products. Only a few compatibility issues had to be considered. Hence, the decentralised PDM and PPM provided the advantage of speed and flexibility.

The advantages of decentralisation disappear once moving towards a more integrated product portfolio and more integrated management. Customers expecting the delivery of larger integrated solutions creates the requirement for compatibility and configurability of products across various BUs. The fragmentation in the processes and practices cause discontinuities in the vital processes that create revenue. The necessity of manual work

and process variance are not ideal. This can involve requirements for mapping both product IDs and component IDs across various systems, functions, and processes. Such continuous mapping and the concentration among a few key personnel causes additional risks to the business. The Q2C process is vital and should function seamlessly to ensure a beneficial appearance in the marketplace. Centralised PDM can become viable and the organisational, data structure and process perspectives are of benefit while considering PDM and PPM centralisation. Not to forget understanding their interlinkages.

The primary benefits of centralisation involve standardised ways of working and enabling economies of scale and scope. The improved ability to comply with standards and regulations helps with customers from domains such as government and healthcare. Cost reductions result from the utilisation of standardised product/process components. The portfolio view is improved as products/processes from different BUs form a centralised portfolio with synergy effects. The view over costs and profitability is improved. Layered products are among the key drivers for centralisation benefits as components can be used in multiple products. It is the faced compatibility issues that drive towards a centrally managed portfolio.

6.2 Scientific contribution

This study provides novel contributions by showing holistic evidence on how PDM and PPM decentralisation impact the revenue-generating Q2C process and involve the interplay of master data, processes, PDM systems, data and product structures, and decision-making. The wide-based consideration is novel by itself, and support the PPM discussion (Crowley, 2017; Lahtinen et al., 2021; Medini et al., 2020; Tolonen et al., 2014b) specifically by linking to the Q2C process and by presenting empirical evidence. The contribution involves strengthening the understanding of related interlinkages. The company evidence of how the Q2C process relates to PDM and PPM is of value. Evidence of true decentralisation challenges are presented with indications on how a more integrated management and product portfolio emphasise the deficiencies of a decentralised approach. The centralisation can be driven by the demands for larger integrated solutions, creating requirements for compatibility and configurability. Specifically, the organisational, data structure and process perspectives are highlighted for decentralisation vs. centralisation of PDM and PPM. The findings support Hannila et al. (2022), Larkin (2008), and Tolonen et al. (2014b) in organisational; Silvola et al. (2011), Trąbka and Soja (2013), Su et al. (2017), and Allen and Cervo (2015) in the data structure; and Das and Mishra (2011), Jetson and Nelis (2008), and Hannila et al. (2020) in processes perspectives. This study clarifies preconditions and the priority for centralisation. This study also confirms previous isolated findings of decentralisation enabling tailored solutions (Velu et al., 2013), and the related independence of BUs (Velu et al., 2013; Modrak, 2013; Mikalef et al., 2021). Also, the flexibility and enabling growth (Schwenker and Bötzel, 2007), but new is provided by displaying the PPM perspective.

6.3 Managerial implications

Managers working with information or in technical organisations can benefit from the finding by understanding the challenges of decentralised PDM and PPM, and the linkages to revenue-creating processes and decision-making. The challenges particularly apply to

situations with customer demands for more complex solutions. The practitioners benefit greatly by realising that the order of priority for centralising PDM and PPM involves considering process alignment before harmonising product data over the organisation. The preconditions distilled for centralised PDM and PPM, involve the governance, management, and operations across the organisational, data structure, and process perspectives, which can prove beneficial with the provided insights. Managers should understand that the need for change towards the centralisation may come from the customer, whereas the decentralisation can be caused by company structures. Also, allocating transaction data to master data becomes easier along with centralisation, benefitting particularly the Q2C process.

6.4 Limitations

The limitations of this study include the number of analysed companies and focusing on a certain field of business. The provided insights should, however, be beneficial when expanding the considerations to other fields. Also, the business model of the product and its impact on centralisation/decentralisation is not directly considered. The cost of complexity and the relation to centralisation/decentralisation is not considered.

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Appendix

Interview questionnaire and process self-assessment form

Table A1 Process self-assessment form

Interview questionnaire (= process self-assessment form + supported by confidential process flow charts)			
Process name: Date: Compiled by: Process owner:			
Process areas	*Assessment criteria*	*Evaluation**	*Evidence*
The objective of the process	*The process objective is defined:* What is the process objective? The objective must be explicitly stated and added to the process description and process documentation.		
Customer value	*The customer value is defined:* What value does the process create for the customer? The customer value must be clearly defined and stated in the process description and the process documentation. The process owner is responsible for aligning the process objective (internal) with the customer value (external).		
Process description	*The process diagram is done:* If the process diagram has been started, but is not complete, answer 2. *The process diagram has been reviewed and confirmed to describe the workflow:* In the review, it has been confirmed that the process diagram shows the actual workflow. The review approves the process diagram if in addition the diagram is considered formally complete (i.e., complies with internal notation rules and describes the reality). Only reviewed and approved process diagrams can be published. In conjunction with the publication, an entry in the process master data register has to be made. *The process diagram has been reviewed, approved, and published:* In the review, it has been confirmed that the process diagram shows the actual workflow. The review approves the process diagram if in addition the diagram is considered formally complete (i.e., complies with internal notation rules and describes the reality). Only reviewed and approved process diagrams can be published. In conjunction with the publication, an entry in the process master data register has to be made. *The process diagram is updated when there are changes to the process:* When recent changes have been made to a process, it should always be checked whether the changes have been documented in the process diagram and other process documentation. *There is a regular process review at least once a year:* The process diagram needs to be reviewed at least once a year, to ensure that the process diagram is still describing the process workflow in reality. When required, the process diagram and other process documentation are updated. In case of an update, a new review is required. The update and the approval of the update (who updated? who reviewed and approved? dates?) must be documented and visible in the process portal. *Have the process improvement and automation potential been assessed?* When creating the process diagram, have the following issues been considered and documented: • potential improvements • potential for automation With regards to automation, please use the automation potential form.		

Note: *Evaluation on a scale from 1–3 (1 = not implemented, 2 = partially implemented/implementation started but not completed, 3 = fully implemented).

Table A1 Process self-assessment form (continued)

Process areas	*Assessment criteria*	*Evaluation**	*Evidence*
Process SOP	*Work instructions have been written according to the SOP guidelines:* Based on the process diagram work instructions have been written according to the SOP (Standard Operating Procedure) guidelines. The SOP must be recorded in the process portal. Link to SOP guidelines *Process work instructions have been published as SOP:* SOP published in the process portal *SOPs have been implemented; they are the primary instructions and have been confirmed as functioning:* SOPs are always updated when there are changes in the process workflow, or a change request has come in from a process actor or other stakeholder. SOPs are reviewed at least every six months. It is ensured that they are up-to-date and remain functional and purposeful. When the process (workflow) changes, the SOPs are updated, and it is ensured that they conform to the process diagram. Changes are documented. Further, it needs to be documented who made the changes, who approved the changes and the respective dates. *Non-SOP instructions: up-to-date instructions are published, documented and they have a specified owner:* If there are work instructions, which are not SOP, they need to be evaluated according to the following criteria: • instructions are up-to-date • instructions are published and accessible by all who need it • instructions have been implemented • instructions are functional, purposeful, and easy to understand • instructions have an owner who is responsible for the timeliness and change request • users can submit change requests and their feedback is considered when the instructions are updated		
Process owner	*The process has a named process owner* *The process owner knows his area of responsibility and works according to the role's description:* For the process owner role's description, please refer to the documentation in the training material. Among the responsibilities of the process owner are: • process development --> development plan • process SOP --> SOP documentation • process metrics --> metrics for purposefulness, quality and efficiency and the measures should the metrics exceed tolerances		

Note: *Evaluation on a scale from 1–3 (1 = not implemented, 2 = partially implemented/implementation started but not completed, 3 = fully implemented).

Table A1 Process self-assessment form (continued)

Process areas	*Assessment criteria*	*Evaluation**	*Evidence*
Process owner	Has the sharing of responsibilities with other stakeholders been clearly agreed upon? (--> RASCI matrix)		
	The process owner knows how to continuously develop the skillset required for the role: For specific process development tasks, support from central process development is available. For process development tools, please refer to the process portal.		
Process metrics	*The process metrics have been specified, considering effectiveness (purposefulness), quality and efficiency:*		
	There are process metrics from all three areas:		
	• effectiveness (purposefulness, i.e., is the process fit for purpose) • quality (intrinsic quality and quality as experienced by the customer) • effectiveness (both resource and time efficiency)		
	The value creation for the customer is a key aspect in the selection of metrics: The key aspect is that the value-add for the (end-) customer has been clearly specified and that there are metrics that confirm that the additional value is being created.		
	The customer can be either internal or external. As with all process metrics, all three areas must be covered:		
	• effectiveness • quality • efficiency		
	Process management metrics are in place, and they are followed regularly (real-time, daily, weekly, other): Process metrics are delivering value that is followed in real-time or at regular intervals. The suitable frequency varies from process to process but is commonly agreed upon and adhered to.		
	Metrics are visualised on a dashboard:		
	Permissible value ranges for process metrics have been defined, as well as actions when metrics exceed the allowed range: Process metrics have a defined allowed range: how much variance is allowed before corrective action is taken? For these instances, concrete actions must be decided in advance, documented, and made accessible to process actors.		

Note: *Evaluation on a scale from 1–3 (1 = not implemented, 2 = partially implemented/implementation started but not completed, 3 = fully implemented).

Table A1 Process self-assessment form (continued)

Process areas	*Assessment criteria*	*Evaluation**	*Evidence*
Process metrics	*Process deviations trigger an immediate reaction:* If the metrics exceed their specified range, actors react by initiating corrective actions. These corrective actions must be defined in conjunction with the specification of the metric.		
	There are conformance metrics for indicating the alignment of the process with governance level guidelines: A conformance metric measures whether a process complies with requirements set by governance. These requirements can be, e.g., laws and regulations, adherence to standards or adherence to internal governance guidelines. Also, the conformance with business goals must be taken into account.		
	The realisation of customer value is measured (process output): The specific customer value is defined and measured with a quantifiable metric.		
Management system	*The concept of the management system has been acquired through the product owner training or other training:* The process owner has participated in the internal process owner training or otherwise acquired the knowledge of the management system.		
	Ownership of sub-processes and support processes has been assigned and the interfaces between them agreed upon: The ownership and responsibilities have been agreed, so that the value stream can be managed without discontinuities: All process actors have a clear understanding of the process workflow as a whole and the handovers between sub-processes and supporting processes.		
	Operational review meetings (or similar management meetings) are held regularly:		
	The operational review meetings (or similar mgmt. meetings) are guiding value stream management: In the operational review meetings, the performance of the value stream is evaluated and optimised. For decision making all process actors are involved as required. The operational review meetings also review the related sub-processes and supporting processes and their value streams. This is to avoid partial optimisation and a too narrow review scope. The goal of the operational review meeting is to provide a holistic view of process performance and manage it from an overall value stream perspective.		
	The operational review meeting is led by the business outcomes metrics: In operational management, the business goals and metrics have to be taken into account. They guide the process management decisions.		
	Ongoing and planned process development items are recorded: there is a description and an initial roadmap: When potential development items have been identified, they need to be recorded and their implementation prioritised and actively followed. Process development items are added to the continuous process development backlog. This ensures transparency of all continuous development projects.		
	The continuous development backlog is in use and actively updated: Process development items are recorded in the continuous development backlog.		
	Customer feedback and customer value are considered when specifying process development items: When specifying process development items, the available customer feedback must be taken into account. Development items are evaluated against their impact on customer value.		

Note: *Evaluation on a scale from 1–3 (1 = not implemented, 2 = partially implemented/implementation started but not completed, 3 = fully implemented).

Table A1 Process self-assessment form (continued)

Process areas	*Assessment criteria*	*Evaluation**	*Evidence*
PPM/PDM specific	*Stage gate criteria for product lifecycle phases have been specified and are regularly reviewed*		
	Stage gate criteria are checked for alignment with governance guidelines		
	Product data is created and maintained in a dedicated product catalogue (specify where)		
	Transaction data generated by the process can be unambiguously mapped to the product catalogue data		
	Product configuration data is stored and maintained and can be unambiguously mapped to a product entity		
	Product instances are stored and can be unambiguously mapped to a product entity, a customer, and a specific transaction		
	Product data archiving practices are aligned with governance guidelines		
	Decisions from the portfolio review guide development work prioritisation		
	Compatibility issues are considered in product updates/upgrades and escalated to the portfolio review		
Roles	*Roles have been clearly defined:* The process actors' roles have been analysed and there are detailed role descriptions/specifications. The purpose is to ensure that a process is not dependent on specific people, but roles that can be assigned to different people.		
	Process actors have attended the training specifically for each role: It has been ensured that process actors can fulfil their specified roles. Adequate training and documentation have been provided to them.		
Resources	*Resources have been specified and classified:* Process resources (e.g., people, systems, data) have been specified and classified into scalable and non-scalable resource classes.		
	Development resources for continuous improvement have been assigned		
Risks	*Risk analysis has been conducted utilising the template provided by internal review or documented in another way approved by internal review:* There are specific guidelines for risk management. Please refer to the material provided by internal review.		
	Risk analysis is updated at regular intervals. Risks are considered in all development work		
	There is an approved business continuation plan of which the process continuation plan is a part. The plan consists of a risk mitigation and risk recovery plan.		
	The sufficiency of the audit scope for risk evaluations by internal review has been assured.		
	Development work for risk mitigation and risk recovery has been documented and prioritised in the development pipeline. The development items are regularly reviewed.		
	Risks that have materialised are documented and reviewed.		

Note: *Evaluation on a scale from 1–3 (1 = not implemented, 2 = partially implemented/implementation started but not completed, 3 = fully implemented).